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Googling to Forget: The Cognitive Processing of Internet Search

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GOOGLING TO FORGET: THE COGNITIVE PROCESSING OF INTERNET

SEARCH

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Abstract

Technology is currently extremely integrated with everyday life. Popular media has made bold claims that the internet is making us "dumber" and people struggle to remember information more now than they ever have in the past. Scientific research on the effect of internet search on cognition and memory is still in its infancy. This research will analyze the literature and theories discussing memory and the internet. Based on an original experiment by Sparrow, Liu, and Wegner. 20 participants (10 young adults and 10 older adults) performed a typing task with twenty trivia statements, followed by a recall and recognition memory test to look for the effects of directed forgetting and transactive memory. This experiment did not replicate the effect found in the original experiment. It calls to question if the effect of transactive memory is applicable to social relationships that only include a person and a computer.

Over 50 years ago, author Bernard Wolfe took note of the effect of technology on human cognition, writing, "the human skin is an artificial boundary: the world wanders into it, and the self wanders out of it, traffic is two-way and constant" (1952). Even 50 years ago, there was a question between the relationship between human mind and computer. Today the technology and internet are fully integrated with daily life. From smart phones to computers to tablets, we are almost constantly connected to the Web. It is becoming an accepted part of dinner routine for someone to take out a smartphone or tablet to win a debate (Miller, 2012). Tech start-up worker Phil Maslow summarizes his love of having Google at his fingertips, saying, "It's a substitute for a good memory. I get to skip a lot of anguish" (Miller, 2012). While the benefits of this constant connection are clear, as we have easy access to a wealth of information, what effect does a constant connection have on cognition?

There is public concern that a constant connection to the internet is making us "dumber." In Nicholas Carr's widely debated article, he quotes playwright Richard Foremand calling today's generation "pancake people – spread wide and thin as we connect with that vast network of information accessibly the mere touch of a button" (Carr, 2008). Carr posits the overreliance on the computer mediates our understanding of the world and leads to reduced concentration and contemplation, because we are constantly switching from tab to tab of information. David et al.'s (2008) study on the Google generation's (born after 1993) internet habits found "skimming" to the extreme. 60% of e-journal users viewed a maximum of three pages of an article, with 65% of readers never returning to finish the articles. Average viewers typically only spent four minutes on e-books and eight minutes on e-journal sites. While these habits are

undeniably different then the information search of the past, it does not actually answer the question of if there is a change in cognition.

Before the days of Yahoo and Google search, looking for information was more effortful. It involved effort to finely craft a specific question, and knowledge about what type of source to use. It frequently involved travel to a library. After putting in all of the effort to find a given fact, people were careful to record it either on paper, computer, or memory, knowing how taxing it would be to find that information again. Today, finding information is a completely different story. You walk ten steps to the nearest electronic device and google your question. An answer to your question will appear in a matter of seconds, and from a wealth of sources. There is debate among psychologists and cognitive scientists if this ease in finding information impacts how and what information we store in the brain.

Though this area of research is new because internet search is a new phenomenon, there are already several hypotheses about how internet search affects memory. Social psychologists have named the effect of internet on memory (and what we choose to remember) a type of transactive memory. Transactive memory is a system of group cognition and memory in which one remembers who knows pertinent information instead of remembering the information itself. It was originally thought that transactive memory had to be between a network of humans, but it is possible this network has expanded to include machine (Wegner, 1986; Sparrow, Liu, & Wegner, 2011). According to cognitive scientist Andy Clark, "It just doesn't matter whether the data are stored somewhere inside the biological organism or stored in the external world…what matters

is how information is poised for retrieval and for immediate use as and when required"
(2003).

Another hypothesis of why people remember information they searched on the
internet differently is directed forgetting. Given the wealth of information available to
remember, intentional or directed forgetting can be used to help lighten the load of
information that needs to be stored. (Bjork 1972).

Sparrow, Liu, and Wegner(2011a): Research on how the internet affects memory

Given the internet's newness, researching the effects of the internet on cognition
is still in its infancy. Sparrow, Liu, and Wegner's paper (2011a) is one of the first major
papers to investigate this topic. In four basic experiments, Sparrow et al. tested how the
internet is changing the way we remember basic information. This paper is the basis of
my research and experiment.

In the first experiment, trivia questions of varying difficulty were presented and
participants responded "yes" or "no" to the question. A block of trivia questions was
followed by a modified Stroop task with basewords that were computer words (e.g.,
"internet", "Yahoo", or "Google.") and noncomputer words that were brands (e.g.,
"Target" or "Nike."). Computer words produced longer RT (reaction time) than
noncomputer words after participants were presented with a series of questions they
could not answer by the experimenter. Names for internet search engines were more
accessible after unanswerable trivia questions, which caused an interference
effect(participants were only to name the font's color). In general, computer terms
showed more interference with color naming even when easy trivia questions were
presented. This pattern of results were interpreted as showing that when participants

encounter difficult trivia questions that they do not know the answer to, they are primed

to think of computers related words. This priming makes the computer words more

difficult to ignore and thus more interfering with color naming.

