

# The Effects of Word Frequency and Context on Different Types of Memory: Evidence from Recognition Memory Test, Cued Recall Test, and Free Recall Test

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## Abstract

The study investigated the effects of word frequency and context on the memory in recognition memory task (Experiment 1), cued recall task (Experiment 2) and free recall task (Experiment 3). The results showed that in Experiment 1 there was no significant main effect of word frequency in accuracy and reaction time analyses, but the performance for low context words was better than that for high context words. In Experiment 2, low-context target words were recalled better than high-context target words, and similar result pattern was obtained in cued recall task. Low-frequency target words, but not the low-frequency cues, were more effective than the high-frequency target words. In Experiment 3, the accuracy of low context words was higher than high-context words, while the accuracy of high-frequency words was higher than low-frequency ones. Moreover, the effect of context on memory was strongest in cued recall task, free recall task is the next, and recognition task is the weakest. The result revealed that the effects of word frequency and context vary across as the function of memory types.

**Keywords:** Word frequency; Context; Recognition memory; Cued recall; Free recall

## 1. Introduction

Memory, the process of accumulating and preserving individual experience, consists the coding, storage and retrieval of the outside information. The German philosopher Hermann Ebbinghaus used the nonsense syllable learning paradigm to carry out one of the earliest studies of human memory [1]. It was argued that memory was not a simple process of memory storage, but the reconstruction and construction which is full of

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imagination, and the presentation or reconstruction of the past experience [2]. Currently, many studies have found that human memory is influenced by many factors such as the characteristic and the quantity of the memorization of the material, the engagement in learning process, serial position effect of material, the learners' attitude and word frequency[3].

Actually, the word frequency effect on memory has gained the support of a number of studies. Holbron has investigated the role of the word frequency and auditory comparability in free recall and recognition memory task, founding that there was no interaction between word frequency and auditory comparability in free recall task condition, but the recall performance of high frequency words were better than low frequency words[4]. Moreover, in recognition memory task, the interaction between word frequency and auditory comparability was significant, namely the recall performance of low frequency words was better than the high frequency words when the auditory comparability was at low level; while the auditory comparability was at high level, there was no significant difference recall performance between high frequency words and low frequency words. The research proved the word frequency mirror effect in the recognition task, that was, the recall performance of low frequency words was always better than the high frequency words [5]. And MacLeod investigated the role of the word frequency in free recall, recognition and words fill task, and found that there was a significant effect of word frequency in recognition and words fill task, with low frequency words recall performance always better than high frequency words [6], but no such word frequency effect in free recall task. Besides, DeLosh and Mcdaniel found that while low frequency and high frequency words were tested separately, the high frequency performance was superior to the low frequency words in free recall task [7]. Recently, Chee used event-related potential (ERP) and functional magnetic resonance imaging (fMRI) to test the memory effect about the word frequency and sequence effect, and found that low frequency words' extraction time was longer than high frequency words in semantic judgment task, nevertheless, the accuracy of low frequency words was higher than high frequency words in recognition task[8]. In addition, the low frequency words could lead to a more actively activation of left frontal lobe, left fusiform gyrus and the anterior cingulate than high frequency words. Thus, it can be seen that word frequency effect is different in different memory task.

Moreover, most studies confused the word frequency and the role of the context in memory studies, namely while those researchers tested the effect of word frequency, they failed to eliminate the influence of context effect. And in many other language processing studies, researchers have proved that both word frequency and context can affect word recognition and semantic understanding [9]. Obviously, there are four types combinations between word frequency and context, showing that high-frequency words can be combined with high context(the words appear many times and appear in different situations), or low context(the words appear many times but concentrate in certain situations), and low-frequency words can be combined with high context(the words appear less times but appear in different situations), or low context(the words appear less times and concentrate in certain situations). Then what are the roles of word frequency and context in memory task? They work independently or have interaction with each other? These problems will need to be further gone into.

