Kjrsten Holt
WRIT 677-50 User Research
Prof. Quan Zhou
Spring 2020
Pilot Study Report

Pilot Study Report:
Cue-dependent forgetting and Online Learning and Recall

Executive Summary

In this research, I investigate whether my research subjects are better able to recall words from a list when the test environment is visually similar to the learning environment. To test this, I created a website with a study page and two versions of a quiz page. All subjects study the same 15-word list presented within a distinctive design (which includes background imagery and a large, unusual typeface). Then, Group A (half of the respondents) are given a quiz where the design is consistent with the original study page (including the imagery and fonts). Group B is presented with a plain-looking quiz in a sans-serif font. The results support my hypothesis that a consistent design between the learning environment and the test environment would result in a greater number of words being recalled correctly.

Introduction

Cue-dependent forgetting is a cognitive bias defined as the failure to recall information due to the loss of cues that were present when the information was learned. These cues can be semantic, state-dependent, or contextual. I reviewed literature about cue-dependent forgetting, studies which utilized word lists for testing and recall, and studies on the subject of memory as it is related to e-learning. I utilized Google Scholar and my university library website to find research papers using the following search terms: *Cue-dependent forgetting, word list recall, cue-dependent forgetting in e-learning, context dependent memory.*

Literature Review

Tulving on cue-dependent forgetting

One paper in particular seemed to be the foundation of research into *cue-dependent forgetting*. This 1974 paper by Endel Tulving is cited by many other sources and seems to have been the first to popularize the term.

According to Tulving, two things are required for remembering: first, a memory trace (stored information in the brain), and second, a cue, the thing that reminds you of the memory. Therefore, when information is forgotten, there are two possible reasons: one is that the memory trace itself is damaged or destroyed, the second is that the trace is still there, but just cannot be retrieved. Tulving favors the idea that forgetting is due to retrieval failure rather than the memory trace itself being destroyed. In the paper, several experiments are discussed for which cue-dependent forgetting fits the results better than the theory that memory decays or is unlearned. The role of the cue in remembering is easily overlooked; more often we think it's because a memory was

particularly strong that it is remembered, or that the person has a good memory. But experiments show that cues are important.

One experiment by Tulving involved asking subjects to remember words given in pairs. In the test, they were given the first word in the pair and had to recall the second word. Subjects did well with the original words (bark-dog, worse-nurse) when given cues with the first word filled in: bark-____ or worse-_____. In the cases where they failed to remember the second word, the researchers tried again with grog-____ and doctor-_____ and more people successfully remembered the second word than was expected. The alternate cues helped them remember the words.

A second Tulving experiment gave subjects clues in the form of the first few letters of the words, or provided cues that were homonyms or synonyms of the to-be-recalled words. Tulving explains that these experiments all showed that failure to recall words may happen because of the lack of cues in the retrieval situation. The subjects' memories didn't deteriorate or vanish; they were able to recall the words with appropriate cues, which showed that the memory was there, but just needed to be 'jogged' correctly.

Another experiment described by Tulving is a recognition test, where the test subjects are shown a list of words, and then in the test, the words are shown in a list mixed up with other words, and they have to pick out which words were in the original list. (Note: this is the methodology I am following in my study.) The results showed that with cues, there was better recall. Memories that seem to have been 'lost' can be retrieved in the presence of the right cue. This would not be the case if the memory had actually been damaged or destroyed.

Studies that used lists of words

Memory experiments often use a list of words as an object to be remembered, this is mainly for convenience and simplicity, as it is very easy to test. Several of the papers I reviewed used word lists or word association as the method for testing subjects' memory and recall. Word lists were used by researchers Markopoulos et. al (2012), Khosravizadeh & Gerami (2011), Jo, Yu, Koh & Lim (2018), Storm & Koppel (2012). In all cases, subjects were tested in their native language, and the words used were "high frequency words" – words that an average speaker would be familiar with.

Short-term vs. long-term memory

In Yu Cao's *Cueing Strategies in Instructional Design*, the concept of short-term and long-term memory is explained. First, a memory is held in sensory recall, which lasts 0.5 to 2 seconds; next, if the person pays attention, information is held in so-called short-term memory, which is generally thought to be able to retain 5-9 chunks of information (could be numbers, words, etc.). In order to move this information into "long-term" memory, a person generally needs to rehearse the information, organize the information into a meaningful unit, or elaborate on it in order to connect the new input with existing knowledge or concepts. Cues can help a person retrieve items from long-term memory. Cao's research proved that cues that facilitated learning the information in the first place can be effective cues to remember the information on a test. The experiments presented text within a designed computer screen. Visual cues such as fonts, colors, arrows were used to direct students to study and remember certain points. The thrust of this was to differentiate important pieces of information

and make them stand out from the background, with the intention of making those points more memorable/learnable.