In the second experiment, participants were tested to see if they remembered

information that they thought they would have access to later, mimicking information one

might typically look up online. Participants read 40 memorable trivia statements meant to

imitate a typical, random Google search. A sample trivia statement is: "The Atlantic

Ocean is saltier than the Pacific Ocean" (Sparrow et al., 2011b). Participants were then

asked to type the statements on a computer and were told either their answer would be

saved/accessible later or the answer would be deleted after they finished typing. Half of

the participants in each condition were explicitly told to try to remember the trivia

statements. Afterwards, the participants were given paper and asked to freely recall as

many trivia statements as possible. They then were given a recognition test in which the

40 trivia statements were presented again to participants in which 20 of the statements

were identical to their first presentation and 20 had been slightly altered (a name or a date

changed). Participants made judgments on each statement as either "exactly as previously

presented" or "altered."

Overall, the participants had poor recall of the trivia statements. Those who

believed the computer had erased their statements had the best recall. There was not a

main effect of the instruction to explicitly remember/not remember. Sparrow et al. point

out the similarity of this finding to research on intentional vs. incidental studying of

material (there is generally no effect of explicit instruction).

In the recognition test results, memory instructions interacted with the save/erase beliefs. The explicit memory instruction had an interaction effect, with the erase remember condition having the best memory. The explicit instruction improved memory only for those who did not expect to have access to the information later though not significantly. Those who were explicitly told to remember, and thought they had saved the trivia statements while typing and would have access to them later, had the worst recognition scores. The results of the recognition test are shown in table 2.

Table 2. Recognition of trivia statements with a saved/erased manipulation.

	Mean
Erase	0.81
Erase Remember	0.87
Saved	0.83
Saved Remember	0.78

In the third experiment, Sparrow et al. examined memory and where to find information. The participants were presented 30 trivia statements and typed the statements into Medialab on a computer. For one third of the statements, after typing, participants were presented with the statement "Your entry has been erased." In the second third they saw "Your entry has been saved." In the final third, participants were shown the message "Your entry has been saved into the folder X." Folder "X" was one of six folders: FACTS, DATA, INFO, NAMES, ITEMS, or POINTS, which were randomly generated. Participants were led to believe that they would have access to "saved" trivia later in the experiment. Upon completion of the typing task, participants performed a recognition test and identified if statements were identical to their previous presentation or slightly altered (by one name or date). They were then asked if the statement had been

saved or erased, and finally if the statement had been saved to a folder. If the statement

had been saved to a folder, the participant chose which folder it had been saved in (they

had to choose from the six options). Participants had the best memory for statements they

believed had been erased (M = 0.93), and the worst memory for statements that they

believed had been saved in specific folders (M= 0.85).

Interestingly, when the questions was changed from "Was this statement exactly

what you read?" to "Was this statement saved or erased?" the opposite pattern was found.

The results for the latter question showed significantly better memory for saved

information, in a specific folder (M = 0.66, SD = 0.21) and saved in a generic folder (M

= 0.61, SD = 0.21), and worst memory for erased statements (M = 0.51, SD = 0.19),

pairwise comparison with both saved conditions p<0.04. Sparrow et al. interpreted these

findings as belief that one will not have further access to information increases memory,

whereas believing the information was saved externally enhances memory for the fact

that the information could be accessed. In other words the first question asked how well

participants remembered the statement itself, whereas the second question focused on

where externally the information had been saved.

In experiment 4 Sparrow et al. investigated whether participants recalled actual

information, or where to find that information. Undergraduate students read and typed

thirty trivia statements into Medialab. During the trivia portion of the experiment, after

typing a statement participants were shown "Your entry has been saved into the folder X"

(Folder "X" was again one of six folders: FACTS, DATA, INFO, NAMES, ITEMS, or

POINTS). Participants were led to believe they would have access to saved information,

based on a practice session. There were two memory tests: a free recall for the trivia

statements and a cued recall task to remember in which folder the trivia facts were saved.

For example, for the trivia fact "An ostrich's eye is bigger than its brain" the DirectRT

question would be "what folder was the statement about the ostrich saved?" Participants

had to type the folder name into a dialog box. They were not reminded of the six folder

names.

Participants showed better memory for which folder ("where") the statements

were kept (M = 0.49, SD = 0.26) than they recalled the actual statements (M = 0.23, SD =

0.14). Sparrow et al. thought these findings were surprising, as the trivia statements were

so memorable and the folder names so generic. A potential problem in design is the cue

given about the question for folder recall, and the lack of cue in the trivia recall portion. It

is also important to note these memory tasks were not of equivalent difficulty. For the

folder "where" judgment, there were only six possibilities to remember. For the free

recall of statements, there were 30 statements to remember.

Sparrow, Liu, and Wegner's theory of transactive memory

Sparrow et al. looked at the results of their four experiments and saw these basic

overall results: (1) people look to computers when they do not know trivia information;

(2) people remembered information better if they thought they would not have access to

that information later; (3) "where" information is saved is prioritized in memory over the

information itself. Sparrow et al. thought the main effect of accessing and storing the

trivia information on computers on memory was the social psychology effect of

transactive memory. Transactive memory is a hypothesis purposed by Dr. Daniel

Wegner. He defines transactive memory as "a set of individual memory systems in

combination with the communication that takes place between individuals" (Wegner,

Giuliano, & Hertel, 1985). In short, people make an effort to remember who knows what information, instead of trying to remember the information themselves. Transactive memory occurs in long-term relationships such as marriages or work teams. For example, instead of remembering which type of ink cartridge the printer uses, you would remember that Judy knows which type.