Of importance, Steyvers [10] proposed context variability to measure the variations of context. The larger variation the context variability is, the widely used the word is. Steyvers and Malmberg found that the words of low context variability had a better performance than the words of high context variability in recognition task [11]. Subsequently, Hicks found that the words of low context variability had a better performance than the words of high context variability in free recall [12]. Coincidentally, Cook discovered when participants were asked to use the vocabulary 'remember', 'know' and 'new' to label the word presented, they were more likely to reported 'remember' in low context variability condition, while they reported more 'know' in high context variability condition. However, due to high degree familiar of the high context variability word, it's more likely to be mistaken for 'know' [13]. Ranbom and Larissa found that the flap variant occurred relatively frequently compared with the citation form variant and is only probabilistically constrained by prosodic and phonemic context [14].

Obviously, many studies took a single memory task to investigate word frequency and context effect on memory respectively, but they had never explored the word frequency and context both at the same time. The

recent research investigated the influence of the frequency and context for cued recall, founding that the recall performance of high frequency target words, but not the high frequency cued words, was better than low frequency target words when the context variability was controlled to a degree [15]. Recently, the result found that priming across contexts is sensitive to the distinctiveness of the trace and the reliance on episodic retrieval mechanisms. These results also shed light on the influence of event boundaries, such that priming occurs across different events for relatively distinct (low-frequency) items [16]. Moreover, the low context variability cued word could promote recall performance, but not the same for the context variability of target word. Note that word frequency and context have different effect on recall performance in cued recall condition. The current study firstly examined the role of the word frequency and context in recognition, cued recall and free recall by using the same materials to reveal the latent mechanism about the word frequency and context in different recall task.

The research in corpus of 46 300 words of salutation, exaggerated, usage, choice of words, words collocation, cognitive verbs and the usage of pronouns indicated the vocabulary choose (lexical choices) and negative semantic rhythm (negative semantic prosody) could be used to destroy the image of candidates, the first Person and second person singular pronoun than first person and third person plural pronouns of high frequency [10].

**2. Experiment 1: The effects of word frequency and context on the performance in memory recognition task.**

- **Methods**
  - **Participants**

A random sample of 26 college students in Guangzhou ( males and females in half, mean age = 19.64±1.31 ) which native language was Chinese and vision or corrected visual acuity was normal. They would some reward after the experiment.

- **Materials**

The experimental words included four categories (the high frequency- high context words, high frequency - low context words, low frequency -high context words, low frequency- low context words). In total, there were 160 words for each category with 40 words. In addition, 80 new words were selected. High frequency- high context words were significantly different to high frequency- low context in the context ,  $t(39) = 25.47$  ,  $p < .001$ . It showed that low frequency- high context and low frequency- low context had a effective difference in context ,  $t(39) = 20.71$  ,  $p < .001$  . High frequency - high context was higher significantly than low frequency -high context in word frequency,  $t(39) = 12.5$  ,  $p < .001$ . High frequency- low context words were significantly different to low frequency - low context in word frequency,  $t(39) = 10.03$  ,  $p < .001$ .The word frequency and context of the words were displayed in Table 1 and Table 2.

**Table 1: The Average Word Frequency (per million)**

Word frequency	Context		The total average
	High context	Low context	
High frequency	65.73 ± 12.72	61.83 ± 11.22	63.78 ± 12.08
Low frequency	38.92 ± 3.47	39.23 ± 5.56	39 ± 4.61
The total average	52.32 ± 16.37	50.53 ± 14.38	

**Table 2: The Average Context (sheets)**

Word frequency	Context		
	High context	Low context	
High frequency	277.73 ± 9.88	133.8 ± 35.51	205.79 ± 76.93
Low frequency	275.63 ± 36.49	132.85 ± 17.28	204.25 ± 77.24
The total average	276.7 ± 26.28	133.33 ± 27.75	

○ **Procedure**

The experiment consisted of 5 blocks which included learning phase and text phase .In the learning phase, there was fixation point “+” in the center of the gray screen (R = 192; G = 192; B=192). Then a pair of word (such as, the President - coefficient) rendering disappear automatically after 3s. Empty screen 500ms later, next pair of words presented. The participant had to learn 32 words about 8 high frequency-high context words, 8 high frequency – low context words, 8 low frequency– high context words , and 8 low frequency – low context words. The four types of words made up 16 pairs of words. After learning words, they would finish a computing task in a minute, e.g., 37+45 = ?. Once the answer was wrong, the program gave feedback to improve their degree of serious and avoid retelling the words. When they had finished the math computing task, they would continue to the text phase. In the text phase, there was fixation point “+” in the center of the gray screen .Next, the participant was asked to key and judge which words had learned as soon as possible, when a pair words presented. Keying was balance between subjects. It included 32 trails which had new and old words in half. After a block, the participant could have a rest in a minute and then went on the next block.

