

An Expanded Spacing Advantage over Equal Spacing on Grammar Learning

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Abstract

Spacing effect is a robust phenomenon especially in cognitive psychology. Many studies proved that there was spacing effect in L2 words learning, but there are sparse studies about whether spacing effect, especially expanded spacing advantage, can be generalized to L2 grammar learning. The present study aims to examine spacing effect on L2 grammar learning. Ninety-seven subjects studied 3 tenses within one week in 3 groups. Group one studied 3 tenses in only one learning episode, namely massed group; group two on day 1, day 2, day 4 and day 7 (1-2-3), namely expanded spacing; group three on day 1, day 3 day 5 and day 7 (2-2-2), namely equal spacing. Results showed that there was spacing effect on L2 grammar learning; expanded spacing had an advantage over equal spacing not only in short-term memory but also in long-term memory. In other words, spacing effect, especially expanded spacing advantage in words learning, can be generalized to L2 grammar learning. Therefore, it is suggested that teachers teach students L2 grammar in an expanded schedule.

Keyword: grammar learning; spacing effect; expanded spacing; equal spacing; tense

Introduction

Grammar and words learning are very important in second language acquisition (SLA). Learners are necessary to repeatedly remember L2 (second language) words and grammar, but it makes a big difference on how to distribute their repetitions. When learners spaced their repetitions in learning, they will learn better. This beneficial effect on memory has been referred to as distributed practice effect or spacing effect (Rohrer & Pashler, 2007).

Many studies focused on spacing effect on L2 words learning (e.g., Bahrick, 1993; Bloom & Shuell, 1981; Dempster, 1987; Nakata & Elgort, 2021; Farvardin, 2019; Schuetze, 2014), and concluded there was spacing effect in L2 words learning. When repetitions are spaced equally, for example learners study the same words on day 1, day 3, day 5 and day 7 (2-2-2), it is called equal spacing; when repetitions are spaced incrementally, for example learners study the same words on day 1, day 2, day 4 and day 7 (1-2-3), it is called expanded spacing (Nakata, 2015). In L2 words learning, there is expanded spacing advantage over equal spacing (Pyc & Rawson, 2009), meaning that expanded spacing is better than equal spacing in learning. However, there are few studies on spacing effect in L2 grammar learning. Words are declarative knowledge, but grammar procedural one. The former does not need induction, but the latter does. Spacing effect is said to be not fit for induction (Kornell & Bjork, 2008). Therefore, it is necessary to study whether spacing, especially expanded spacing advantage, can be generalized to L2 grammar learning.

Literature review

Spacing effect on L2 vocabulary learning

In spaced learning, according to contextual variation theory, learners encoded information with a particular context, for example what they induce from many examples during learning. This context leaves many memory traces for learners. The greater the number of memory traces is, the greater the number of retrieval routes for later recall is. Furthermore, the information redundancy in long-term memory decreased, which reduced interference and made it easier for new learned information to enter into long-term memory (Raaijmakers, 2003).

Many studies focus on spacing effect on L2 words learning (e.g., Bahrack, 1993; Bloom & Shuell, 1981; Dempster, 1987; Farvardin, 2019; Karpicke & Roediger, 2007; Schuetze, 2014), especially in word pair settings. The above studies concluded there was spacing effect on L2 words learning, and proved contextual variation theory. For example, Bloom and Shuell (1981) conducted a study with high school students in a French course. The class was divided into massed group who learned 20 French words once for half an hour, and spaced group who studied the words on three consecutive days for 10 minutes each respectively. The results showed that learners in spaced group had about one third later recall more than those in massed group in long-term memory.

Retrieval difficulty and retrieval success are used to explain expanded spacing advantage over equal spacing. Expanded spacing combined retrieval difficulty and retrieval success (Pyc & Rawson, 2009). Expanded spacing involves immediate recall, while equal spacing involves delayed recall. In expanded spacing, the first recall takes place almost at the same time as the first learning, delaying only 0 or 1 trial. At this time, the coding cue and the target item are still in short-term memory, so it is easy to retrieve. This is retrieval success. However, with expanded interval, the encoding cue and target item are put into long-term memory little by little, so learners are increasingly difficult to retrieve. The more difficult the retrieve is, the more efforts it will consume. This is retrieval difficulty. Therefore, expanded spacing facilitates long-term memory.

