

No Frequency Effect but Spacing Effect in Words-Writing

Kang Zhai

Lyceum of the Philippines University Manila, Intramuros Manila Philippines 1002
Email: 290809765@qq.com

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Abstract

Learners frequently write L2 words down to learn words. There is frequency effect in incidental vocabulary acquisition and spacing effect in word pair study, but there is no study about whether the above results can be generalized to words-writing. This study aimed to explore frequency effect and spacing effect in words-writing. Ninety-one subjects were divided into three groups to write 16 words down with form and meaning. Group one wrote 16 words down 3 times in one learning episode without any spacing, group two wrote 16 words down 6 times in one learning episode without any spacing, but group 3 wrote 16 words down 3 times in 2 learning episodes with 20 minutes interval. The results showed that frequency effect did not promote L2 words learning; but spacing effect did. In other words, spacing effect in word pair study can but frequency effect in incidental vocabulary acquisition cannot be generalized to words-writing. It is suggested that learners do not write words down for many times without spacing, but spaced their words-writing.

Key words: L2 vocabulary acquisition; words-writing; frequency effect; spacing effect

Introduction

In L2 vocabulary learning, words-writing is frequently used (Gu & Johnson, 1996). Some studies have shown that this method helps to maintain word form and meaning (Sarah, Irina, Decoinck, & Eyckmans, 2017; Webb & Piasecki, 2018). Frequency is important in language learning (Ellis, 2002; 2012), and frequent words-writing may affect the creation of memory traces. However, if there is no enough repeated practice, memory traces will not be created and learning performance will not be reflected (Sarah et al., 2017). Therefore, words-writing also requires a lot of repeated practice, frequency effect, which refers to the more number of times of practicing language materials is, the more efficient the learning is (Harrington & Dennis, 2002: 261-268). However, frequency is only one of the necessary factors, not the decisive factor. All problems in language acquisition can not be solved only by increasing frequency, but by considering other factors such as spaced learning. Though many studies prove that spaced learning is better than massed learning, spacing effect (e.g., Koval, 2019; Nakata, 2015; Nakata & Elgort, 2021), no research to our knowledge has been found to prove whether there is frequency effect and spacing effect in words-writing. Therefore, this study aims to explore frequency effect and spacing effect in L2 words-writing.

Literature review

Frequency effect on L2 vocabulary acquisition

Law of practice explains frequency effect. In law of practice, human beings improve their knowledge and skill by repeated practice. The more practice they have, the more skillful or knowledgeable they will be. However, as learners master the skill or knowledge little by little, the improvement is slower and slower. It stops to improve when they master the learned knowledge or

skill to their potential (Newell & Rosenbloom, 1981: 1-55). The study of frequency effect concentrates on incidental vocabulary acquisition from reading. Saragi, Nation and Meister (1978) put forward that it was main way to acquire vocabulary during reading incidentally, and noted that learners need at least 6 encounters to acquire words. From then on, how many encounters are needed to acquire vocabulary in reading has been hot topic. Former studies varied in encounters, for example, Rott (1999) 6 times, Chen & Truscott (2010) 3-7 times, Eckerth & Tavokoli (2012) 7 times, Webb (2007) 10 times, and Mohamed (2018) 11-12 times. However, they concluded that the more encounters learners have, the more words learners will acquire, proving law of practice. Though they had no consensus in encounters, most of them were above 6 encounters, Therefore, maybe 6 encounters are threshold to acquire words in reading incidentally. Words-writing is explicit learning, but incidental vocabulary acquisition implicit learning, representing two different methods to learn words. In words-writing, human beings can also acquire more words knowledge by repeated writing. The more writing they have, the more knowledgeable they will be. Law of practice may be suitable for words-writing, so hypothesis one in this study is that there is frequency effect in words-writing.

