Word-length effect on working memory

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Abstract

This study aims to verify or falsify Baddeley's theory, which claims the existence of the working memory. According to Baddeley the working memory holds temporary information that is only needed for the task at hand. One part of the working memory is the articulatory loop, the "inner voice" which is used to memorize short strings of words by rehearsing them. An experiment with 20 participants was conducted. All participants were presented with a set of long and a set of short words, which they would read out loud once. They were then asked to repeat the words they just read. In all 20 cases, the subjects remembered more short than long words. This result goes hand in hand with Baddeley's theorem, as the theorem states, that the rehearsal time is a key factor for memorization.

Keywords: memory, working-memory, word-length effect, articulatory loop, Baddeley's theory

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1. Introduction

Within cognitive psychology, the problem of how we store and retrieve information has been the subject of many research studies. While memory is a vital concept for every species, it is in particular so for humans, since we rely heavily on it in society. In order to be able to interact with other people and our environment, we need to be able to perceive and remember information (such as names, locations and much more).

A lot of research has been conducted on memory and one of the theories within this research is that memory is based on two main attributes: strength and activity. On the one hand, memories with a high strength can be remembered for a long time and can be used in the future. This is what we call long-term memory. On the other hand, those with a high activity and low strength are what we consider short-term memories.

A theory within cognitive research is that the capacity of short-term memory is 7 (± 2) "chunks" of information. The principle of the "chunking" of information relates to the fact that we automatically group some information to remember the whole data. For example, when we have to remember a phone number, we don't remember each digit individually. Had it been the case, we wouldn't be able to remember a whole phone number. What we unconsciously do is grouping some numbers together. For instance, to remember 5-6-7, we remember the number 567 as a whole rather than the 3 digits separately. Given that the chunks' size can vary greatly, our short-term memory can remember efficiently a larger amount of information (Miller, 1956).

In addition to Miller's theory about short-term memory capacity further theories of short-term memory were developed. One theory proposes that information we attend first go from a transient sensory memory to a limited short-term memory if it's relevant. From there, the information has to be rehearsed to get into our long-term memory. Thus, the more we rehearse something the more likely it is that we remember it. In the 1980s, Baddely presented another interesting theory of the rehearsal processes, although it was not at all tied to long-term memory. He presented the theory of working memory (Baddeley, 1986) where he stated that working memory is the memory needed to perform a task. This working memory, he meant, consists of two systems, the visuospatial sketchpad and the phonological loop. Of these two, the phonological loop has been studied the most and according to Anderson (1999) it consists of several parts including an articulatory loop and a phonological store. The articulatory loop is a system that rehearses information while we are performing a task and the phonological store listens to the articulatory loop and stores the information being rehearsed (Ibid.).

One of the strongest evidences for the existence of the articulatory loop can be found in the so-called word length effect. This effect implies that the longer a word is, the longer it takes to say the word and therefore you won't be able to rehearse a list of long words as many

times as a list of shorter words. Thereby one will remember less of the longer words than the shorter words (Ibid.). This phenomenon and Baddely's (1986) theory of working memory has intrigued us to examine if we can come to the same conclusion about the working memory and the existence of the articulatory loop. Therefore we will conduct an experiment of our own in order to research the word length effect and finding out how much material we can keep in the articulatory loop. Knowledge about this effect could be taken into consideration while writing speeches or preparing presentations. Knowing that short words will be remembered better, the speaker could use short words when trying to make sure a certain point or statement will be remembered by the listeners.

2. Methodology

2.1 Research design

In being able to answer the research question, a within-subjects research design was used. The experiment involved only one member of the team and one subject each time. When the experiment began the subjects were presented with a powerpoint presentation, displaying all the instructions of the experiment. The instructions were presented this way to ascertain that every participant got exactly the same instructions and thereby it could eliminate possible error variance (Kerlinger & Howard, 1999). After that, any questions related to the procedure were answered by the conductor of the experiment. The experiment was then conducted through the same controlled powerpoint presentation so that when the subject had read the set of words out loud once we could move to a slide that hid the words. The results were then saved by the conductor in a secured web document.

2.2 Variables

The definition of the right variables is very important because it helps in a better executed experiment. It does this by defining exactly the matter of research. By identifying the variables that might influence the research object, we can make sure that these variables are constant throughout the experiment, thus reducing the error variance in the experimental design.

Dependent variable: refers to what it is that we are trying to study and understand from the experiment

- Working memory and how much material can be temporarily stored. We will measure this with the word length effect.

Independent variables: refer to the stimuli presented to the subject.

- Short-length words (1 syllable words): bike, day, snow, cry, bed
- Long-length words (5 syllables words): recommendation, possibility, cooperative, anniversary, communication.