Cao credits Bourne Jr. et al., 1986 in saying that "For a given retrieval cue to be effective, it must be encoded with the original event." Cao also states: "the effectiveness of cueing strategies in computer-screen delivered text has not been widely investigated. Future research needs to be conducted to clarify this issue."

Remembering words in context: sentences
In Hofmeister and Shravan (2014), the researchers point out that much prior research on memory and language has been done using word lists; their research, conversely, investigates word recall in the context of full sentences, and in particular, investigates how the grammatical structure of sentences influences comprehension and recall. Cue-based recall in this research referred to the process by which we comprehend complex sentences by remembering the subject or antecedent throughout the course of reading the sentence. If this process is disrupted or the sentence structure isn't clear, recall is impaired.

Environmental semantic context
Researchers Markopoulos et. al (2010) repeatedly used the terminology "EC" to abbreviate "environmental context". They differentiated Local EC from Global EC – Local was the immediate context of the information (on a page, on a computer screen, colors, fonts, etc.). Global EC was the surroundings of both the subject and the information, for example, in an office, outdoors, etc. The experimental design these researchers used is similar to mine: half of the items were tested on the same Local EC, and the other half were in a new and different Local EC. However, part of the Local EC in these experiments involved additional words that acted as cues at recall time. The words chosen in this study were nouns, with a minimum frequency (10 occurrences per million). Frequently-used words are often used in this kind of memory test, because presenting subjects with words totally unknown to them would not be a fair test; frequently-used words are easier to recall. A number of cognitive studies have shown that frequently-used words are more quickly processed and recognized (Jo, Yu, Koh & Lim, 2018).

Insights from game-based learning
I found the paper about Game-Based Learning (Jo, Yu, Koh & Lim 2018), particularly interesting because it focused on online learning (e-learning). This research out of Korea examines methods for assessment of learning. The researchers aimed to make it easy to verify students' comprehension of video lectures (within a MOOC (Massively Open Online Course) via an automated self-test routine ("minimum learning judgment system") that generates a word game. This machine-generated verification is presented to the student at several points in their study session, and is envisioned as an alternative to a post-lecture quiz written by instructors. (The paper describes results of research that tested the game.) The creation of the *minimum learning judgment* quiz is completely automated, generated from the subtitles of the video and algorithms that determine the frequency of the words. If students recognize the frequently-used words, it is assumed that they watched that portion of the video. I was particularly interested in the UX diagrams of the structure of the system, and the format of the word test. The automated test was a word-recognition test. Students are shown 14 words at a time and asked to mark whether or not they thought the word appeared in the video

lecture. This is similar to my test; I am also using word-recognition and a form to collect responses. Another similarity is that random words are mixed in to the test and subjects must choose whether or not they recognize each word.

Can cue-dependent forgetting be adaptive?

Storm & Koppel's 2012 research takes the problem of forgetting in another direction. Cue-dependent forgetting is a failure to recall information because necessary cues are absent. But there is also forgetting apparently induced by the process of thinking and remembering. Researchers used a word-association test called a Remote Associates Test (RAT), in which subjects must think creatively to come up with a word that relates to three other given words. For example, given the words cat, sleep, board... what is the one word that is could be paired with each of these words? (The answer is "walk"). The researchers found that if they cued the subjects with erroneous word pairs: cat-nap, sleep-night, board-wood, then the subjects were less likely to be able to solve the RAT test. On the other hand, if they had not been exposed to those cues, they were more able to solve the problem. *The researchers made the case that cue-dependent forgetting is adaptive:*

"Often, information that we do not want in one context is still very important in other contexts, and it would be useful for that information to retain its accessibility in those contexts."

Questions as cues

Finally, Sehulster & Koppel (1972) examined cued recall for passages of prose. Student subjects were asked to read a 200-word informational article, and then either write down what they could recall of the facts (free recall), or respond to specific questions about the content. The group who responded to specific questions (which acted as cues) recalled more from the readings. This research bolsters the view that cues are helpful to effective recall, and can cause a subject to remember more than they otherwise might.

Analysis

The literature informs my research in the following ways: Like most of the sources I reviewed, I am testing fewer than 100 subjects, using a memory test that presents material for a limited amount of time, and then tests recall. I will be using a 15-word list, which is close in number to some of the reviewed studies, and it is a recognition test (like some of these studies used) – subjects will be asked to identify words that they saw in the first part of the experiment.