Spacing effect on L2 vocabulary acquisition

Attention attenuation theory explains spacing effect. Learners attenuate not only in the beginning of learning but also in reviewing other items in the list. Attenuation is related with redundancy in memory. There is much redundancy in massed learning, reducing real learning time. However, in spaced learning, when learners learn again, redundancy is reduced largely, because learners stop to learn for some time (Shaughnessy, Zimmermant & Underwood, 1974). Spacing effect in L2 vocabulary learning concentrates on two aspects: word-pair and incidental vocabulary acquisition from reading. On the one hand, many studies proved that there was spacing effect in these two fields. For example, in word-pair, Sobel, Cepeda and Kapler (2011) had fifth graders learned 8 English words. In word meaning test, spaced group learned 28%, while massed group only 7.5%. Goossens, Camp, Verkoeijen, Tabbers and Zwaan (2012) had grade 3 primary school students learned 15 new words, and both immediate post-test and delayed post-test showed that spaced learning is better than massed learning. In addition, Nakata (2015), Lotfolahi & Salehi (2017) and other studies made similar conclusions. On the other hand, some studies noted that there was spacing effect in incidental vocabulary acquisition from reading. For example, in Serrano and Huang (2018), massed group obtained higher scores in short-term memory, but spaced group in long-term memory. Koval (2019) found a potential advantage for spaced learning in acquiring words incidentally from reading. Nakata and Elgort (2021) noted that spacing effect occurred in contextual word learning for the development of explicit vocabulary knowledge. Therefore, above empirical studies prove attention attenuation theory.

Word-pair is explicit learning, but incidental vocabulary acquisition implicit learning, representing two different methods to learn words. Therefore, spacing effect exists in these two distinct methods, proving its wide-adaptability. The reason may be no matter what learning method is, there is less redundancy between two practices in spaced learning. Words-writing is explicit learning, and there is less redundancy between two practices of words-writing. Therefore, hypothesis two in this study is that there is spacing effect in words-writing.

Words-writing

Studies on words-writing believe that it helps to maintain word form (e.g., Webb & Piasecki, 2018), but Sarah et al. (2017) noted its advantage lay not only in paying attention to word form, but also in creating a memory in word meaning. For how many times learners can create a memory in words-writing, Webb and Piasecki (2018) noted when learners have limited time, they can not master words well, because they can only write words less times; but when learners have enough time,

they can write words down several times. Therefore, learners can master form and meaning better. Above studies mentioned repeated practice in words-writing, but not address whether there is frequency effect and spacing effect in words-writing. That is to say, we do not know whether frequency effect in incidental vocabulary acquisition from reading and spacing effect in word-pair can be generalized to words-writing.

The present study

From discussions in the above three parts, it is possible that there is frequency effect and spacing effect in words-writing. Therefore, the study answered the following two questions:

- (1) Is there frequency effect in words-writing?
- (2) Is there spacing effect in words-writing?

Methodology

Subjects

Ninety-six subjects were from some university in Fuzhou China. They are students majoring in accounting. However, five students did not attend the delayed post-test, so the number of the participants decreased to 91. They were about 18 years old, including 39 male and 54 female. The English proficiency was subject to CET4, an authoritative English test in China. Ninety-one subjects were randomly distributed into 3 groups. One way ANOVA showed that there was no significant difference in English proficiency among three groups ($F = 2.315$, $P = 0.105 > 0.05$).

Materials and tools

Experimental words

The experimental words were selected from Nation's BNC/COCA words list 9000-10000 level. One thousand words were put into PPT slides. One month before the experiment, in an English class, the subjects wrote Chinese equivalents of words they knew. Some of subjects know 30 words of 1000, so these 30 were deleted. There were 970 new words to subjects. Sixteen words were selected randomly from these 970 words, including 6 nouns, 5 verbs and 5 adjectives. These 16 words were "abject, bemoan, abstention, abet, belittle, wiry, aeronautics, afoot, perturb, gullible, baboon, adage, assiduous, regent, ambulate, hallmark" (see appendix 1 for detail).

Vocabulary tests

Meaning recall and recognition of 16 words were tested. In meaning recognition test, when subjects were given "abstention", they should give its Chinese meaning "弃权". In meaning recall test, when subjects were given "弃权", they should give its English form "abstention". There were 32 items for 16 words in total in immediate post-test and delayed post-test, respectively (see appendix 2 for detail). In order to counterbalance testing effect, item orders in delayed post-test were different from those in immediate post-test, and meaning recall test was prior to meaning recognition test.