Controlled variables: the controlled variables refer to conditions that we need to keep under control so that they do not introduce error variance into the experimental design.

- The words will be presented in English, all in lowercase format, not closely associated with one another and won't be too complex in the meaning.
- The participants will have approximately the same level of English knowledge.
- The sets of long and short words are going to be the same in every single experiment on the subjects.

- The environment will have to be as quiet as possible in order for the subjects to be able to concentrate better.

2.3 Subjects

20 individuals took part in the experiment. All the participants are friends of the experimenters and some are also other students at Stockholm University at the department of computer and system sciences. All subjects have English as their second language.

2.4 Procedure

Due to the ongoing pandemic we were not able to conduct the experiment in the exact same place with every participant since we didn't find it ethical to have them all travelling, especially by public transport, in these times.

First round

The slideshow started counting down from 3 and then the first set of words appeared on the screen. After the subject read the words out loud once the experimenter changed the slideshow picture so that the words were no longer visible. Directly after changing the slide, the subject was asked to repeat all the words he/she remembered. When it was obvious that the subject did not remember further words, the experiment proceeded. Examples for indicators of the subject not remembering more words would be the subject expressing this or the subject not saying any other words. The number of words remembered were noted.

Second round

Whenever the subject was ready, the slideshow once again did a countdown and the second set of words were presented to the subject. After the subject had read each word out loud once the experimenter made the words invisible to the subject by changing the slide in the slideshow, and again the subject was asked to repeat the words. Also this time the number of words remembered were noted by the experimenter.

These two rounds were varied, meaning that half of the participants were presented with the short words first and the long words next and the other half of the group were presented with long words first and the short words next. This was to make sure that one particular order of the conditions didn’t negatively affect the outcome.

Before we carried out this experiment we did a pilot study to ascertain that our format of the experiment and the material that was used in it didn’t negatively affect the outcome. In the pilot we were able to better examine if the words we had chosen for the experiment were suitable and if it was reasonable to have the subjects read the words out loud when

introduced to them. The participants in the pilot study were not a part of the real experiment and the outcome of the study was not included in the final results of the experiment.

3. Material

Since the words were displayed in a powerpoint presentation, a laptop was necessary. We also used a notepad to write down the subjects results during the experiment. This so that we did not forget the number of words a subject remembered and so that we did not have to swap between the presentation and a document on the computer during the experiment. Once the experiment was finished, we transferred the results to a document on the laptop.

4. Research ethical issues

It was important that the subjects felt comfortable in participating in our experiment and that they knew it was out of free will. Before we began the experiment, we therefore informed the subjects of the fact that their participation was completely voluntary. Furthermore, they were allowed to withdraw from the experiment at any time they wanted. We also made sure that they understood that if they wanted to leave the experiment it would be without any repercussions.

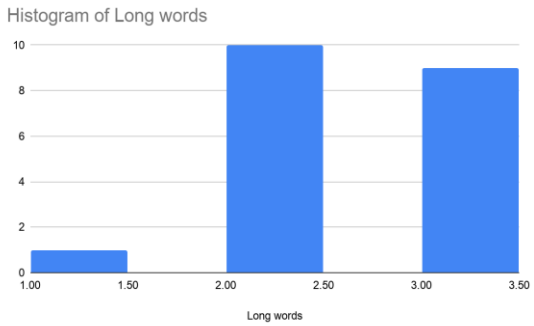
The subjects were also informed that the data we were collecting would not be disclosed to anyone else in a way that could identify them. The subjects were anonymous and we would not share any personal information about them. The only thing we recorded was their results but no one would be able to connect a result to a specific subject. By signing the consent form (Appendix A) the subjects confirmed that they received this information.

5. Results

Before conducting the final experiment, a pilot study was carried out. Two subjects were presented with the experiment for us to check if the whole procedure of the experiment was understandable. No issues were faced throughout the experiment and the results were as expected. More shorter words were remembered in contrast to longer ones. That meant we could continue and conduct the final experiment.

The experiment was carried out with 20 subjects. The results of the experiments are shown in figure 1. Figure 1a corresponds to the number of long words remembered by the subjects. A majority of the participants (50%, 10 people out of 20 subjects) remembered two long words, another 40% (8 people) remembered three long and 10% (2 people) could recall one long word. Most of the subjects were able to repeat all of the short words (70%, 14 people out of 20 subjects), 20% (4 people) remembered four words and 10% (2 people) recalled three words.

The average for the short words remembered was 4.6 words in comparison to 2.4 words remembered for the long words. The median number of short words remembered is 5 (st.dev : 0.66) whereas the median number of long words is 2 (st.dev : 0.58). The linear correlation between the 2 sets is 0.28, which is low.