I am testing for basic word recall, and there is no hierarchy among the words, nor is there any intentional organization of the list. The strategy of making particularly important information stand out via the use of a design that highlights the emphasized content (as in Cao, 2005) is not one that I will be using in my experimental design.

While some of the studies delved into techniques for retention of information including elaboration and connection to existing knowledge, I am not expecting my subjects to employ "memory tricks" (such as visualization, organization or elaboration) to recall the items in the word list. Recognition of previously-seen words will depend on the organic process of viewing the words in a designed context and holding them in

memory. Test subjects who have had practice with special techniques might use them, and thus do better on the test.

Researchers investigating word recall in the context of sentences of text (Hofmeister & Shravan, 2014) found that superficial visual changes – a word in green, for example – did not enhance recall. (But if the visual change reinforced organization of the information, or helped to connect it with existing knowledge, it did help.) Since my list of words is not semantically related to the visual design, I do not expect semantic processing to enhance memory in my experiment.

In my research, the only thing that changes is the Local EC (environmental context), which is the design of the test screens upon which the words appear.

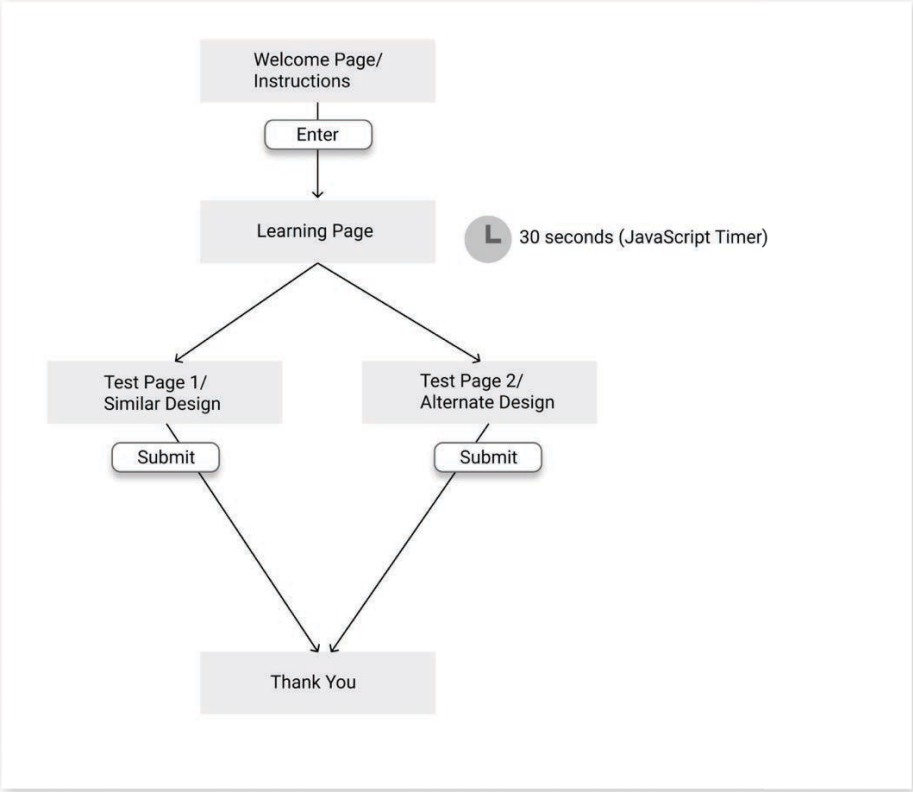
In Markopoulos et. al (2010), the order of the words in the list was randomized for each participant. My experiment uses the same list (in the same order) for each condition, and for all participants. If there is a recency effect or a primacy effect (making certain positions in the list more memorable), it will be the same for all participants.

Research Process and Procedures

The study uses quantitative analysis of test scores for a remote, online experiment consisting of a short e-learning module with a self-test at the conclusion. Fifteen words are presented on a website within a distinctive visual design, for a 30-second period. After viewing, a testing screen (part of the same website) is offered in which participants use a web form to mark checkboxes next to the words they recognize from the previous screen. The design of the testing screen is the independent variable: one is similar to the learning environment, and one is different. After completing the test, subjects click a “submit” button to submit their answers.

I created the test website, including code to randomly sort respondents into Group A and Group B. When users finished the quiz, data was returned to me via email (Appendix C includes the data that was collected).