Sparrow et al. theorize that today we look at the computer as a person in our transactive memory system. We make an effort to learn what information the computer knows so we do not have to keep track of it. They continue the theory by saying we learn "when we should attend to where we have stored information in our computer-based memories. We are becoming symbiotic with our computer tools" (Sparrow et al., 2011a). While the internet offers the advantage of access to a wealth of information, it also comes with the disadvantage of needing to be constantly "on-line" to have access to information that we perhaps would have remembered before the internet.

My concerns with Sparrow, Liu, and Wegner's methods

While reading over the methodology and design of Sparrow et al.'s four experiments, there were several major concerns I found with the experimental design. In the second, third, and fourth experiment participants typed trivia statements into a computer with a variety of different save/erase conditions. The amount of time a participant took to read and type this information was not controlled or recorded. If a subject believed there would be a memory test later in the experiment (as Sparrow et al. admitted participants may have caught on to), the amount of time someone spent reading and processing the trivia statements is extremely relevant to how well they recall the statement in the memory portion of the experiment.

In the third and fourth experiment Sparrow et al. wanted to compare one's ability to remember a trivia statement to one's ability to remember where that information is stored. To do so the team created six generic folder names that thirty sentence-long trivia statements could potentially be placed in. The cognitive load of remembering a one-word folder name (when there were only six ever presented) versus a complex trivia statement (thirty presented) are vastly different and make a comparison difficult. Also, I do not think is reflective of most people's experience on the internet. When looking up trivia statements, the website (analogous to a folder) and the statement itself are usually in a 1:1 ratio.

Also in experiment four, during the recall portion of experiment, there was a comparison between cued and uncued questions, which makes results difficult to interpret. When asked to recall the folder names, participants were asked about a trivia question, which is a cue. For example a participant would answer: "what folder was the statement about the ostrich saved?" While recalling the trivia statements themselves, participants were given ten minutes and a blank sheet of paper. It is poor methodology to compare recall scores in which there was a cue in one test and not in the other. Also, there were only six folder names and thirty statements, once again making it difficult to compare the recall scores.

These flaws in experimental design made the results of the experiments difficult to understand. Additionally, the experimental design was not sensitive to how cognitive processing works (cues make statements easier to remember, limited categories make statements easier to remember), which is crucial in when comparing how material is encoded in long-term memory. The only theory used was transactive memory, instead of

incorporating known cognitive processing phenomena into their design and explanation of results.

My concerns with Sparrow, Liu, and Wegner's theory

I have some disagreements with Sparrow et al.'s theory of transactive memory as the hypothesis behind the internet's effect on memory. While I agree with the basic conclusion that we do not make the effort to encode most information from the internet in memory, I think transactive memory is a term that oversimplifies the complex cognitive decisions that go on during the encoding process. Transactive memory was proposed by Wegner (1987) as a type of "group memory" in which a tightknit group such as a husband and wife make the effort to remember what their partner knows instead of remembering the actual information. Sparrow, Liu, and Wegner suggest that the user and the computer are one of these tightknit groups, so the user only remembers what the computer "knows" and not the facts.

While this is a fine theory that is well documented in various groups such as husbands and wives or office teams (Wegner 1987; Wegner 1995), it is more of a social psychological label for a phenomenon, and does not explain cognitive processing that underlie the beneficial effects. Transactive memory was used to explain changes in cognition, which I think is a fine application of the label, but is overextending the label when using it as a main explanation or to make predictions. To truly understand the cognitive effects of internet search on one's memory, I think well documented cognitive processes, such as levels of processing should be applied to internet search.

Levels of Processing

Craik and Lockhart (1972) proposed that when an item is processed it can be processed at a superficial/shallow level, or it can proceed to deeper levels of processing. A thought that has been processed on a deeper level has strong retrieval memory traces that are durable in the mind and will be easier for someone to remember. A thought processed at a shallow level has weak traces that are difficult to retrieve, and that thought will be difficult to recall.

Craik and Tulving (1975) performed an elegant experiment testing the levels of processing on memory. The subject preformed one of three tasks: a judgment of whether the presented word was in uppercase or lowercase letters (shallow task), a rhyming judgment (for example: "Does the following word rhyme with bait?" – "Fate (intermediate processing) and whether the word fit into a sentence (deep processing). For example, if presented with the word "park", the subject would decide yes or no if the word fit into the sentence "Yesterday I took my dog for a walk in the…" Shallow processing) produced the poorest word recognition on a subsequent unexpected memory test, intermediate processing produced better word recognition than shallow processing and deep processing produced the best word recognition. If a subject partook in a deeper level of processing when asked questions at encoding, they performed better at recall, showing more effective memory.

In this task it is important to note there was better recall for words that were in questions that prompted a "yes" response (words that did fit into the sentence) than questions that evoked a "no" response. Craik and Tulving theorized there was better memory when there was compatibility between the question and the answer. In questions

where the answer was "yes" the question became an additional cue to the answer trying

to be remembered. For example, if a participant had been presented the word "log" and

then later asked "does it rhyme with dog?" the word dog may sound familiar, which

primes the word "log", prompting a "yes" response.

