

# Forgetting Curve and Spacing Effect: Pre-experiments on Remembering Intervals

Ping Zhan\*, Jeffrey Hanks\*\*

## Abstract

With the globalization and impact of the Internet, a new wave of English as an official language is occurring in Japanese corporations ([5]). Learning English in efficient ways is still a challenge. Unfortunately, English vocabulary is often introduced to students only once. Students are not provided with tools for retention. Our ultimate aim is to provide these tools in the form of available technology for efficiently spacing reviews of new vocabulary to ensure retention. This manuscript is the second step of our inquiry, see [1] for details. Since the forgetting curve is about human memory, and some tests are done by students voluntary, lots of uncertainty can be expected. In this manuscript, our pre-experiment, or pre-tests are recorded. To our surprise, we found that one week recitation spacing is also effective. This is an important result because classes are generally held once a week. From the data of the test, the spacing effect is apparent.

**Keywords** : spacing effect, forgetting curve, recitation spacing, experiments.

## 1. Introduction

The 'forgetting curve' has been researched and tested in various ways ([2] - [4]). In this manuscript, we combine the forgetting curve with English education, mainly testing on how to remember English words efficiently. For further information, see [1]. Since the forgetting curve is related to human memory, and some of tests are done by students voluntary, with so many variations of students' backgrounds and variations in exposure to English vocabulary, lots of uncertainty is expected. Also a meaningful result needs a certain quantity of tests. To prepare ourselves for an insight into understanding the direction of the experiments, and have an appropriate plan to determine the appropriate direction, our tests here are pretests for further research. The pre-test also includes a question as to whether we can obtain meaningful results and can verify our assumptions.

The manuscript is organized as follows. In Section 2, we introduce the background of our test. Section 3 gives examples about how motivation may affect the results. In Section 4, how to explain the meaning of forgetting (or remembering) is described. 'Spacing effect' results are given in Section 5. Section 6 shows that one week recitation spacing is also effective. In the final section, we analysis and summarize our pretest.

---

2013年11月8日受付

\* 江戸川大学 情報文化学科准教授 数理計画

\*\* 江戸川大学 情報文化学科専任講師 語学教育

## 2. The pretest words and experiment

There are two groups of words, one from the Academic Word List (AWL). This group is for students, as pointed out in [1], the list was developed by Averil Coxhead at Victoria University in Wellington. It was developed as a companion to the General Service List (GSL), but focuses on words occurring frequently in academic texts. The reason for selecting this list is that a majority of the words will be unfamiliar to our experiment's subjects (Edogawa University students), but will be potentially useful to them in their careers.

For the concept described above, from the list, we carefully selected the words one by one in a certain levels, i.e., between level 5 to 10, of a popular English-Japanese dictionary, Weblio. This is to avoid words that are too simple and might be known to the students, or too difficult, that students will be unlikely to encounter them in future. Before the test, we verify that the subjects are not familiar with the words to be tested.

The other group is for the test by one author of the manuscript, picked up and accumulated from unknown words in reading. To avoid the result of temporary forgetting, the level was also checked against the same dictionary, Weblio, as being above levels 8-10.

The number of words for one test setting was first planned at 25, but it proved to be excessive for the student subjects within an appropriate time period, then we reduced the number to 10-15. The test by author's groups remained at 25 words.

Given the English words, we only test whether the Japanese definition can be remembered. The precise spelling of words is not relevant to our test. We think this is the more beneficial practice for learning English. The meaning is the most important for many people, because there are many ways, through technology, to verify spelling.

After an initial test of recall, testers are allowed to review the Japanese meaning. As a result, the test is not simply a test of recall, but also a repetition process. We adopted the procedure because it is more suitable to English education.

We used an Excel spreadsheet in recording our tests. After one test, or one check, we use the Excel randomizing function 'RAND' to shuffle the order of words.

Each pattern of tests was repeated 6-7 times. By experience, "magic seven" is the number of repetitions needed to lodge the words in long-term memory.

## 3. Motivation in tests

Motivation in tests is a key factor.

One author began the test with 25 English words, a student assistant, Tetsuya Inaba, also did pre testing with a group of 26 English words ([1]). Therefore we thought that it would be appropriate to use the same number of words for the student subjects. But when we began the test, without strong motivation, most students gave up trying. Then we reduced the number to 10-15 words. Even with 10 words, a number of students still could not remember a significant percentage, i.e., below 2 words out of ten. We dropped these data from our results.

There were some additional limiting factors. We tested mainly during English lecture time. As to

not interfere excessively with the regular curriculum, the time used on the test was limited. Our test was conducted during a set period of weeks, during which, some students were absent once or twice. So, some these data also needed to be excluded.

Initially, we planned several interval patterns. The test was not to be done only in lectures, but after lectures. We wanted students to answer our email by mobile phone. Regrettably, only a small percentage of students replied. So some test patterns were abandoned.