Site map of test site:

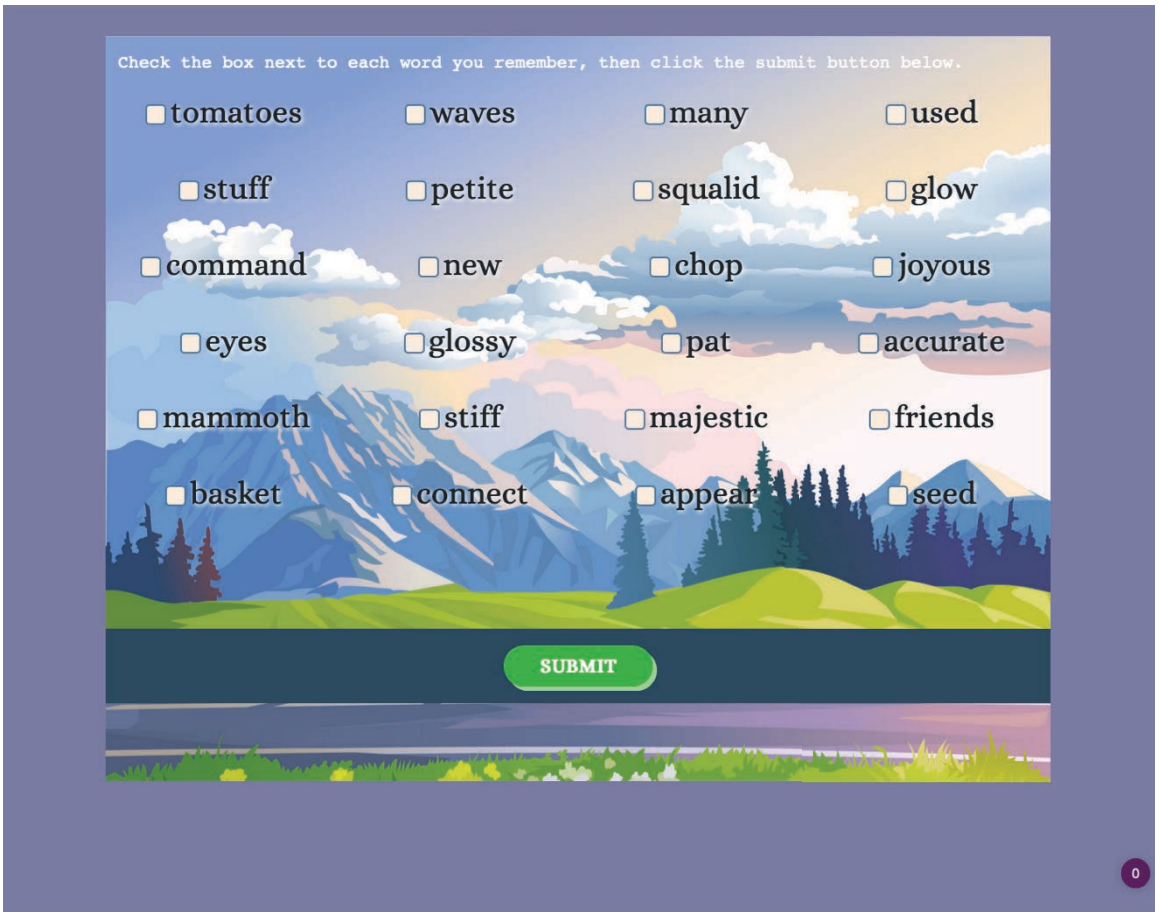


Messaging on the home page of the test website:

> Hello!
>
> Thanks for visiting my test site. This test should be completed on a desktop or laptop computer, not a mobile device.
>
> On the next screen, you will be presented with 15 random words. Your task is to study the word list for 30 seconds. When 30 seconds is up, the page will automatically refresh and you will be shown a quiz in which you will mark all of the words that you recognize from the word list, and then click the "Submit" button.
>
> Don't think too hard about this, it is expected that you will not remember all of the words, and all of the words may not appear in the test. :)
> Please do not take a screenshot, view the source, or do anything that would give you an unfair advantage.
>
> Please only take the test once.
>
> When you are ready, click "NEXT", below.