However, some empirical studies varied in the above hypothesis (e.g., Nakata, 2015; Kang, et al., 2014). For example, Nakata (2015) had 128 Japanese college students studied 20 English-Japanese word pairs. In delayed post-test, they only demonstrated a limited yet statistically significant advantage of expanded spacing. However, Kang et al. (2014) had 37 subjects studied 60 Japanese-English word pairs under equal and expanded spacing, but no statistically significant difference was found between them two on the delayed post-test. Even some studies have obtained advantages of equal spacing over expanded spacing in long-term memory (e.g., Logan & Balota, 2008).

Maybe, words are declarative knowledge, learners do not need to induce but memorize, processing not deeply. Therefore, learners do not manifest stable expanded spacing advantage over equal spacing. However, grammar is procedural knowledge, so learners need to induce rules from many examples, processing deeply. Moreover, grammar may be more difficult than words for learners to learn. A significant expanded spacing advantage was observed when task is more difficult (Logan & Balota, 2008). Therefore, there may be expanded spacing advantage over equal spacing in L2 grammar learning.

Spacing effect in L2 grammar learning

Many examples of one concept together may enable learners to discover features that define this concept, so it may be easier to induce in massed learning. However, spacing may make induction more difficult because long intervals between examples may limit learners' ability to notice similarities among examples (Nakata & Elgort, 2021). Therefore, spacing is sometimes considered the

enemy of induction (Kornell & Bjork, 2008). Words, declarative knowledge, may not need induction, because there are no rules in words learning for learners to induce. However, grammar, procedural knowledge, may need learners to induce rules from many examples. Therefore, spaced learning may not facilitate grammar learning from the above discussion.

However most former studies proved there is spacing effect in L2 grammar learning (e.g. Miles, 2010, 2014; Rogers, 2017). For example, Miles (2010) showed that spaced learning group outperformed massed group in delayed post-test. Rogers (2017) revealed no significant difference between massed and spaced group on immediate post-test, but spaced group outperformed massed group on 6-week delayed post-test. In a similar way, in Miles (2014), immediate post-test showed no statistical difference, but delayed post-test showed that spaced group outperformed massed group on grammar error analysis and correction. The above studies may imply that spaced learning may not be the enemy of induction, because there is much contextual variation in spaced learning, leaving many memory traces for learners to induce hidden rules (Raaijmakers, 2003). However, Suzuki and DeKeyser (2015) found no spacing effect in L2 grammar. In conclusion, there is controversy about spacing effect in L2 grammar learning. Namely it is still unclear about whether spacing learning deters learners from inducing. Moreover, grammar learning is more difficult than words learning, so teachers often use explicit teaching to explain grammar rules to learners, facilitating learners induction in grammar rules. Therefore, it is still necessary to study spacing effect in L2 grammar learning.

From perspective of interval's length, spaced learning can be divided into long spacing (an hour, a day or a week interval), and short spacing (a second, an intervening trial, or a minute interval). Bird (2011) compared short and long spacing, indicating that L2 grammar learning can benefit from long spacing. Nakata & Elgort, (2021) thought the effect in the study of Bird (2011) was lag effect. However, Suzuki (2017) concluded that 3-day interval group (short spacing) outperformed 7-day interval group (long spacing) on both 7-day and 28-day delayed post-test. However, the present studies in L2 grammar learning does not address whether there is expanded spacing advantage over equal spacing.

The present study

From discussions in literature review in spacing effect of L2 grammar learning and words learning, there will be the following 2 research questions:

- (1). Is there spacing effect in L2 grammar learning?
- (2). Is there expanded spacing advantage in short-term and long-term memory in L2 grammar learning?

Methodology

Participants

A total of 113 junior middle students in grade three from China participated in this study. However, pretests indicated that 6 students had a good mastery of tenses, and 10 subjects relearned target materials out of treatment, so the number of the participants decreased to 97 with 46 female and 51 male. Moreover, all the subjects were native speakers of Chinese who have never been in English-speaking countries. The average age of 97 subjects was 14.69 years old.