#### 4. Forgetting or remembering process ?

The forgetting curve indicates that, with a longer interval, the percentage of forgetting increases. As illustrated in Section 2, we tested the same word list 6-7 times in a defined period. After each test, the meaning of the tested words was reviewed. So, it is hardly a simple forgetting test. It is a process of re-enforcement.

There are also some other factors. Before the next test, some students tried to remember more words, they kept repeating the words in their minds, in spite of our attempts to exclude this type of mental repetition.

The feature of remembering process can be easily seen from some of the test data. See the Table 4-1 for parts of examples.

**Table 4-1 : The remembering or forgetting process**

0 min	15 min	35 min	1 week
7   10	9   10	10   10	9   10
0 min	15 min	35 min	2 week
7   10	9   10	10   10	5   10

This forgetting or remember process not only occurs in a short interval, but also a long interval. See the Table 4-2 for this type of example.

**Table 4-2: The remembering or forgetting process**

0	1 week	1 week	1 week	1 week
25   25	6   25	15   25	18   25	22   25
20 min	1 hour	1 day	1 week	2 week
learning	24   25	25   25	16   25	20   25

Note 1: The contents of the above table (also the following tables) are as follows.

interval (or patterns) between two tests
the number of words remembered   total test words

#### 5. Spacing effects

Spacing effects are widely assumed to be easily tested and verified. To test the spacing effects, we add a test pattern with a relatively short inter-interval, one day. The interval of this pattern, denoted by D, is equal, around one day. The other planned patterns, together with pattern D, are summarized in Table 5-1.

**Table 5-1: The intervals of 3 patterns**

F	E	D
0 min	0 min	0 min
20 min	1 week	1 day
1 hour	1 week	1 day
1 day	1 week	1 day
1 week	1 week	1 day
2 week	1 week	1 day
2 week	1 week	1 day

The results of tests are summarized in Table 5-2.

**Table 5-2: The comparing of 3 patterns (see also Notes 1 and 2) .**

F1	F2	E1	E2	D1	D2
20   25	20   25	21   25	23   25	25   25	25   25
21   25	20   25	18   25	20   25	12   25	10   25

Note1: The second row denotes the results at the ending of a certain test period. The last row denotes the results after more than two weeks-one month had past.

Note 2: There are some deviations in the practical intervals, see the Appendix for details.

From the last row of Table 5-2, the difference between Patterns F and E is not clear, but the difference between Pattern D and other two patterns is obvious. Concerning the last row more precisely, Pattern D is two weeks later, Patterns F and E are one month later, see Appendix for details.

## 6. One week interval

When people recite English words, they usually do it by themselves. If one concentrates on reciting new words, for example, before a test, it is seldom that the spacing for the first recitation is one week. Because our tests are aligned on classes, it is natural for us to add a pattern of a one-week interval.

The results from this one-week test interval are unexpected, and the most important part of our pre-tests. See again Table 5-2, the difference between Patterns F and E is not clear. That also means that one week interval, i.e., Pattern E, is also an efficient way in reinforcing new words.

**Table 6-1: The process of Pattern E, one week interval**

1 week	1 week	1 week	1 week	1 week	1 week	1 month
21   25	18   25	19   25	21   25	22   25	21   25	18   25
0	1 week	1 week	1 week	1 week	1 week	1 month
25   25	6   25	15   25	18   25	22   25	23   25	20   25

In Table 6-1, there is obvious difference between two tests. The first one, i.e., rows 1 and 2, there is no sharp drop in the first week or second week. The reason may be that new words are picked up from reading not so long ago. It is reminded in some extended. The second test, rows 3 and 4, only little part of words are reminded in first week. The fact seems to match intuition or our assumption. The surprising

thing is that after 2-3 times reinforcement, see also Section 4, most words are retained. So it appears that an one-week reinforcement spacing is not a big obstacle in learning new words.

Although, the results may be an encouraging for teachers, it does not mean that we recommend taking lot of class time just for repeating new words.

## 7. Summarizing

### 7-1 The interval leads to retrieval failures.

There are two factors that affect retrieval failure, the interval and the number of previous repetitions. Table 6-1 shows such example.

**Table 6-1: Retrieval failure example**

20min	1 hour	12 day
22   25	23   25	1   25

Comparing the example above, we can say that at an early period, one week is near the longest interval. Two weeks will lead to retrieval failures.

### 7-2 The down and up phenomenon

In the processing of tests, we found a phenomenon: After a relative lower percentage of recall, a high percentage followed.

**Table 6-2: Down and up phenomenon**

0 min	38 hour	14 hour	1 day	1 day	20 min	1 hour
23   25	16   25	24   25	14   25	25   25	18   25	22   25

This phenomenon is reasonable. After failure in remembering a lot of words, more time or focus was used in reviewing the forgotten words. Conversely, in the later period of Pattern D, with equal intervals, one day, almost all words were remembered and little time was needed in the corresponding review. We think this is also an important factor influencing the spacing affect.