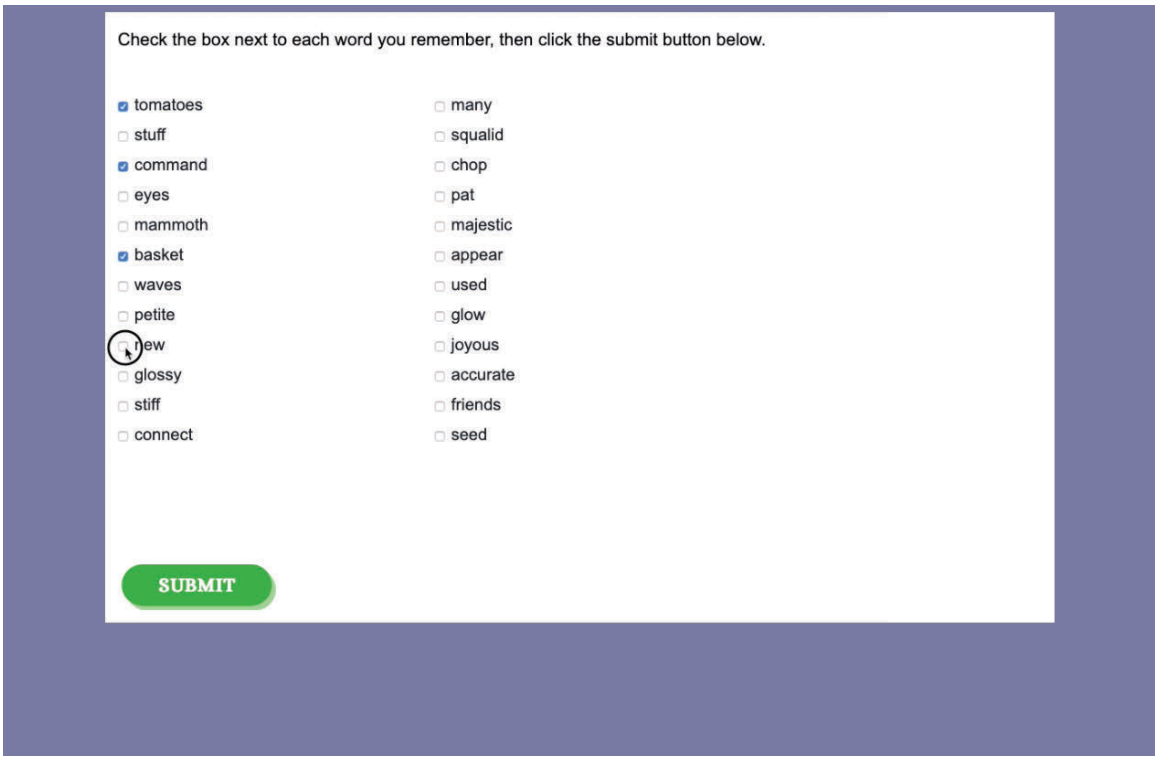
After clicking “NEXT”, the subject is taken to the following screen:

This “learning page” appears for 30 seconds, during which subjects may study the list. When the time is up, Group A sees the following quiz:



In both quizzes, respondents mark checkboxes next to the words they recognize from the learning page. Additional words appear on the quiz page, for a total of 24 words. The words, and their order, is the same on both quiz views.

This is the quiz that Group B is shown:

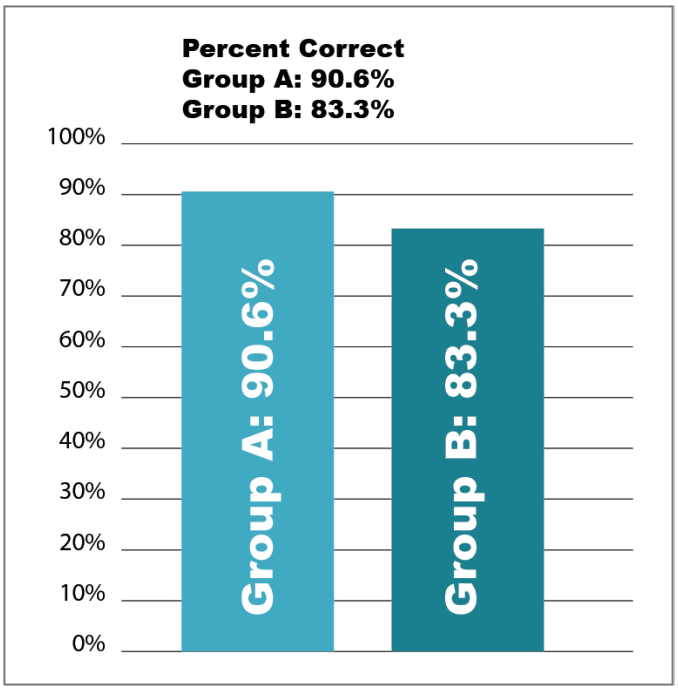


I recruited participants from a community of graphic design students at Minneapolis College. They were the most available participants to me, and likely to be interested in the subject matter and volunteering for such a study. Participants were not screened, except for confirming that they were native or proficient English speakers.