Tenses are not totally new to junior middle school students in grade three in China, so before taking part in this study, they took part in pretest of tenses. Ninety-seven participants were randomly divided into 3 groups: massed group (N=32), expanded group (N=33) and equal group (N=33). One-

way ANOVA showed that there was no significant difference in their pretests of three groups ($F=.543$, $P=.583>0.05$).

Tools

Grammar learning materials

Tense, needing much induction, is one of important and also difficult grammar points for L2 students, so it is chosen to be target grammar points. Teaching materials in this study about rules and their example sentences were all selected from <https://lingbase.com/en/english/grammar/all-tenses>, one of the most authoritative English grammar learning websites. Because of limit of treatment time, materials contained 3 kinds of common tenses: Present Simple, Future Simple, Past Simple (see appendix 1 for detail). All materials were in PPT for the same teacher to teach all subjects within 20 minutes for every learning episode.

Grammar tests

Multiple choice and gap filling are one of common items to test grammar, so these two were selected to be pretest, immediate post-test and delayed post-test. For every tense, there were 4 multiple choices and 4 gap fillings, respectively, so in total there were 12 multiple choice items and 12 gap fillings. All items were selected and edited from Test for College Entrance Examination, one of the most authoritative tests in China (see appendix 2 for detail). For pretest, immediate post-test and delayed post-test, the order of 24 items were randomly sequenced to counterbalance testing effect as much as possible.

Procedures

This study followed a pretest, treatment, immediate post-test and delayed post-test design. Pretest has been conducted before the treatment. In treatment where the same teacher explained rules of 3 tenses to each group, respectively, group 1 (massed group) studied 3 tenses in only one learning episode (80 minutes in total) without any interval; group 2 (expanded group) studied 3 tenses on day 1, day 2, day 4 and day 7 (1-2-3) for 20 minutes respectively; group 3 (equal group) studied 3 tenses on day 1, day 3 day 5 and day 7 (2-2-2) for 20 minutes respectively. After the treatment, every group immediately participated in immediate post-test. Exactly, group 1 attended immediate post-test on day 1, but group 2 and group 3 on day 7. Rohrer and Pashler (2007) indicated that idealized ratio of intersession interval (ISI) to retention interval (RI) was 10-30% (ISI/RI). In this study, ISI was 2 days, so RI should be from about 7 days to 20 days. Delayed post-test was chosen to carry out in 14 days after immediate post-test with 14% ISI/RI. Therefore, group 1 took part in delayed post-test on day 15, but group 2 and group 3 participated in delayed post-test on day 22. All tests were conducted in Questionnaire Star, an online platform for tests in China. After all tests, all subjects reported that whether they learned 3 tenses out of the treatment. Ten subjects learned one of three tenses out of the treatment, so they were excluded.

Scoring and data analysis

Immediate and delayed post-tests of 97 subjects were collected. The names of the subjects were removed from test sheets in Questionnaire Star. The strict grading was done automatically for multiple choice. There were 24 items in each sheet, and each item was 1 point, with a full score of 24 points. For multiple choice, subjects chose the right one to get 1 point, but the wrong one to get 0 point. For gap filling, loose criteria was adopted. As long as subjects filled the blank with right form of verb, they would get 1 point, even though they wrote one letter wrong, more or less. For example, in “The teacher is busy, so he only _____ (sleep) six hours a day.”, if a subject filled in the blank with “sleps”, “sleepes” or “sleets”, he or she would get 1 point. In other words, as long as subjects

knew that they should fill this blank with third person singular of “sleep”, they would get this 1 point.

The original score of each item was output from Questionnaire Star in excel format. Total scores were counted in immediate and delayed post-tests in excel format for SPSS 26.0 to analyze. One-way ANOVA was used to compare 3 groups to answer 2 questions. If the homogeneity of variances among 3 groups was not uniform, the value of Tamhane is referred. P value is set as .05, and η^2 value is set as $>.0099$ (small), $>.0588$ (medium), and $>.1390$ (large) in Cohen (1992).