Experimental procedures

The experiment followed a pilot study, treatment, immediate post-test and delayed post-test design. In pilot study, a parallel class with similar English proficiency wrote 16 words' meaning and form down 3 times, and then participated in the vocabulary test. The results showed that it took about 10 minutes to write 16 words down 3 times and about 10 minutes to complete the vocabulary test. In treatment, during normal class hours, the treatment was integrated into normal teaching activities. Subjects were not informed to participate in any tests. The subjects looked at 16 words on the PPT over projector, and then wrote their form and meaning down. Maybe 6 encounters are threshold to acquire words (e.g., Saragi, et al., 1978; Rott, 1999). Therefore, in this study group one (N=30) wrote 16 words down 3 times in one learning episode without any spacing with 10 minutes; group two (N=30) wrote 16 words down 6 times in one learning episode without any spacing within

20 minutes; but group 3 (N=31) wrote 16 words down 3 times with 10 minutes, then they listened to English for 20 minutes, and then they wrote 16 words down with 10 minutes once again. In test stage, each group participated in immediate post-test after treatment immediately in Xuexitong, an online learning and test platform. Rohrer and Pashler (2007) indicated that idealized ratio of inter-session interval (ISI) to retention interval (RI) was 10-30% (ISI/RI). In this study ISI was 20 minutes, so RI should be from about 200 minutes to about 600 minutes. Delayed post-test was chosen to carry out 200 minutes after their immediate post-test, respectively. Between immediate post-test (test 1) and delayed post-test (test 2), there were 200 minutes class for accounting, so subjects may have no time to review these 16 words. Moreover, after delayed post-test, subjects reported that they had no any review for 16 words. Experimental procedures were in table 1.

Table 1. Experimental procedures

| | Learning 1 | Listening | Learning 2 | Test 1 | accounting | Test 2 |
|---------|------------|-----------|------------|-----------|----------------|-------------|
| Group 1 | 8:00-8:10 | | | 8:10-8:20 | 200 minutes | 11:40-11:50 |
| Group 2 | 8:00-8:20 | | | 8:20-8:30 | | 11:50-12:00 |
| Group 3 | 8:00-8:10 | 8:10-8:30 | 8:30-8:40 | 8:40-8:50 | | 12:10-12:20 |

Scoring and data processing

Immediate post-test and delayed post-test of 91 subjects were collected. The names of the subjects were removed from test paper in Xuexitong, and the grading was done by the researcher. There were 32 items in each paper and each question was 1 point, with a full score of 32 points for every paper. In meaning recall test, strict grading criteria was adopted. Namely, 0 mark was for any kind of error, including one letter less, more or wrong, and 1 mark for no any error. For example, for “易受骗的” subjects write “gullible”, he or she would get 1 point, but gullble, gulliable, and gullable 0 point. In meaning recognition test, loose grading criteria was adopted. Namely as long as its meaning was similar to references, one point was given, because it was not necessary to give the same meaning to target word. For example, for “assiduous” if subjects wrote “刻苦的”, the same as the reference, or “努力的”, a little different from the reference, he or she would get 1 point.

The original score of each item was downloaded from Xuexitong in excel format, and total scores were counted out in immediate and delayed post-tests. Scores of 91 subjects were stored in excel format for SPSS 26.0 to analyze. One-way ANOVA was used to compare 3 groups to answer 2 questions. In post hoc tests, it was to answer Question one by comparing group 1 and 2, and Question two by comparing group 2 and 3. If the homogeneity of variances among 3 groups was not uniform, the value of Tamhane is referred. In this study, significant level was set as .05, and the standard of η^2 was small(>.0099), medium(>.0588), and large(>.1390) in One-way ANOVA (Cohen, 1992).

Results

Descriptive tests of 3 groups in immediate and delayed post-test

Descriptive statistics for 3 groups in immediate post-test and delayed post-test were presented, respectively in Table 2.