The random assignation resulted in 4 subjects being assigned to Group A, and 7 to Group B.

Findings and Discussion

The results were close. Group A scored an average of 90.6 percent correct, and Group B had an average score of 83.3%.



While these results do support the hypothesis that visual cues helped to increase recall with in Group A, the effect found by this experiment is not large. Further study, with a larger number of respondents may be needed to determine if the effect is real.

Limitations

Limitations include the small number of respondents, and the fact that the groups were not balanced in number (4 in one group, 7 in the other). Ideally a much larger, equally-divided group should be studied.

With this small sample, individual differences in natural ability and memory techniques could have skewed the results. In fact, one of my subjects wanted to know how they did on the test. Because I could identify the timestamp, and was curious, I looked it up and found that she was in Group A, and had gotten a perfect score (24 words correctly identified as previously-seen or not-previously-seen). I asked her what she did to remember the words, and she described making up a sentence that used all 15 of the target words. (This is an example of elaboration or connecting pieces of knowledge to improve recall – a trick that only some students are familiar with.)

Conclusion

I think that further research into this phenomenon is warranted. My research is unusual in that it isolates the design of the screen as the differentiating variable. This research has relevance to online teaching, where we may enhance recall on tests by manipulating the test environment, but also sheds light on how a well-designed message may be more memorable than one that is plain or nondescript. Other applications include online reading, instructional or help text and information browsing. As communicators we wish to have our messages remembered. I hope to show that interesting visual context can boost recall.

APPENDIX A: SOURCES CITED

Search keywords/phrases: *Cue-dependent forgetting, word list recall, cue-dependent forgetting in e-learning, context dependent memory*

Sources Searched: Google Scholar, Academic Search Premier (via Minneapolis College Library)

Works Cited:

Cao, Y. Cueing Strategies and Instructional Message Design. *2005 Annual Proceedings-Orlando: Volume# 2*, 131.

Hofmeister, P., Shravan, V. (2014). Distinctiveness and encoding effects in online sentence comprehension. *Frontiers in Psychology*, 5, 1237. https://www.frontiersin.org/article/10.3389/fpsyg.2014.01237

Jo, J., Yu, W., Koh, K. H., & Lim, H. (2018). Development of a Game-Based Learning Judgment System for Online Education Environments Based on Video Lecture: Minimum Learning Judgment System. *Journal of Educational Computing Research,* 56(6), 802–825. https://doi.org/10.1177/0735633117734122

Khosravizadeh, P., & Gerami, S. (2011). Word-list Recall in Youngsters and Older Adults. *BRAIN: Broad Research in Artificial Intelligence & Neuroscience*, 2(1), 5–10.

Markopoulos, G., Rutherford, A., Cairns, C., & Green, J. (2010). Encoding instructions and stimulus presentation in local environmental context-dependent memory studies. *Memory*, 18(6), 610–624. https://doi-org.mctproxy.mnpals.net/10.1080/09658211.2010.497764

Saint-Aubin, J., & LeBlanc, J. (2005). Word Frequency Effects in Immediate Serial Recall of Pure and Mixed Lists: Tests of the Associative Link Hypothesis. *Canadian Journal of Experimental Psychology*, 59(4), 219–227. https://doi-org.mctproxy.mnpals.net/10.1037/h0087477

Sehulster, J. R., & Crouse, J. H. (1972). Storage and Retrieval of Prose Material. *Psychological Reports*, 30(2), 435–439. https://doi.org/10.2466/pr0.1972.30.2.435

Storm, B. C., & Koppel, R. H. (2012). Testing the Cue Dependence of Problem-Solving-Induced Forgetting. *Journal of Problem Solving*, 4(2), 50–65. https://doi-org.mctproxy.mnpals.net/10.7771/1932-6246.1125

Tulving, E. (1974). Cue-Dependent Forgetting: When we forget something we once knew, it does not necessarily mean that the memory trace has been lost; it may only be inaccessible. *American Scientist*, 62(1), 74-82. Retrieved April 22, 2020, from www.jstor.org/stable/27844717