Results

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

Table 1. Descriptive statistic of 3 groups in immediate and delayed post-test

Test	Group	N	Mean	Std. Deviation	Std. Error
immediate post-test	1	32	18.28	2.289	.405
	2	32	21.16	1.780	.315
	3	33	18.52	2.210	.385
	Total	97	19.31	2.460	.250
delayed post-test	1	32	17.03	2.868	.507
	2	32	20.34	1.558	.275
	3	33	17.36	2.460	.428
	Total	97	18.24	2.772	.281

As noted in table 1, in immediate post-test, the mean number of group 1, 2 and 3 was 18.28, 21.16 and 18.52, respectively. However, in delayed post-test, the mean number of group 1, 2 and 3 was 17.03, 20.34 and 17.36, respectively. The results showed that expanded group and equal group may be better than massed group, and expanded group may be better than equal group not only in short-term memory but also in long-term memory.

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

One-way ANOVA analysis was adopted in this study. Test of homogeneity of variances showed that the number of immediate post-test and delayed post-test was .361 and .005, respectively. Therefore, the value of Tamhane was referred in delayed post-test.

Table 2. 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	163.792	2	81.896	18.464	.000	.2820
	Within Groups	416.930	94	4.435			
	Total	580.722	96				
delayed post-test	Between Groups	213.723	2	106.861	19.176	.000	.2898
	Within Groups	523.824	94	5.573			
	Total	737.546	96				

As noted in table 2, in immediate post-test there was significant difference among 3 groups ($F=18.464$, $P=.000$, $\eta^2=.2820$) with a large effect size; in delayed post-test there was also significant difference among 3 groups ($F=19.176$, $P=.000$, $\eta^2=.2898$) with a large effect size. The results showed that there was main effect of group in immediate post-test and delayed post-test with a large effect size.

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

Dependent Variable	(I) group	(J) group	Mean Difference (I-J)	Std. Error	Sig.
immediate post-test	1	2	-2.875*	.527	.000
		3	-.234	.523	.655
	2	1	2.875*	.527	.000
		3	2.641*	.523	.000
	3	1	.234	.523	.655
		2	-2.641*	.523	.000
delayed post-test	1	2	-3.313*	.577	.000
		3	-.332	.664	.944
	2	1	3.313*	.577	.000
		3	2.980*	.509	.000
	3	1	.332	.664	.944
		2	-2.980*	.509	.000

As noted in table 3, multiple comparisons of post hoc tests showed that in immediate post-test there was significant difference between group 1 and group 2 ($P=.000$), group 2 and group 3 ($P=.000$), but there was no significant difference between group 1 and group 3 ($P=.655$); in delayed post-test there was significant difference between group 1 and group 2 ($P=.000$), group 2 and group 3 ($P=.000$), but there was no significant difference between group 1 and group 3 ($P=.944$). The results showed that there was spacing effect in L2 grammar learning; expanded spacing had a significant advantage over equal spacing with a large effect size not only in short-term memory but also in long-term memory.

Discussion

Spacing effect in L2 grammar learning

The answer for question one is that there is spacing effect in L2 grammar learning. A likely explanation is that in spaced learning of grammar, learners encode rules of 3 tenses with its contextual sentences and what they induce during treatment. This context leaves many memory traces for learners to recall and induce grammar rules of 3 tenses. The greater the number of memory traces is, the greater the number of retrieval routes for later recall is in learning of 3 tenses. Moreover, the information redundancy in long-term memory decreases in spaced learning, which reduces interference in learning 3 tenses, and makes it easier for new rules of tenses into learners' long-term memory. However, in massed learning, learners learn 3 tenses in only one learning episode, so there are no contextual clues variation but much information redundancy. As a result massed learning in-

creases interference in learning 3 tenses, and makes it more difficult for new rules of tenses into learners' long-term memory.