As noted in table 2, in immediate post-test, the mean number of group 1, 2 and 3 was 18.10, 19.40 and 23.55, respectively. However, in delayed post-test, the mean number of group 1, 2, and 3 was 18.10, 19.20 and 22.48, respectively. From rate of words acquisition, in group 1 and group 2, subjects acquired about 60%, but subjects in group 3 more than 70% in immediate and delayed post-

test. The results may show that there was no large difference between group 1 and group 2 in immediate post-test and delayed post-test; but group 3 was much better than group 2 in immediate post-test and delayed post-test.

Table 2. Descriptive of 3 groups in immediate and delayed post-test

| Test | Group | N | Mean | Std. Deviation | Std. Error |
|---------------------|-------|----|-------|----------------|------------|
| immediate post-test | 1 | 30 | 18.10 | 5.933 | 1.083 |
| | 2 | 30 | 19.40 | 5.347 | .976 |
| | 3 | 31 | 23.55 | 3.776 | .678 |
| | Total | 91 | 20.38 | 5.551 | .582 |
| delayed post-test | 1 | 30 | 18.10 | 6.483 | 1.184 |
| | 2 | 30 | 19.20 | 4.715 | .861 |
| | 3 | 31 | 22.48 | 4.007 | .720 |
| | Total | 91 | 19.96 | 5.440 | .570 |

One-way ANOVA analysis in immediate and delayed post-test

Test of homogeneity of variances among 3 groups showed that the value of immediate post-test and delayed post-test was .036 and .005, respectively, not conforming to homogeneity of variances, so the value of Tamhane of one-way ANOVA analysis was adopted.

Table 3. One way ANOVA analysis of 3 groups in immediate and delayed post-test

| Test | Name | Sum of Squares | df | Mean Square | F | Sig. | η^2 |
|---------------------|----------------|----------------|----|-------------|-------|------|----------|
| immediate post-test | Between Groups | 495.961 | 2 | 247.981 | 9.581 | .000 | .1788 |
| | Within Groups | 2277.577 | 88 | 25.882 | | | |
| | Total | 2773.538 | 90 | | | | |
| delayed post-test | Between Groups | 318.582 | 2 | 159.291 | 5.977 | .004 | .1196 |
| | Within Groups | 2345.242 | 88 | 26.650 | | | |
| | Total | 2663.824 | 90 | | | | |

In order to compare 3 groups in immediate post-test and delayed post-test, one-way ANOVA was used. As noted in table 3, in immediate post-test there was significant difference among 3 groups ($F=9.581$, $P=.000$, $\eta^2=.1788$) with large effect size; in delayed post-test there was also significant difference among 3 groups ($F=5.977$, $P=.004$, $\eta^2=.1196$) with middle effect size. The results showed that there was main effect of group in immediate and delayed post-test with relatively large effect size, but what two groups existed significant difference was up to multiple comparisons.

Table 4. Multiple Comparisons of 3 groups in immediate and delayed post-test

| Dependent Variable | (I) Group | (J) Group | | | | 95% Confidence Interval | |
|---------------------|-----------|-----------|-----------------------|------------|------|-------------------------|-------------|
| | | | Mean Difference (I-J) | Std. Error | Sig. | Lower Bound | Upper Bound |
| immediate post-test | 1 | 2 | -1.300 | 1.458 | .757 | -4.71 | 2.51 |
| | | 3 | -5.448* | 1.278 | .000 | -7.81 | -.96 |

| Dependent Variable | (I) Group | (J) Group | | | | 95% Confidence Interval | |
|--------------------|-----------|-----------|-----------------------|------------|------|-------------------------|-------------|
| | | | Mean Difference (I-J) | Std. Error | Sig. | Lower Bound | Upper Bound |
| | 2 | 1 | 1.300 | 1.458 | .757 | -2.51 | 4.71 |
| | | 3 | -4.148* | 1.189 | .003 | -6.04 | -.52 |
| | 3 | 1 | 5.448* | 1.278 | .000 | .96 | 7.81 |
| | | 2 | 4.148* | 1.189 | .003 | .52 | 6.04 |
| delayed post-test | 1 | 2 | -1.100 | 1.464 | .839 | -4.89 | 2.29 |
| | | 3 | -4.384* | 1.385 | .008 | -8.61 | -2.29 |
| | 2 | 1 | 1.100 | 1.464 | .839 | -2.29 | 4.89 |
| | | 3 | -3.284* | 1.122 | .015 | -7.08 | -1.22 |
| | 3 | 1 | 4.384* | 1.385 | .008 | 2.29 | 8.61 |
| | | 2 | 3.284* | 1.122 | .015 | 1.22 | 7.08 |