APPENDIX B: RESEARCH PROTOCOL

Kjrsten Holt
WRIT 677-50 User Research
Research Protocol

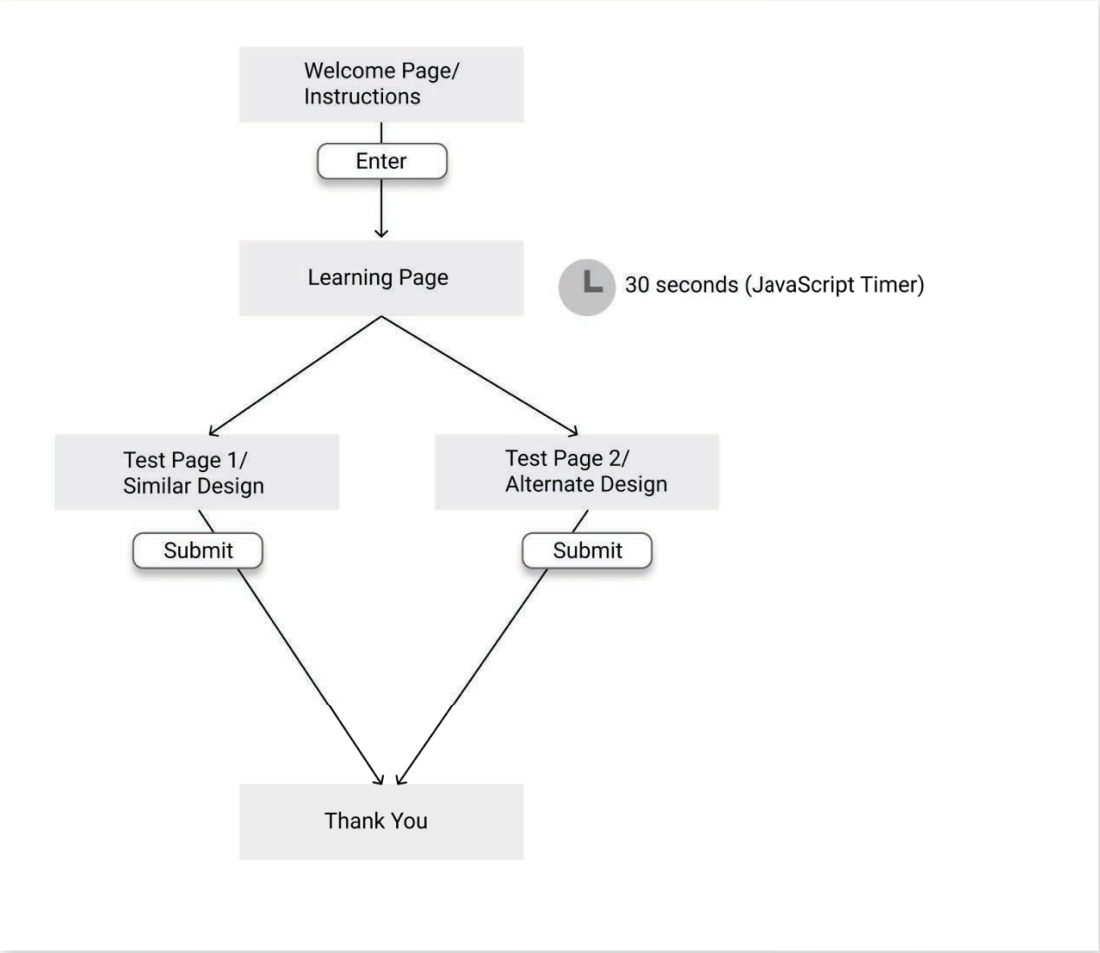
Cue-dependent forgetting: Does a distinctive visual layout enhance word-recall in an online learning setting?

Summary
This project will explore the topic of *Cue-Dependent Forgetting*, a cognitive phenomenon in which the ability to recall information is impaired when certain cues are absent. Research has shown that environmental, semantic or other setting-based cues can help people retrieve memories. The goal of my research is to test whether online learners recall more information (by remembering a list of words) when tested within an online visual environment that is similar to the environment in which they first learn the information, and recall fewer words when the test environment looks different. My hypothesis is that learners will recall more of the words when the test environment is similar to the original presentation of the list.

Study Design and Methods

1. Research Hypothesis: Online learners will recall more words from a previously learned list if the test environment looks and feels like the original learning source.

2. Study Design: The study will use quantitative analysis of test scores for a remote, online experiment consisting of a short e-learning module with a self-test at the conclusion. Fifteen words will be presented on a website within a distinctive visual design, for a 30-second period. After viewing, a testing screen (part of the same website) will be offered in which participants use a web form to mark checkboxes next to the words they recognize from the previous screen. The design of the testing screen will be the independent variable: one will be similar to the learning environment, and one will be different. After completing the test, subjects will click a “submit” button to submit their answers.



3. Study Population: 10 graphic design student volunteers will visit the website, do the learning activity, and complete the test screen. (Graphic design students were selected because they are available to the researcher, and they are the target population for e-learning developed by the researcher.) Since the information to be learned consists of English words, non-native English speakers will be excluded.