This is an example of how semantic richness can affect the level of processing. It

is relevant to this experiment because it shows the importance of factors that are easily

overlooked such as how is the question asked, and is there an effect of a yes/no answer.

Though there is debate over levels of processing's completeness as a theory, it does

capture differences in memory dependent on behavior at encoding, which is what I

propose is actually happening when cognitively processing an internet search. Sparrow,

Liu, and Wegner designed some questions that gave additional semantic information in

some recall questioning, which can skew a memory effect, and gave no additional

semantic information in other recall questions. When studying memory and internet

search, it is important to be extremely careful in how the memory questions are asked to

get results reflective of a participant's true memory. Directed forgetting was used in

Sparrow, Liu, and Wegner's explanation of the second experiment.

Directed Forgetting

The psychological label of directed forgetting is used to help explain the results of

the second experiment. Directed forgetting is a paradigm in which subjects are instructed

to forget/remember particular items from a list they are presented. (Gargano 1990).

Subjects are then given recall tasks, and their performance on words they were directed to

forget are compared to words they were directed to remember. There is debate in the

psychological community if the effects of directed forgetting are seen at the encoding

level or at the retrieval level (MacLeod 1989).

The dominant theory of directed forgetting is that "forgetting" happens when a

participant has impaired recall for the item they were directed to forget, also called the

retrieval inhibition hypothesis. (Bjork 1989). If subjects are given two lists, they are

given list one to study and then get a break. During this break, the subjects in the

"remember" condition are explicitly told to try and remember list one. In the "forget"

condition, they are explicitly told to forget list one. All subjects then study a second list,

and everyone is explicitly instructed to remember list two. In this theory the "forget"

instruction starts a process that suppresses/blocks retrieval the access to list one items,

which is the cost of directed forgetting.

In Sparrow, Liu, and Wegner's experiment, they thought their effect of worse

saved memory (in which participants believed they would see a folder of saved

information before their memory test) was similar to work in directed forgetting, in which

people recall information at worse rates if they believe they will not need it later (Bjork,

1972).

A newer analysis of directed forgetting, researched by Sahakyan and Delaney,

looks at the importance of contextual change (Sahakyan,& Delaney 2002). They

proposed that the benefits and costs of directed forgetting come from a change in internal

context that occurs during the break between the two lists in response to the "forget"

instruction. They proposed that directed forgetting would also be seen if another large

change of context occurred between lists, such as if the "forget" group was led to think of

something other than the experiment. Directed forgetting is often shown with neutral

stimuli, and it is important to note when the stimuli is emotional.

Aging and Memory

As adults age, there is some decline in their memory for new information. (Hasher

& Zacks, 1988; Zacks, Radvansky, & Hasher, 1996). Many psychologists and scientists

have researched cognitive aging in broader capacities, though few have studied the

interaction between an aging memory and the internet. Though there is little direct

research, a lot of research on the aging memory is applicable to this particular topic.

Memory is unique from other cognitive factors in aging, as some aspects of memory are

affected by age while others remain at the same level from young adulthood (Schaie &

Willis, 1991). This research will focus on semantic memory, explicit memory, and long-

term memory.

Semantic memory is memory for information one acquires about the world, or

"general knowledge." Semantic information includes names, birthdays, trivia facts, and

history lessons. Chiarello defined semantic memory as "when we think about the

meanings of concepts without reference to when or how we acquired such knowledge"

(Chirello 1994). Semantic memory is a type of declarative memory, which is a broader

umbrella-term for consciously recalled memory of facts and knowledge (Ullman, 2004).

Numerous researchers have shown an age-related decline of semantic memory (Craik,

1994). An example of age-related decline of semantic memory would be older adults

struggling to remember names more than younger adults.

Long-term memory is defined differently than many people think. If a piece of

information is being stored in memory for longer than 60 seconds, it is considered long-

term memory. Long-term memory focuses on the remembrance of events that have left

consciousness (Tulving, E., & Lepage, M. 2000). Long-term memory is another area of

memory that shows age-related decline. A lot of research has been done on long-term

memory, and there are several frequently used ways of testing it, including: free recall,

cued recall, and recognition tests.

Free recall tasks include presented semantic information to adults (often a list of

words), and then a recall test in which an adult is asked to recall as many pieces of

information as possible. Cued recall tasks are a presentation of semantic information,

usually in pairings. For example, a cued recall task might have a list with paired words

(fruit-apple, animal-dog, etc.). When asked to recall the information previously

presented, a subject would be given one of the paired words in order to "cue" the other

word (you are presented the word "fruit" to help you recall "apple"). A recognition task

is when information is presented for example, a list of words, and during the "test"

portion, a subject is presented with a second list of words. The subject must choose which

words were previously presented on the second list of words. While all of these tasks

access long-term memory, some are more sensitive than others to the effects of aging.

Free recall is a memory test sensitive to aging, in which older adults perform

significantly worse than younger adults (Burke & Light, 1981). This is possibly from

changes in memory organization, or a search deficit when searching through their

memories. Recognition tasks vary, but recognition tasks that focus on familiarity instead

of recollection do not show age related differences (Bastin & Van der Linden, 2003).