In order to know which group was better in immediate post-test and delayed post-test respectively, multiple comparisons were used. As noted in table 4, multiple comparisons of post hoc tests showed that in immediate post-test there was significant difference between group 1 and group 3 ($P=.000$), and group 2 and group 3 ($P=.003$), but there was no significant difference between group 1 and group 2 ($P=.757$); in delayed post-test there was significant difference between group 1 and group 3 ($P=.008$), and group 2 and group 3 ($P=.015$), but there was no significant difference between group 1 and group 2 ($P=.839$). The results showed that in immediate post-test and delayed post-test, there was no significant difference between group with 3 times and group with 6 times of massed learning, but significant difference between group with 6 times of massed learning and group with 6 times of spaced learning. Namely, combined with descriptive statistic in table 4.1, the results showed that there was no frequency effect but spacing effect in words-writing in this study.

Discussions

No frequency effect in words-writing

The answer for question one is that there is no frequency effect in words-writing when learners write words down 3 times or 6 times without spacing. A likely explanation is that learners attenuate not only in the beginning of writing the first word down but also in reviewing other 15 words in the list. Attenuation is related with redundancy in memory, so there is much redundancy in massed learning, deterring their subsequent learning. Maybe when learners write words down the fourth or more times, redundancy in memory will deter more memory traces about words inserting into their mind. Therefore, though learners write 16 words down for 6 times, they can not acquire more than they write 16 words down for the 3 times.

The results of this study are different from Eckerth & Tavokoli (2012), Mohamed (2018), Rott (1999), and Webb (2007) that there is frequency effect in incidental vocabulary acquisition from reading. The reasons may be there is spacing between two encounters in incidental vocabulary acquisition from reading. Experimental words are impossible to be massed in incidental vocabulary acquisition from reading, because these words are spaced by other words. The unit of spacing can be either time or learning materials (Nakata, 2015), so in fact, non experimental words spaced experimental words in incidental vocabulary acquisition from reading. Namely, in study of Eckerth & Tavokoli (2012), Mohamed (2018), Rott (1999), and Webb (2007), it may be not frequency effect but

spacing effect facilitates words learning (see 5.2 in this study for detail). Therefore, frequency effect in incidental vocabulary acquisition from reading may not be generalized to words-writing in this study.

The results of this study are consistent with previous studies on words-writing (Sarah et al., 2017; Webb & Piasecki, 2018), which further proves that words-writing can promote vocabulary acquisition. It is necessary to increase the frequency, but it can not be simply attributed to how many times learners can encounter words (Chen & Truscott, 2010), because frequency is not the only determinant to influence words learning and can not solve all the problems of words learning. In this study, learners writing 6 times down without spacing was not better than those 3 times without spacing. However, learners writing 6 times down with spacing was better than those 6 times without spacing. Therefore, other factors such as spacing effect should be considered in words-writing (see 5.2 in this study for detail).

The results may put some concerns to law of practice. Human beings indeed improve their knowledge and skill by repeated practice. However, when learners nearly master what they learn, their improvement may be slower and slower. In other words, it may be not the more practice learners have, the more skillful or knowledgeable they would be. If more practices are massed, more redundancies will come into being in learners' mind, deterring new information coming into their memory. As in this study, learners writing 16 words 6 times down without spacing was not better than those 3 times without spacing. Therefore, though Webb and Piasecki (2018) noted when learners had enough time, they could write words down several times, but they had better space their words-writing. That is to say, in words-writing, law of practice may be reasonable. However, spacing learners' practice may be more suitable to this theory.

Spacing effect in words-writing

The answer for question two is that there is spacing effect in words-writing. A likely explanation is that in this study subjects attenuated not only in the beginning of writing the first word down but also in reviewing other 15 words. Attenuation is related with redundancy in their memory, so there is much redundancy in massed learning, deterring their subsequent learning. However, in spaced learning, subjects have removed redundancy of the first treatment when they wrote words down in the second treatment. Therefore, when subjects wrote words down in the second treatment, new memory about words might be inserted into their mind. As a result, this process facilitated their words' learning.