Moreover, in L2 grammar teaching practice, teachers are unavoidable to use explicit teaching because of its difficulty compared to words. Teachers' explicit teaching may facilitate students' understanding to rules of grammar. In implicit teaching, teachers distribute many materials to students and do not explain to students directly, so students need to induce the hidden rules from what they learn by themselves. However, in explicit teaching, teachers would directly explain rules to students, and they may use many examples to make students understood. Moreover, in explicit teaching of spaced learning, every time teachers explain rules of 3 tenses to subjects, they may have different senses and understanding to subjects, which may provide different contextual clues for students to induce rules of 3 tenses. Therefore, spaced learning with explicit teaching facilitates L2 grammar learning.

The result is consistent with Bird (2011), Miles (2010, 2017) and Rogers (2017), but not with Suzuki and DeKeyser (2015). However, in Suzuki and DeKeyser (2015), they tested target words four times, so test effect may counterbalance spacing effect. Moreover, Suzuki and DeKeyser (2015) did not use explicit teaching in spaced learning, so there was no spacing effect in their study. However, this study and Bird (2011) used explicit teaching to teach students 3 tenses. The results further show that there is spacing effect in L2 grammar learning. It may conclude that spaced learning will not impede inducing in grammar learning. In spaced learning, there is much contextual variation (Raaijmakers, 2003), leaving many memory traces for learners to induce hidden rules of 3 tenses. Grammar rules in language learning is relative more difficult than words, so learners may not induce rules in only one learning episode. Moreover, there is much redundancy in learners' memory in massed learning, impeding their induction. Maybe, learners need more learning episodes to contemplate many examples to induce hidden rules. Spaced learning provide learners these several episodes to induce grammar rules, especially with the help of explicit teaching.

An advantage of expanded spacing in short and long-term memory

The answer for question two is that there is expanded spacing advantage over equal spacing in short-term and long-term memory in L2 grammar learning. A likely explanation is that expanded spacing combined retrieval difficulty and retrieval success (Pyc&Rawson, 2009). Expanded spacing involves immediate recall, while equal spacing involves delayed recall. In expanded spacing, learners are easier to retrieve, because of delaying only 0 or 1 trial. However, in equal spacing, learners are more difficult to retrieve because of delaying 2 or more trials. Moreover, in expanded spacing, learners retrieve the information more and more difficult owing to increasing intervals, devoting more efforts to study. However, in equal spacing learners retrieve the information constantly difficultly on account of the same intervals, devoting less efforts to study.

The result is line with Nakata (2015), but not with Farvardin(2019), Karpicke and Roediger(2007) and Schuetze(2014) in L2 words learning. In fact the result is mixed in L2 words learning about expanded spacing advantage over equal spacing. The reason may be vocabulary is declarative knowledge, but grammar is procedural one. Different knowledge may vary in spacing effect. Generally speaking, procedural knowledge is a little more difficult than declarative one. Therefore, grammar learning consumes more attention resources of learners in the beginning, so makes learners devote more efforts to facilitate grammar learning. Moreover, expanded spacing involves desirable difficulty to elicit more retrieval efforts of learners. However, words are declarative knowledge, so learners do not need to induce but memorize, processing not deeply, but grammar, procedural know-

ledge, needs learners to induce, processing deeply. Therefore, it is easier to find expanded spacing advantage over equal spacing in grammar than in words. Namely, grammar may be more difficult than words for learners to learn, favoring expanded spacing. It may conclude that grammar may be more suitable for expanded spacing than words. As noted in study of Logan and Balota (2008), expanded spacing advantage may be observed when the task is more difficult.

Pedagogical implications and limitations

In teaching grammar, expanded spacing with explicit teaching is suggested. Teachers can arrange their grammar teaching in expanded schedule. Maybe it is impossible to have a complete expanded schedule only in classroom, but extracurricular activities can also be involved. Namely, it is not necessary to be complete expanded schedule, because as long as it is near to expanded schedule, it will be likely to have expanded spacing advantage. At the same time, when students learn grammar, teachers are also suggested to instruct them to observe grammatical rules to facilitate their inducing.