● **Results**

A two-way analysis of variance (ANOVA) with repeated measures was applied to 2 (accuracy) × 2 (reaction time) , as a dependent variable . The result of accuracy indicated that the main effect in the word frequency was not significant,  $F(1, 25) = 1.1, p > .05$  and the main effect in the context was significant,  $F(1, 25) = .58, p = .005$ . The accuracy in the high context (.82) was lower than low context (.86). An interaction between word frequency and context was not significant,  $F(1, 25) = .58, p > .05$ . The context in result showed that the main effect in the word frequency was inconspicuous,  $F(1, 25) = 7.42, p = .012$ . In addition, the reaction time in the low context (770 ms) was shorter than in the high context (820 ms). There was an insignificant interaction between word frequency and context,  $F(1, 25) = 0.5, p > .05$ .The result were showed in the Table 3 and Table 4.

**Table 3: The Goal Memory Accuracy of Various Conditions in Recognition Tasks (M ± SD)**

Word frequency	Context	
	High context	Low context
High frequency	.83 ± .11	.87 ± .11
Low frequency	.8 ± .1	.86 ± .09

**Table 4: The Reaction Time of Various Conditions in Recognition Task (M ± SD, ms)**

Word frequency	Context	
	High context	Low context
High frequency	811 ± 185	780 ± 181
Low frequency	830 ± 175	761 ± 164

● **Discussions**

The result in the experiment 1 only indicated that there was a main effect between accuracy and reaction time in the recognition task and had no interaction within word frequency and context. These results pointed out that context influenced on forming of recognition memory, and its role was independent from interfere of word frequency. Due to the word frequency and context had a certain degree of covariance [11] [17], high frequency word generally have high context and low-frequency word generally have low context. Therefore, in order to balance between word frequency and context, the words in our study were selected in the range 20.8 to 98.7 times per million, the less gap between the high and low frequency of only 24.71 times per million. In addition, another research found the simple task was more difficult to detect the factor effect, comparing to the relative hard task [18].Thus, the recognition was the relatively simple task and the average accuracy in this experiment was over 80%. So it was disadvantage to explore the less difference in word

frequency. The result also improved context was more sensitive and stronger than word frequency to influence memory recognition.

**3. Experiment 2: The effects of word frequency and context on the performance in clue recall task.**

• **Methods**

○ **Participants**

A random sample of 26 college students in Guangzhou ( males and females in half, mean age =20.31±1.85 ) which native language was Chinese and vision or corrected visual acuity is normal. They didn't participate in the experiment 1 and would some reward after the experiment.

○ **Materials and Procedure**

The materials were identical to the experiment 1. Similar to experiment 1, the experiment consisted of 5 blocks and each block included learning phase and text phase. In the learning phase, it was consist with the experiment 1. After learning words, they would finish a computing task in a minute. Then, in the text phase, there was fixation point “+” in the center of the gray screen. Next, the clue words (one from every pair words in the learning phase was selected as clues and the clue word selection was balance between subjects.) were presented and the participants were asked to accord the clue and write a corresponding target words. After a block, the participant could have a rest in a minute and then went on the next block to complete the order of the block balance between subjects.

• **Results**

To investigate the word frequency and context influenced on to the target word memory, the correct numbers in the target words in order to calculate the accuracy. The repeated measures analyze indicated the main effect in the word frequency was significant,  $F(1,25) = 4.37, p < .05$ . The recall accuracy in the high-frequency words (.52) was better than in the low-frequency word (.48). The main effect in the context was also evident,  $F(1,25) = 3.11, p = .09$  and the recall accuracy in the high context words (.45) was less than the low context words (.57). An interaction between word frequency and context was obvious,  $F(1,25) = 3.11, p = .09$ . The simple effect analyze found in high frequency words, the recall accuracy in the high context words (.45) was less than the low context words (.60),  $(1,25) = 34.32, p < .001$ . And in the low frequency words, the recall accuracy in the high context words (.45) was also less than the low context words (.52), but the gap reduced,  $F(1,25) = 4.48, p < .05$ . Thus, in the high contextual words, the high frequency and low frequency had no difference,  $F(1,25) < 1$ , but in the low contextual words, the accuracy in the high frequency (.60) was higher than the accuracy in the low frequency (.52),  $F(1,25) = 7.99, p < .01$ . The result was displayed in the Table 5 and Table 6.