Directed-forgetting is often studied in episodic memory of aging patients.

Participants are presented with sets of items and the items are either cued as to be

remembered (TBR) or to be forgotten (TBF). In an unexpected memory test, memory for

TBF items is normally worse than TBR items (Johnson, 1994; MacLeod 1998). Older

adults struggle more than younger adults at inhibiting TBF items (Hasher & Zacks 1988).

When a cue to forget/remember is given on an item by item basis, it is called item-

method. When item-method directed forgetting is tested, it is purposed that TBR and

TBF items are encoded differently (Titz & Verhaeghen, 2010). In the saved/erased

condition (which are essentially item-method directed forgetting), encoding happens

differently which is the effect seen in Sparrow, Liu, and Wegner's experiment. Their

findings match the typical result of TBR ("erased") statements are remembered better

than TBF ("saved").

Understanding what types of memory are being tested and how they are being

tested is crucial to making a study about how internet search effects memory, especially

when comparing young and aging adults.

Present Study

I have modified Sparrow, Liu, and Wegner's original experiments. I think their

experiments were a good start to addressing the issues of internet and memory, but I have

problems with both their methodology and explanation of their results.

I have redesigned Sparrow, Liu, and Wegner's experiments 2 and 3, which look at

the saved/erased conditions' effect on memory in recognition (Experiment 2) and recall

(Experiment 3). They tested recognition and recall separately, but I will only have one set

of stimuli and perform both memory tests on that set (one experiment). In Experiment 2,

they tested for an effect of explicitly telling participants there would be a memory test

versus a surprise memory test, and found the effect of explicit instruction was not significant. In my experiment I will explicitly instruct all participants to remember the statements. Experiment 2 had a between subject design, and Experiment 3 within subject. My experiment will only be a within-subject design, as I believe the effect of the saved/erased condition is most interesting within-subject.

Additionally, I will reduce the quantity of stimuli. In Experiment 2, participants typed 40 trivia statements and in Experiment 3 they typed 30 statements (both from the same set of stimuli). I will reduce the total number of statements to 20. I am making this reduction because of the main change to the experimental design: I will be adding the component of older participants.

Sparrow, Liu, and Wegner posit that the difference in saved and erased recall can be attributed to directing forgetting and transactive memory. Younger adults are better at directed forgetting than older adults, who struggle to inhibit material that was to be forgotten. Sparrow, Liu, and Wegner only tested younger adults, and saw the saved/erased "directed forgetting" effect. By adding older adults, I can better examine their explanation of the directing forgetting result, as the younger/older effect will either strengthen or weaken their explanation.

Sparrow, Liu, and Wegner's main explanation of the saved/erased effect was transactive memory and social-information sharing. If this effect is truly occurring, I predict there will be a marked difference between younger and older adults. Transactive memory relies on a close bond between a social group (in this case a user and their computer/the internet) (Wegner, Giuliano, & Hertel, 1985). Because younger adults grew up with personal computers/internet connection and are constantly connected through

laptops and smartphones, I would predict a significant difference in the effect on younger and older adults. I will add a short questionnaire to confirm that younger adults spend more time on their computer/the internet and feel more comfortable using this technology.

The other major addition to the experiment is the interest component. I expect whether a participant is interested in a statement/not is influential on their memory for the statement later. One of my concerns with Sparrow, Liu, and Wegner's experiment is that participants made no effort to remember the trivia statements because they were not interesting. I hypothesize a correlation between a subject's interest rating in a trivia statement and their recall of it on the memory test.

I hypothesize, based on Sparrow, Liu, and Wegner's research, that there will be a directed forgetting effect in younger adults (replication) and not in older adults, who have well-documented struggled with directed forgetting. I hypothesize transactive memory effect in younger adults, but not in older adults, who do not have the type of relationship with technology needed to see a transactive memory effect. I hypothesize that the effect of interest on memory is more important than the transactive memory effect (regardless of age), and there will be a correlation between interest and recall.

Methods

Participants: The participants for young adults included ten undergraduate students at the Claremont Colleges. There were 7 male and 3 female (average age 20.6 years). The mean Nelson-Denny vocabulary score (maximum score = 25) was 17.7. Data from the questionnaire showed they spend a mean of 25 hours per week on the Internet. When

asked about their comfort with daily computer use, the mean score was between "very

comfortable" and "extremely comfortable." The experiment was within subject.

Participants received a small gift (candy) for participation.

The participants for older adults included ten citizens from the town of Claremont and the

surrounding area. They were recruited from the Claremont Colleges Project on Memory

and Aging database. There were 4 male and 6 female (average age 69 years). Their mean

Nelson-Denny vocabulary score (maximum score = 25) was 21.2. Data from the

questionnaire showed they spend a mean of 11.5 hours per week on the internet. When

asked about their comfort with daily computer use, the mean score was between

"comfortable" and "very comfortable." They received a small honorarium for their

participation in the study. OA participants were screened for general mental faculties

using the MMSE (Mini Mental Status Exam. A score of 28 out of 30 was the cut-off to

participate in the experiment, and all ten participants achieved this score or higher.