However, there are some limitations for this study. At first, for one study it is impossible to have all grammar points studied, but grammar points vary in rules, so whether this result can be generalized to other grammar knowledge is still open. Next, although spacing effect may exist in L2 grammar learning, there are long, medium and short spacing, namely absolute spacing. Expanded spacing and equal spacing, relative spacing, may also interact with absolute spacing (Bahrck et al., 1993). Even Karpicke and Bauernschmidt (2011) found that the influence of absolute spacing was greater than that of relative spacing in words learning. Therefore, in L2 grammar learning, whether absolute spacing has an advantage over relative spacing is still open. At last, in this study, it aimed to generalize spacing effect in words learning to grammar learning in classroom settings, so explicit teaching with spaced learning was designed. However, explicit teaching may interact with spacing effect in facilitating L2 grammar learning, so it is still open to differentiate them two in later studies.

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Appendix A: Learning materialsTenses (Retrieved from <https://lingbase.com/en/english/grammar/all-tenses> on April 6th, 2022)**I. Present Simple (Present Indefinite)**

(-) She doesn't pick berries.	
(?) Does she pick berries?	
How to form	I/you/we/they — infinitive he/she/it — infinitive + -s
Auxiliary verb	do, does
Main use	Regular actions, habits, abilities, common knowledge
Other uses	Public timetable Stative verbs (think, believe, hope, love, want etc.) News headlines A sequence of short actions
Signal words	always, every day/month/year, usually, often, seldom, sometimes etc.

II. Future Simple (Future Indefinite)

(-) She won't pick berries next week.	
(?) Will she pick berries next week?	
Formation	will + infinitive
Auxiliary verb	will, shall
Use	Telling facts and predictions about the future Spontaneous decisions, promises, requests, refusals if-sentences (the first conditionals)
Signal words	tomorrow, next week/month/year, in X days/months/years

III. Past Simple (Past Indefinite)

(-) She didn't pick berries last summer.	
(?) Did she pick berries last summer?	
Form	infinitive + -ed (the second verb form)
Auxiliary verb	did
Use	Actions that happened and were completed in the past In combination with the past continuous, where the past continuous shows longer background action and the past simple shows short action
Signal words	yesterday, last week/month/year, X days/months/years ago

Appendix B: Grammar tests**Multiple choice****I. Present Simple**

- I ____ that she will pass the final test.
A. expect B. have expected
C. had expected D. was expected
- He ____ novels, whenever his wife goes shopping.
A. is reading B. reads
C. has read D. has been reading
- She reminded me that Beijing ____ the capital of China.
A. is B. was C. had been D. have been
- You will not know if it fits you before you ____ it on.
A. will try B. are trying
C. try D. have tried

II. Past Simple

- When I called you this morning, nobody answered the phone. ____ ?
A. where have you been
B. where had you been
C. where did you go
D. where were you
- Tom had not reached the restaurant when Jim ____ there.
A. got B. has got
C. had got D. had been
- where did you go last weekend?
—I ____ to the Great Wall.
A. go B. went C. will go D. have gone
- China ____ the WTO and became a new member of it in 2002.
A. joined B. join C. will join D. had joined

III. Future Simple

- Sorry. I forgot to post the letter for you.
Never mind. ____ it myself after school.
A. I would rather post
B. I will post
C. I posted
D. I had better post
- I ____ you the book as soon as possible, I promise you.
A. would send B. will send
C. sent D. send
- If you give up smoking and drinking, your health ____ soon.
A. will improve B. improve
C. improved D. improving
- Many scientists believe that robots ____ able to talk like humans in 50 years.
A. were B. are C. will be D. have been

Gap filling

I. Present Simple

1. My mother often _____ (tell) me not to read in bed.
2. I must take it back the day after tomorrow. You only _____ (keep) it for 24 hours.
3. I will tell him the news as soon as he _____ (come) back.
4. The teacher is busy, so he only _____ (sleep) six hours a day.

II. Past Simple

1. He _____ (come) back a month ago.
2. In his letter, he said that he _____ (miss) us very much.
3. Every time he tried to start the car, the wheels _____ (sink) deeper into the mud.
4. I am sorry you have missed the last bus. It _____ (leave) ten minutes ago.

III. Future Simple

1. I _____ (tell) Tom the good news as soon as I see him.
2. There _____ (be) a physics test next Monday.
3. It is very cold these days. It _____ (snow) soon.
4. Most of us do not think their team _____ (win).