**Table 5 the Goal Memory Accuracy of Various Conditions in Clue Recall Tasks. (M ± SD)**

Word frequency	Context	
	High context	Low context
High frequency	.45 ± .16	.60 ± .16
Low frequency	.45 ± .2	.52 ± .19

**Table 6 the Clue Word Accuracy of Various Conditions in Clue Recall Tasks. (M ± SD)**

Frequency	Context	
	High context	Low context
High frequency	.46 ± .19	.58 ± .19
Low frequency	.43 ± .17	.55 ± .18

• **Conclusions**

Our research investigated the word frequency and context influence in the target word memory. We found that word frequency affected the clue recall forming, but also their interaction was significant. However, we just found the context had influence by discovering the word frequency and context impacted on target word memory. The study only discovered the context in clue words had a role in the target word memory [14], but our research found the context in the clue word and target word could both affect with target word memory. From the result in the experiment 1, we knew words of context in the simple memory tasks were able to show the effect, so in clues to more difficult clue recall tasks, its own contexts in target words influence the extraction was reasonable, as well. The reason for the research in Criss didn't have the same result was that may be related to the materials they used. In addition, the interaction between word frequency and context illustrated that word frequency and context was not completely independent, but influenced each other [15].

**4. Experiment 3: The effect of word frequency and context on the performance in the free recall task**

• **Methods**

○ **Participants**

A random sample of 26 college students in Guangzhou (males and females in half, mean age = 19.68±1.28 ) which native language was Chinese and vision or corrected visual acuity is normal . They didn't participate in the experiment 1 and would some reward after the experiment.

○ **Materials and Procedure**

The materials were identical to the experiment 1. Similar to Experiment 1, the experiment consisted of 5 blocks and each block included learning phase and text phase. In the learning phase, it was consist with the experiment 1. After learning words, they would finish a computing task in a minute. Then, in the text phase, the participants were required to write the learning words as more as possible and the memory time was not limit. After a block, the participant could have a rest in a minute and then went on the next block to complete the order of the block balance between subjects.

• **Results**

The correct numbers in the target words was in order to calculate the accuracy. The repeated measures analyze indicated the main effect in the word frequency was significant,  $F(1,25) = 12.91, p = .001$ . The memory accuracy in the high-frequency words (.25) was better than in the low-frequency word (.21). The main effect in context was evident,  $F(1,27) = 35.06, p < .001$ , the memory accuracy in high contextual words (.19) was less significantly than in the low contextual words (.27). There was indifferent interaction between word frequency and context,  $F(1,27) = .07, p > .05$ . The result was displayed in the Table 7.

**Table 7: The Target Word Accuracy of Various Conditions in Free Recall Tasks. (M ± SD)**

Frequency	Context	
	High context	Low context
High frequency	.21 ± .1	.29 ± .11
Low frequency	.18 ± .1	.25 ± .1

• **Discussion**

In the experiment 3, the word frequency and context both influenced free recall. It was in accordance with the influence of the experimental 1 and experiment 2. The memory accuracy in the thight frequency words was higher than that in low frequency words, and the recall accuracy in the high context was lower than in the low context of words. That is to say, in the free recall, there wasn't exist word frequency of mirror

effect, but there was the mirror effect of context. In addition, in order to compare word frequency and context of the relative influence on three types of memory.

In addition, in order to compare the word frequency and the context of the relative influence of three types of memory. An analysis of variance on the accuracy, for three (memory type: recognition, clue recall and free recall) x 2 (word frequency: high frequency, low frequency) x 2 (context: high context and low context). The results showed that the main effect in type of memory was significant,  $F(2,77) = 199.1$ ,  $p < .001$ ,  $\eta^2 = .84$ . The recognition accuracy was highest (.84), the clue recall accuracy was second (.50) and free recall accuracy was the lowest (.23). The interaction between context and word frequency was evident,  $F(2,77) = 3.68$ ,  $p < .05$ ,  $\eta^2 = .09$ . The purpose to further explore the relative impact on three types of memory, first of all, memory accuracy of high and low context between word had a subtraction processing (contextual effect). Comparing about the difference between three types of memory tasks, we found that cued recall context difference between high and low (-.11) significantly greater than that between recognition memory task (-.05),  $F(1, 50) = 6.23$ ,  $p < .05$ ,  $\eta^2 = .11$ . The free recall of high and low context difference (.07) between recall and recognition memory task and they had no respectively significant difference. In addition, the interaction among word frequency, context, types of memory and another interaction between word frequency and types of memory were both not significant. To sum up, the influence of context on three kinds of memory task was different, for clues to recall most affected, findings and the free recall and recognition memory at least.