Materials: All participants completed a questionnaire prior to the experiment. The

questionnaire asked for an estimate of hours one spends on the internet per week and

comfort level with daily computer use. It can be found in Appendix A. They also

completed a Nelson-Denny vocabulary (see Appendix B). The Nelson-Denny vocabulary

test to measure their vocabulary/reading level, to ensure all participants had a high level

of vocabulary. Older adults completed the MMSE(Mini Mental Status Exam) to test

general mental faculties (see Appendix C). The testing material was taken directly from

Sparrow, Liu, and Wegner's original experiment (Appendix D).

Design and Procedure: One experimenter tested all participants were tested individually

in one of two testing rooms, each of which had comfortable seating. They completed

questionnaires, Nelson-Denny vocabulary tests, and the MMSE if applicable. The

participants were given instructions on a computer screen to create two within subject

conditions (saved and erased). They were instructed there would be a typing task and a

memory test and to do their best to remember all of the statements. They were told if a

statement was "saved" they would see it twice: once during the typing task and once

more before the memory test, and if was "erased" they could only view it during the

typing task. They were asked to type twenty trivia statements into SuperLab (see

Appendix D), which were taken from Sparrow's original experiment. The statements

appeared one at a time, and stayed on the screen for thirty seconds (regardless of quickly

you typed it below). During those thirty seconds, participants were instructed to type the

statement verbatim. The statements were all one sentence in length. After typing a

statement, participants were asked to rate their interest in the statement on a 1 (least

interested) to 5 (most interested) scale. After rating their interest, Superlab either

displayed a folder and the text "your answer was saved" or a trashcan and the text "your

answer was erased." The order of saved/erased statements was randomly generated, but

all participants had an equal number of saved and erased statements. The order of the

statements was randomly generated by Superlab.

Participants then performed a pen and paper free recall task in which they were

asked to recall as many of the twenty statements as possible. They were told to

remember partial statements if they could not remember the full statement. There was no

time limit. The free recall task was scored as 0 points for no memory of a statement, 0.5

points for partially recalling a statement, and 1.0 point for perfect recall of a statement.

The maximum possible score was 20 points.

When participants could not recall any more statements, they completed the

recognition test using Superlab. In random order, statements were presented one at a time

and remained on the screen until they made a recognition judgment. Participants saw all

twenty statements, half of which were identical to their first presentation, and half of

which had been slightly altered (name, date etc. See Appendix E). Participants judged

"same" as original presentation or "changed." Due to experimenter error, there was an

unequal categorization of statements. Though all 20 statements were presented, only 16

were used in the final scoring in order to have a fair comparison between saved and

erased hits (correctly identified statements) and false alarms (incorrectly identified

statements). There were 4 saved-same, 4 saved-changed, 4 erased-same, and 4 erased-

changed statements analyzed in the results.

Results

Recall:

The first goal of this experiment was to replicate Sparrow et al.'s previous

findings that participants are more likely to recall information they believe will be erased

than information they believe will be saved. Table 1 shows that this effect was not

replicated in either older or younger adults. Young adults recalled an average of 6 saved

statements and 5.2 erased statements. Older adults recalled an average of 3.4 saved

statements and 3.5 erased statements. A repeated-measures ANOVA comparing age

(young, old) and condition (saved, erased) revealed a main effect of age, in both the

saved and erased conditions. In the saved condition $F(1,10.8) = .004$, $p < 0.01$ and erased

condition F(1, 4.808) = .042, p < .05. There was not a significant interaction effect

between age and condition.

Age had no effect on recall accuracy of saved vs. erased statements. No

significant difference was found in recall accuracy of saved vs. erased statements in

younger adults by a paired samples t-test. The same was found to be true in older adults.

Table 1. Comparison of mean correctly recalled statements in the Saved and Erased
condition by Age

	Saved mean recall	SD	Erased mean recall	SD
Young adults (n = 10)	6.00	1.93	5.20	1.40
Old adults (n = 10)	3.40	1.58	3.50	2.01

Recognition:

The second goal of this experiment was to replicate Sparrow et al.'s findings of

the saved/erased effect on recognition. Table 2 shows the saved/erased effect was not

significant in the recognition task, using mean hits minues false alarm rates in younger or

older adults. No significant difference was found in recognition accuracy of saved vs.

erased statements in younger adults using a paired samples t-test. The same was found to

be true in older adults.

An alternate analysis using d-prime showed no significant results in the

recognition data. The result of d-prime analysis was highly suggestive of a ceiling effect,

as all participants had very large d-prime values.

Table 2. Comparison of mean false alarm subtracted from hit recognition responses of
saved and erased conditions by age.

	Saved Recognition	SD	Erased Recognition	SD
Young Adults (n = 10)	3.3	0.640	3.2	0.6
Old Adults (n = 10)	3.1	1.197	3.1	0.994

Interest:

The third goal of this experiment was to look for a correlation between a participant's interest rating in an individual statement and the likelihood of him or her recalling that statement. The average correlation coefficient for young adults was $r(18)=0.127$, $p = 0.595$, $p > 0.05$. The average correlation coefficient for older adults was $r(18) = 0.061$, $p = 0.800$, $p>0.05$, which was also not significant. There was one individual participant for whom the correlation was significant. An independent samples t-test was conducted to compare mean overall interest in the statements in younger and older adults. Younger adults had significantly lower mean interest in the statements provided (M=3.13, SD=1.22) to that of older adults (M=3.49, SD=1.47); $t(398) = 2.66$, p=0.008.