4. Methods and Procedures for Data Collection: Half of the participants will see a version of the module in which the designs match; the other half will see a version in which the test page looks very different. Upon completing the test at the end of the module, the number of correct/incorrect answers will be captured and automatically emailed to the researcher. Participant results will be anonymous, but the data will indicate which test screen was used.

Analysis

The average number of correct answers for subjects completing each condition (visually similar test screen versus visually different test screen) will be compared.

Anticipated Problems
This test possible to cheat; subjects must be trusted to submit honest results. Detailed instructions to the subject will explain that wrong or incomplete answers are expected.

The small sample size may allow individual differences in word-recall ability to overshadow differences caused by the design variation. This could be mitigated by running the experiment a second time with a larger number of subjects.

Confidentiality
Research subjects' test results will be kept private, but overall/average results from the study will be provided to subjects if there is interest.

APPENDIX C: DATA

(following pages)

a1 on	a1 on	a1 on	a1 on	**a1 on**			
a2	a2	a2	a2	**a2**			
a3 on	a3 on	a3 on	a3 on	**a3 on**			
a4	a4	a4	a4	**a4**			
a5	a5	a5	a5	**a5**			
a6 on	a6	a6 on	a6 on	**a6 on**			
a7	a7	a7	a7 on	**a7**			
a8 on	a8 on	a8 on	a8 on	**a8 on**			
a9 on	a9	a9 on	a9 on	**a9 on**			
a10	a10	a10	a10	**a10**			
a11	a11	a11	a11	**a11**			
a12 on	a12 on	a12 on	a12	**a12 on**			
a13 on	a13	a13	a13	**a13 on**			
a14	a14	a14	a14	**a14**			
a15	a15	a15	a15	**a15**			
a16 on	a16 on	a16 on	a16 on	**a16 on**			
a17 on	a17 on	a17 on	a17 on	**a17 on**			
a18	a18	a18	a18	**a18**			
a19 on	a19 on	a19 on	a19 on	**a19 on**			
a20	a20	a20	a20	**a20**			
a21	a21	a21	a21	**a21**			
a22 on	a22	a22 on	a22 on	**a22 on**			
a23 on	a23 on	a23	a23 on	**a23 on**			
a24	a24	a24	a24	**a24**			

Column A: 24/24
Column B: 20/24
Column C: 22/24
Column D: 21/24

21.75/24
90.6% Correct

a1 on	a1 on	a1 on	a1 on	a1 on	a1 on	a1 on	**a1 on**
a2	a2	a2	a2	a2	a2	a2	**a2**
a3 on	a3 on	a3 on	a3 on	a3	a3	a3 on	**a3 on**
a4	a4	a4	a4	a4	a4	a4	**a4**
a5	a5	a5	a5	a5	a5 on	a5	**a5**
a6 on	a6 on	a6 on	a6 on	a6 on	a6 on	a6 on	**a6 on**
a7	a7 on	a7	a7	a7	a7 on	a7	**a7**
a8 on	a8 on	a8 on	a8 on	a8 on	a8	a8 on	**a8 on**
a9 on	a9 on	a9	a9 on	a9	a9	a9 on	**a9 on**
a10	a10	a10	a10	a10	a10	a10	**a10**
a11	a11	a11	a11	a11	a11	a11	**a11**
a12 on	a12	a12 on	a12 on	a12 on	a12	a12 on	**a12 on**
a13 on	a13	a13	a13 on	a13	a13 on	a13 on	**a13 on**
a14	a14	a14	a14	a14	a14	a14	**a14**
a15	a15	a15	a15	a15	a15	a15	**a15**
a16	a16	a16	a16 on	a16 on	a16 on	a16 on	**a16 on**
a17 on	a17 on	a17 on	a17 on	a17 on	a17 on	a17 on	**a17 on**
a18	a18	a18	a18	a18	a18	a18 on	**a18**
a19	a19 on	a19	a19 on	a19 on	a19 on	a19	**a19 on**
a20	a20 on	a20 on	a20	a20	a20	a20	**a20**
a21	a21	a21	a21	a21	a21	a21	**a21**

Column A: 20/24
Column B: 18/24
Column C: 19/24
Column D: 23/24
Column E: 20/24
Column F: 16/24
Column G: 22/24

20/24
83.3% Correct

a22	a22	a22 on	a22 on	a22	a22	a22 on	**a22 on**				
a23	a23 on	a23 on	a23	a23 on	a23	a23	**a23 on**				
a24	a24	a24	a24	a24	a24	a24	**a24**				