### 7.3 What is the pseudo-optimal inter-repetition interval ?

As pointed out in [1], the ultimate objective is to find the pseudo-optimal inter-repetition interval.

These are the maximum intervals that the human memory is capable of between forgetting and remembering. This is consistent with the spacing effect and also coincides with the following in some sense. In chance theory or credibilistic theory (可信性理論) or uncertainty theory, 0.5 (the probability value, or the fuzzy characteristic value) is the most salient value, in this case (the longest interval) between the success (remembering) or failure (forgetting). At this point, brains work most efficiently.

After the pre-tests, we still think that the pseudo-optimal inter-repetition interval is short before a significant percentage of words are totally forgotten. In this way, we can retrieve words and keep our brain in an active state. For more precise research or verification, we also need to record the duration of the reviews.

## 7.4 Conclusion

Up to this point we have the following conclusions:

1. New vocabulary, introduced but never repeated, is highly unlikely to be retained. Unfortunately this is how much vocabulary is introduced to students.
2. The number of repetitions of 6-7 is sufficient for motivated people.
3. The maximum review spacing is around one week, especially in early repetitions.
4. Until now, no obvious difference exists between Patterns F and E.
5. The duration of the test period is not the only factor influencing the spacing effect.
6. The review interval of one week is also effective in leaning words. This interval is relatively easy to match, not only in the schedule of educational institutions, but also in others fields. This is an encouraging result.
7. To get a more meaningful result, not only the interval, but the total review time should also be recorded.

## Appendix: Test data

### Group1

1 week	1 week	1 week	1 week	1 week	1 week	1 month
21   25	18   25	19   25	21   25	22   25	21   25	18   25
0	1 week	1 week	1 week	1 week	1 week	1 month
25   25	6   25	15   25	18   25	22   25	23   25	20   25

20 min	1 hour	1 day	1 week	2 week	2 week	6 week
18   25	22   25	24   25	21   25	22   25	20   25	21   25
20 min	1 hour	1 day	1 week	2 week	2 week	1 month
learning	24   25	25   25	16   25	20   25	20   25	20   25

1 day	1 day	1 day	1 day	1 day	2 day	15 day	
14   25	25   25	22   25	25   25	24   25	25   25	12   25	
0 min	38 hour	14 hour	19 hour	25 hour	47 hour	23 hour	1mon
23   25	16   25	24   25	25   25	24   25	25   25	25   25	10   25

20 min	1 hour	12 day
22   25	23   25	1   25

Group 2

20 min	50 min	3 day	4 day	1 week	2 week
4   15	6   15	8   15	6   15	12   15	13   15
20 min	50 min	3 day	4 day	1 week	2 week
9   15	11   15	10   15	10   15	10   15	10   15

1 week	1 week	1 week	1 week	1 week	1 week
8   15	12   15	13   15	13   15	14   15	15   15
1 week	1 week	2 week	1 week	1 week	
8   15	7   15	7   15	8   15	6   15	

0 min	15 min	35 min	1 week
7   10	9   10	10   10	9   10
0 min	15 min	35 min	2 week
7   10	9   10	10   10	5   10
0 min	15 min	35 min	2 week
3   10	0   10	2   10	1   10
0 min	15 min	35 min	2 week
1   10	3   10	3   10	0   10

20 min	50 min	1 week	1 week	1 week	2 week
10   10	10   10	7   10	9   10		5   10
20 min	50 min	1 week	1 week	1 week	1 week
10   10	9   10	7   10	6   10	4   10	7   10
20 min	50 min	1 week	1 week	1 week	1 week
10   10	9   10	7   10	6   10	4   10	7   10
20 min	50 min	1 week	1 week	1 week	1 week
4   10	2   10	4   10	2   10	3   10	0   10
20 min	50 min	1 week	1 week	1 week	1 week
6   10	8   10	9   10	9   10	9   10	2   10
20 min	50 min	1 week	1 week	1 week	1 week
6   10	8   10	9   10	9   10	9   10	2   10

20 min	50 min
4   10	4   10
20 min	50 min
6   10	6   10
20 min	50 min
8   10	6   10

20 min	50 min	1 week	2 week
10   10	10   10	10   10	9   10

### References

- [1] Jeff Hanks, Ping Zhan, The Forgetting Curve and Learning Algorithms, (江戸川大学紀要 No. 23), p53-60, 2013.
- [2] John Henderson, Memory and Forgetting, Routledge, 1999.
- [3] Michael Jacob Kahana, Foundations of Human Memory, Oxford University, 2012.
- [4] Sergio Della Sala, Forgetting, Psychology Press, 2010.
- [5] 特集, グローバル英語力, Harvard Business Review, p108-115, 21012/10.