Discussion

Previous research on computers and memory focused on the concept of "transactive memory." Transactive memory is a form of social remembering, in which memories reside in a system, and the system is made up of individuals with a close social relationship. Transactive memory used to only include memories systems made solely of people, but some current memory researchers have expanded the term to include Internet-capable devices like laptops and smartphones (Sutton et al, 2010). Sparrow, Liu, and Wegner's research suggested that a close relationship with the computer (deep understanding and trust of reliability of information) accounted for younger adults trusting the Internet as a part of their memory system. I hypothesized I could replicate the

saved/erased effect in younger adults (explained by transactive memory and directed

forgetting), but not in older adults. Older adults struggled with directed forgetting and do

not have a close social connection with the internet.

   The present results did not replicate Sparrow et al.'s finding of better memory for

erased than saved info, contrary to the hypothesis. The present results showed younger

adults' memory performance for saved statements was not significantly different than

their memory for erased statements, in both recall and recognition memory tests. The

effect was also not seen in older adults on either recall or recognition memory tests as

hypothesized, due to decreased directing forgetting abilities and lack of social bond with

internet devices. The main effect of age with older adults performing worse on the recall

task was expected, as many previous studies have shown this effect (Rabinowitz, Craik,

& Ackerman, 1982). The fact that the experiment was sensitive enough to capture this

effect suggests that it should have captured other age-related memory differences.

Additional research should be done to see if the saved/erased effect is replicable in

younger adults.

   It is possible that applying the label of transactive memory to the human-

computer relationship is an overextension of the term. All previous research of

transactive memory looks at the phenomenon within human-only groups (Harris et al.,

2011). Further experiments should examine if this label is appropriate for the relationship

between person and computer/smartphone.

   The recognition task showed a ceiling effect for both older and younger adults.

This is probably due to the experimenter error in which only 16 statements were used in

the recognition analysis. Future research should use more than 16 statements when

testing for recognition memory. Sparrow, Liu, and Wegner were able to see a significant effect of saved/erased conditions using 30 statements.

I hypothesized a participant's level of interest in a given statement would be the most important factor in him/her remembering it later. This experiment did not find that effect. However, some individual participants showed the predicted correlation. When looking at a correlation between interest in a given statement and recall, one young adult had a significant correlation efficient, $r(18)= 0.471$, $p =0.036$, $p< .05$. Several other participants (both young and old) had correlation coefficients that were suggestive of a relationship between interest and recall, though not statistically significant. Given this experiment's small sample size, this effect should be examined further in other studies.

Additionally, there was a significant difference in the mean interest ratings of all statements, showing a difference in how interesting younger and older adults found the statements: younger adults were significantly less interested. The statements were general trivia, and perhaps did not do a good job mimicking the types of statements young adults would regularly google today. In order to properly study the correlation between interest and memory, it is vital to have interesting stimuli. In order to better study the effect of interest, new stimuli statements should be chosen.

At this point, the current fear/fascination with the Internet replacing our ability to remember information lacks evidence. Though, if you are unconvinced, I suggest you google it.

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Appendix A: Subject Information Questionnaire

Date: _____

Subject Number: _____

Gender: _____

Age: _____

Please estimate Hours you spend on the Internet per week:

Less than 5   5 – 10   10 – 20   20 – 30   30 – 40   40+ hours

Please rate your comfort level with daily computer use (Checking email, Google searches, etc).

| Not Comfortable | Somewhat Comfortable | Comfortable | Very Comfortable | Extremely Comfortable |

Appendix B: Nelson – Denny Vocabulary Test

Vocabulary

We are interested in your knowledge of the meanings of words. Please complete each of the following items with the alternative that best fits the sentence. For instance, consider the example below:

A linguist is trained in:

a. art   b. law   c. language   d. writing   e. history

You should have cited c above. There are 25 more items for you to work on. You may begin whenever you are ready.

Please circle the best alternative for each item.