## **5. General Discussion**

In the present study, word frequency had no significant effect on memory accuracy in recognition task, but had significant effect in both cued recall task and free recall task, that is, the accuracy of high frequency words was always better than the low frequency words. The Retrieving Effectively from Memory model [19] argued that in recognition task, the recall accuracy of low frequency words was higher than high frequency words, for those low frequency words had more specific characteristics. For example, compared with the high frequency words, low frequency words had some unusual letters and combinations [20]. The chance of these unusual letters and combinations confuse with other words was smaller and then the low frequency words recognition accuracy was higher, because these unusual letters and combinations had those specific characteristics which contained those in the model of REM. Besides, the Search of Associative Memory [21] insisted that in free recall task, both before and during the experiment, the high frequency words could had more contact with other words so that they could have a higher recall accuracy. Therefore, SAM model predicted when the high frequency words were also the cued words, they could help to extract the related words.

The current study found that high frequency cued words didn't have a significant effect, but there was a trend to help to extract the target words. Overall, the result of this study was consisted with previous studies. In this study, the disparity between the high and low frequency was small, but there was frequency effect in cued recall and free recall task, which was to state words frequency had a stable effect in words memory and the effect would be enlarged when the memory task was difficult.

In turn, the current study also found that the context had a main effect in three different memory tasks, namely the recall accuracy of low context words were consistently better than high context words, but the effect degree was slightly different, seeing that context had the greatest impact on the memory in cued recall task, free recall task next, and recognition task last. Marsh [22] argued that the environment information had an important role in people's memory organization. The low context words were refined deeply in a limited situation for low context words had less contact with other environment, and then they could be easier to identify. Instead, high context words involved more environment information, and then participants were hard to distinguish the change from the original one. Slattery suggest that words can be misperceived as their higher frequency neighbor HFN, and that top-down information from sentence context strongly modulates this effect [23].

Obviously, low context words were deeply processed than those high context words, and then it was easier to distinguish the minor changes from the words if there were any difference. So, not only in easy recall memory task like recognition, but also in difficult recall memory task such as cued recall memory task and free recall memory task, the memory performance accuracy of low context words were stably higher than high context words. We suggested that the more difficult the recall task was, the more participants would rely on the context, that was to say participants need some extra contextual cues to help them extract the words. In consequence, it was reasonable to find that the context effect was larger in cued recall task and free recall task.

The current study primarily investigated the effects of word frequency and context on the memory in recognition memory task, cued recall task and free recall task, and the effect of each other was different. Note that the recall accuracy of the high frequency words was always better than the low frequency words, while the context effect was just the opposite, showing that the recall accuracy of low context words was steadily better than high context words. In addition, the effects of word frequency and context were solely influenced pasts' performance in recognition and free recall task, for there was no significance interaction between word frequency and context under recognition and free recall task. Moreover, in the current study, we found an interaction between word frequency and context in cued recall task, with larger mirror effect of context during high frequency words than during low frequency words. We held the point that the words of high frequency and low context had less contact with environment and then the number of times a single word appeared in each context would be more, which not only strengthened the relationship between words and context but also the connection between words and cued words, undoubtedly, it would help to extract the words of high frequency and low context. Of interest, the procedures in these three studies were consistent except the recall tasks were slightly different between recognition task, cued recall task and free recall task, which demonstrated that the influencing mechanisms of word frequency and context happened at memory retrieval phase.

In general, word frequency and context were the two important factors in recall task with different influence. That's to say, with the change of the memory tasks, the role of word frequency and context would also change. Moreover, the effects of word and context were separated in recognition and free recall task, but they had an interaction in cued recall task.

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