(a) Amount of long words

(b) Amount of short words

Figure 1: Correctly remembered words

6. Discussion

The results we got from our experiment were very similar to those Baddeley presented. He found that people on average repeated back 4.5 out of the one syllable words he tested, and 2.6 out of the five syllable words. Our results then also strengthen his theory about the existence of the articulatory loop, in which according to Baddeley we can keep however much information we can rehearse in a fixed duration (Baddeley, 1986). These results also contradict the theory of humans being able to keep a certain amount of chunks of information in their short term memory. This since the subjects were shown five chunks of information in both sets of the experiment, but clearly remembered the short words better than the long ones.

However one aspect that could have affected the outcome of the study is the fact that the experiment was conducted in english and not in the subjects' native language. As presented in the results chapter, 14 out of 20 people remembered all five of the short words and 8 out of 20 people remembered three of the long words, which was the highest amount of long words remembered. There is a possibility that the subjects would have performed better if the experiment had been conducted in their native languages.

Another aspect that could have affected the outcome of the experiment is the two sets of words that were chosen. Even though we conducted a pilot study where we found out that the words that we had chosen worked well, there is a risk that not all of the subjects in the real experiment thought so. The subjects in the experiment could have struggled more with the words and therefore were not able to remember as many of them. Being presented with complicated words may also have led to the subjects feeling anxious or stressed when they were supposed to read the words out loud, and therefore focused more on the task to pronounce the words correctly instead of trying to remember them.

Even though we presented the experiment to all the subjects before conducting it, some subjects didn’t really know what to expect from the experiment. Therefore, when they were presented to the first set of words, they “discovered” the experiment. Then, when they were presented to the second set, they were more prepared and could focus on remembering the words efficiently. We can then expect the results of the subjects who were presented to the short words first to be below average for the short words and above average for long words and vice-versa for the subjects who were presented to the long words first. The fact that we had these two options (long words first and short words first) allowed us to still have valid results. However, we could have let the subjects pass a mock experiment before the real experiment with different sets of words, so that they would have been prepared to the experiment when they were presented to the real one and they would have been as focused on the task of remembering the words for the first set as for the second set.

Since the experiments were not conducted at the same place, they might have been influenced by the atmosphere of the different rooms. The rooms could have triggered certain feelings within the subject; a subject might be less motivated to do the test in a bedroom, since this is a place where he/she would normally rest. As opposed to this, the lighting in an office-room might help the subject to focus better, since he/she normally is in a concentrated state, when in an office.

Another aspect that was not taken into consideration in the experiment was the activity before the experiment. While some subjects might have had a very smooth and restful day, others might have been studying for a few hours or might have had a very busy and therefore stressful day. Physical and especially mental workload before the actual experiment might have influenced the performance of some subjects, which would lead to errors in the overall studies.

Something that should also be taken in consideration is that some subjects might be more competitive in general, which could cause a self induced rise of stress, which in turn could worsen the subject's performance. On the other hand, being competitive could also help the subject to perform better, since they would focus better on the task at hand. We tried to minimize this by making sure that the subjects understood, that their personal performance did not matter and therefore put them in a less stressful situation. However, some of the subjects still expressed after the experiment that they became very nervous, and a possible reason for that could be that they felt that we were examining their personal performance.

6.1 Conclusion

The study and the results of the experiment verify Baddley's (1986) theory on the articulatory loop. There seems to be a fixed capacity in our working memory and that is proven by the fact that more short words were remembered in contrast to long words in every single experiment.

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Appendix

Consent form

Word-length effect on working memory

1. Background	The study is conducted within the course of Human Cognition in Human-Computer Interaction at the department of Computer and System Science, Stockholm University. The study examines working memory, particularly the existence of the articulatory loop.
2.Procedure	During the experiment you will first be presented with a powerpoint presentation with the instructions of the experiment. When you are ready the experiment will begin and you will be shown five words in the powerpoint presentation. Your task is to read those words out loud. After this the words will disappear from the screen and you will be asked to repeat the words out loud. This procedure will then be repeated once again but with another set of words. The experiment will take approximately 5 minutes.
3. Management of data	As a participant you will remain anonymous, and the data collected will not be discussed with others than the experimenters.
5. Voluntariness	Participation in the study is voluntarily and can at any be terminated without further explanation. You can, according to GDPR, at any point withdraw your consent.
6. Responisble experimenter	The study is conducted by [Name], student at the course METOD, of Human Cognition in Human-Computer Interaction. Telephone: [Telephone number]

Informed consent

- I confirm that I have received this written, as well as oral information about the study.
- I give my consent to participating in the study and I am aware that participation is voluntary.
- I am aware that I can withdraw my consent at any point without further explanation.
- I allow that the information I have received and the collected data is stored and managed digitally by the responsible students.

……	……	……
Date	Participant's signature	Name clarification

……

Experimenter, [Name], Signature