1. Uniform objects are:
        a. similar   b. decorated   c. manufactured d. complete   e. new

2. To gain eminence means to gain:
        a. wealth   b. health   c. distinction   d. happiness   e. knowledge

3. An acrid taste is:
        a. cloying   b. milky   c. soothing   d. bitter   e. neutral

4. A casualty is an:
        a. expedition   b. accident   c. effect   d. insurance e. accusation

5. Feverish activity is:
        a. rapid   b. dangerous   c. medical   d. childish   e. useless

6. Idolatry involves:
        a. worship   b. masonry   c. laziness   d. thieving   e. preaching

7. To show clemency is to show:
        a. wisdom   b. fear   c. leniency   d. revenge   e. tolerance

8. To feign is to:
        a. fret   b. faint   c. molest   d. pretend   e. portend

9. Variegated article is:
        a. green   b. obscure   c. parti-colored   d. ill-fitting   e. dirty

10. A heinous act is:
        a. timely   b. altruistic   c. impulsive   d. sincere   e. outrageous

11. A garrulous person is:
        a. talkative   b. homely   c. sedate   d. poor   e. huge

12. A parable is a:
        a. dialogue   b. fable   c. playlet   d. doctrine   e. miracle

13. Rampant means:
        a. uncouth   b. unearthly   c. intense   d. restrained   e. riotous

14. A deplorable act is:
        a. unfortunate   b. revealing   c. fatal   d. destructive   e. insane

15. Omnipotent means:
        a. all-wise   b. forgiving   c. tolerant   d. avenging   e. all-powerful

16. Ethereal means:
        a. rugged   b. idling   c. inhospitable   d. airy   e. alternate

17. To extol is to:
        a. exalt   b. compare   c. re-tell   d. complain   e. ponder

18. A prosaic person is:
        a. witty   b. intelligent   c. dull   d. abusive   e. poetic

19. A presumptuous person is:
        a. humble   b. designing   c. audacious   d. witty   e. subtle

20. To accost means to:
        a. assist   b. defy   c. greet   d. identify   e. fine

21. Homeopathy is a branch of:
        a. domestic science   b. physics   c. geology   d. religion   e. medicine

22. A lewd person is:
        a. shallow   b. stingy   c. sanctimonious   d. depraved   e. shrewd

23. An incumbent burden is:
        a. obligatory   b. hateful   c. annoying   d. bulky   e. bearable

24. A troglodyte is a:
        a. singer   b. deposit   c. surveyor's instrument   d. cave dweller   e. bird

25. An officious person is:
        a. thoughtful   b. meddlesome   c. queer   d. faithful   e. democratic

Appendix C: MMSE

The Mini-Mental State Exam

Patient_____ Examiner _____ Date_____

Maximum	Score	
		Orientation
5	( )	What is the (year) (season) (date) (day) (month)?
5	( )	Where are we (state) (country) (town) (hospital) (floor)?
		Registration
3	( )	Name 3 objects: 1 second to say each. Then ask the patient all 3 after you have said them. Give 1 point for each correct answer. Then repeat them until he/she learns all 3. Count trials and record. Trials _____
		Attention and Calculation
5	( )	Serial 7's. 1 point for each correct answer. Stop after 5 answers. Alternatively spell "world" backward.
		Recall
3	( )	Ask for the 3 objects repeated above. Give 1 point for each correct answer.
		Language
2	( )	Name a pencil and watch.
1	( )	Repeat the following "No ifs, ands, or buts"
3	( )	Follow a 3-stage command: "Take a paper in your hand, fold it in half, and put it on the floor."
1	( )	Read and obey the following: CLOSE YOUR EYES
1	( )	Write a sentence.
1	( )	Copy the design shown.

/
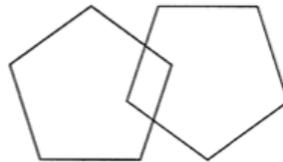
_____ Total Score
ASSESS level of consciousness along a continuum _____
Alert   Drowsy   Stupor   Coma

Appendix D: Statements Typed Into SuperLab

1. Saddam Hussein has been executed.

2. A cow produces nearly 200,000 glasses of milk in her lifetime.

3. Bluebirds cannot see the color blue.

4. Michael Jackson was acquitted of molestation charges.

5. Only two countries border three oceans, the United States & Canada.

6. Ingrown toenails are hereditary.

7. ABC news anchor Peter Jennings was a high school dropout from Canada.

8. The highest point in Pennsylvania is lower than the lowest point in Colorado.

9. Europe is the only continent without a desert.

10. A quarter has 119 grooves around the edge.

11. French Fries are originally from Belgium, not France.

12. Al Capone's business card said he was a used furniture dealer.

13. The Dominican Republic has the only national flag with a bible in it.

14. There are an average of 178 sesame seeds on a McDonald's Big Mac bun.

15. In Chinese script, there are more than 40,000 characters.

16. An ostrich's eye is bigger than its brain.

17. A person burns more calories when sleeping than when watching television.

18. The great Pyramids of Giza are the only one of the Seven Wonders of the Ancient World that still exists.

19. The longest classical composition would take 639 years to perform.

20. A person will shed over 40 pounds of skin in their lifetime.

Appendix E: Changed Statements from Recognition Task (changed statements are bolded)

1.   Michael Jackson was acquitted of molestation charges.

2.   ABC news anchor Katie Couric was a high school dropout from Canada.

3.   An ostrich's heart is bigger than its brain.

4.   The great Pyramids of Giza are the only one of the Seven Wonders of the Ancient World that still exists.

5.   Asia is the only continent without a desert.

6.   The longest classical composition would take 639 years to perform

7.   A person burns more calories when sleeping than when watching television.

8.   The highest point in Pennsylvania is lower than the lowest point in Colorado.

9.   A cow produces nearly 550 glasses of milk in her lifetime.

10.   Bluebirds cannot see the color red.

11.   A person will shed over 120 pounds of skin in their lifetime.

12.   There are an average of 178 sesame seeds on a McDonald's Big Mac bun.

13.   In Chinese script, there are more than 3,000 characters.

14.   The Dominican Republic has the only national flag with a bible on it.

15.   Only two countries border three oceans, the United States & Canada.

16.   Don Corleone's business card said he was a used furniture dealer.

17.   Osama bin Laden has been executed.

18.   Ingrown hairs are hereditary.

19.   French fries are originally from Belgium, not France.

20.   A quarter has 119 grooves around the edge.