This experiment is consistent with Lotfolahi & Salehi (2017), Nakata (2015), and Sobel et al. (2011) in word-pair study, and Koval (2019), Nakata & Elgort (2021) and Serrano & Huang (2018) in incidental vocabulary acquisition from reading. Therefore, spacing effect may promote vocabulary acquisition not only in explicit but also in implicit learning. It may conclude that spacing effect has wide-adaptability in L2 words learning. In word-pair, incidental vocabulary learning from reading or words-writing, learners will have no much redundancy as long as they spaced their words learning. Namely, spaced learning makes learners have more opportunities to reduce their redundancy in different kinds of words learning activities. Therefore, spacing effect may be generalized to words-writing.

Implications and limitations

In conclusion, spacing effect in word pair study can be generalized but frequency effect in incidental vocabulary acquisition cannot be generalized to words-writing. Ellis (2002, 2012) noted frequency is the decisive factor in L2 language learning, but this study proves that frequency in words-writing needs spacing to play a role. Due to various restrictions at school, English teachers

require students to write English words 5 times, 10 times or more times without spacing, massed learning. However, students cannot accomplish even if they stay up late. At the same time, they cannot master words though they devote much time and energy. Therefore, repetitive and punitive words-writing should not be arranged. Namely, in L2 words teaching, it is recommended that students do not write down words many times without spacing, but space their practice.

Nevertheless, due to limited experimental conditions, there are few experimental subjects, so there is heterogeneity of variance in this study. When the experimental results are generalized to college students, it should be cautious. In order to solve the above problem, the subjects can be increased in the following research. Next, because of subjects limitations, this study only compares words-writing 3 times and 6 times without spacing, so it is also necessary to compare words-writing twice, three times, four times, five times, six times, seven times or even more times to study frequency effect on words-writing further. Finally, although it is proved that there is spacing effect on words-writing, spacing can be divided into equal spacing and expanded spacing (Nakata, 2015). This study only proved that there is spacing effect in words-writing, but it is still open that what optimal spacing mode (equal spacing or expanded spacing) in words-writing is optimal.

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Appendix 1: Experimental words

1. abet [ə'bet] vt. 怂恿
2. aeronautics [,erə'nɔ:tɪks] n. 航空学
3. adage ['ædɪdʒ] n. 谚语
4. afoot [ə'fʊt] adj. 计划中
5. abject [æb'dʒekt] adj. 卑微的
6. abstention [æb'stenʃən] n. 弃权
7. ambulate ['æmbjʊleɪt] v. 走动
8. baboon [bæ'bu:n] n. 狒狒
9. belittle [bɪ'ltl] vt. 轻视
10. hallmark ['hɔ:lma:rk] n. 特点
11. perturb [pər'tɜ:rb] vt. 使(某人) 烦恼

12. regent ['ridʒənt] n. 摄政者
13. wiry ['wairi] adj. 像金属丝的
14. gullible ['gʌləbəl] adj. 易受骗的
15. assiduous [ə'sɪdʒuəs] adj. 刻苦的
16. bemoan [bi'məʊn] vi. 悲悼

Appendix 2: Vocabulary tests

Meaning recognition

Write Chinese meaning of following words

1. abject _____
2. bemoan _____
3. abstention _____
4. abet _____
5. belittle _____
6. wiry _____
7. aeronautics _____
8. afoot _____
9. perturb _____
10. gullible _____
11. baboon _____
12. adage _____
13. assiduous _____
14. regent _____
15. ambulate _____
16. hallmark _____

Meaning recall

Write English words of following Chinese

1. 计划中 _____
2. 特点 _____
3. 摄政者 _____
4. 烦恼 _____
5. 怂恿 _____
6. 弃权 _____
7. 轻视 _____
8. 卑鄙的 _____
9. 航空学 _____
10. 刻苦的 _____
11. 谚语 _____
12. 走动 _____
13. 易受骗的 _____
14. 悲悼 _____
15. 獬豸 _____
16. 像金属丝的 _____