Saving-enhanced memory in the real world

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Abstract

People frequently offload cognitive tasks onto the environment by, for example, digitally storing information they want to remember later. This frees up cognitive resources, leading to an increased ability to learn new information (the "Saving-Enhanced Memory Effect"). We tested whether this effect would generalize beyond the digital realm. On every trial, participants studied two printed lists of words before being tested on their memory for both lists. For half the trials, participants shredded the first list before attempting to learn the second one. For the remaining trials, they saved the first word list in a folder before learning the second list. Results revealed a robust Saving-Enhanced Memory Effect, as people remembered more words on average from the second list when they had saved the initial word list. These findings suggest that the effects of offloading memories onto the external world are similar for information stored in digital and physical formats.

Keywords: Saving-Enhanced Memory Effect, cognitive offloading, physical information format, extended cognition

Introduction

The philosopher Andy Clark has argued that Homo sapiens are "natural born cyborgs," able to seamlessly integrate tools and artifacts into our cognitive ecology to enhance our mental faculties (Clark, 2003). This claim goes beyond prosthetic sense organs, neural implants, and other staples of science fiction; Clark suggests that even (relatively) simple cultural technologies like writing (and other forms of symbolic representation) leverage the plasticity of the human brain to boost our cognitive powers. Consider, for example, the simple act of writing something down you wish to remember—like a grocery list, which dramatically increases your ability to successfully fill your cart. The prospect of installing a computer system in your skull to increase your memory capacity—as featured in popular Keanu Reeves films from the 1990's like *The Matrix* and *Johnny Mnemonic*—is simply an extension of this basic process.

In recent years, researchers have begun to investigate the consequences of this sort of cognitive *offloading*—a term that characterizes how people exploit features of the environment or use tools or physical actions to reduce cognitive task demands (Risko & Gilbert, 2016; Wilson, 2002). While most of the emphasis has been placed on how cognitive offloading facilitates performance (e.g., by changing the information processing requirements of the task at hand; Clark, 2003; 2008; Clark & Chalmers, 1998; Kirsh & Maglio, 1994; Risko & Gilbert, 2016; Wilson, 2002), some research has raised concerns about how an over-reliance on digital technologies could disrupt our own internal, biological cognitive processes (e.g., Carr, 2011; Henkel, 2014; Loh & Kanai, 2016; Sparrow, Liu, & Wegner, 2011; Stothart, Mitchum, & Yehnert, 2015; Ward, Duke, Gneezy, & Bos, 2017).

Henkel (2014), for example, found that participants on a museum tour remembered less about objects they were instructed to photograph than about objects they were simply instructed to observe (though this effect disappeared when they were told to zoom in on a small section of the objects before taking the photograph. See also Barasch, Diehl, Silverman, & Zauberman, 2017, for evidence that volitional photography sometimes enhances visual memory). These findings suggest that when people expect to have future access to externally stored information they may expend fewer cognitive resources trying to remember the information on their own.

In an explicit test of this hypothesis, Sparrow, Liu, and Wegner (2011) conducted an experiment where participants typed a series of 40 trivia statements onto a computer and were led to believe that the computer would either save or delete the information. The results showed that participants who thought the computer erased the trivia file remembered more statements than those who believed the computer had successfully saved the file. This was the case whether or not participants were explicitly instructed to try to remember the statements. In other words, the expectation that digitally stored information could be accessed at a future time was associated with worse free recall of the stored information, even when participants were actively trying to remember the information for themselves.

On the other hand, external "memory" storage may also confer a cognitive advantage: because internal cognitive resources are not being taxed to retain digitally stored information, it may be easier for people to learn and remember *new* information. Storm and Stone (2015) dubbed this the "Saving-Enhanced Memory Effect." In their research on the topic, participants completed six trials of a basic word recall task on the computer. On each trial, participants had to memorize two PDF lists of common nouns (List A and List B) before being tested on their memory for both lists. On half the trials, participants deleted List A before attempting to study List B. On the other half of trials, participants saved List A in a folder before studying List B (which meant they would be able to re-study List A before being tested on it). Participants were then tested on their memory for List B first, followed by List A. The results of three experiments revealed a robust Saving-Enhanced Memory Effect: people remembered more words from List B when they had saved List A than when they had deleted it (though only if they believed the saving process itself was reliable and the word lists contained at least eight words). In other words, saving List A appears to reduce the effects of proactive interference observed on the deletion trials.

One important question is whether the cognitive consequences of memory offloading are exclusive to digital technologies, or whether they generalize to other forms of information storage (e.g., writing something down with a pen in a notebook). On the one hand, the effects observed by Sparrow, Liu, and Wegner (2011) and Storm and Stone (2015) might reflect a generic cognitive response to expectations of future information access. If this is the case, then the format of information storage should not matter. Indeed, Clark and Chalmers (1998) used a pen-and-paper notebook example to illustrate this very point in their seminal philosophical treatment of the "extended mind" (i.e., their famous "Otto's notebook" thought experiment). And historically speaking, concerns about the effects of writing on memory have been traced as far back as Ancient Greece, where Socrates warned that writing things down might do more harm than good (Konnikova, 2012).

On the other hand, people today are so used to relying on modern computer systems to store and access information that those born and raised in this technological milieu may have fundamentally different ways of attending to and processing digital—as compared to physical—forms of information (Carr, 2011; Loh & Kanai, 2016). The consistent, fast, and reliable interconnections between an individual and their smartphone or computer that enables almost immediate retrieval of stored data at any time may be a critical component of extended cognition (Clark, 2003). Therefore, it is possible that (some of) the cognitive consequences of external information storage could be unique to digitally stored content.

In the present study, we investigated this issue by adapting the methods of Storm and Stone (2015) to test whether participants would show a Saving-Enhanced Memory Effect when they studied, stored, and destroyed physical word lists printed on paper. In a series of exploratory analyses, we also examined whether individual differences using physical versus digital technologies in the classroom and at home among our student sample moderated behaviour in our task. In addition to providing a conceptual replication of a significant finding from the recent literature on extended cognition and memory, the results of this study help illuminate the scope of the Saving-Enhanced Memory Effect and offer novel insights into the nature of cognitive offloading.

Experiment

Methods

Participants We recruited 50 participants (37 female) from an Introduction to Psychology course at a public liberal arts college in the northeastern United States. Ages ranged from 18-22 (M = 19.2, SD = 1.0) and participants received course credit used to help fulfill a research participation requirement.

Sample size was determined through a conservative power analysis based on the results of Storm & Stone (2015); they recruited 20-24 participants for the key condition in each of their three experiments and observed relatively large effect sizes (d = 0.72-0.93) for the Saving-Enhanced Memory Effect. By more than doubling the sample size from their experiments, we ensured that we would be able to detect even a moderately sized effect (as low as d = 0.4) with roughly 80% power.

Materials & Procedure The study used a within-subjects design and was modeled after Experiment 1 from Storm and Stone (2015). Word list stimuli consisted of 12 individual lists of ten common nouns drawn from Storm and Stone (2015), printed on standard 8.5" by 11" sheets of white printer paper. The words were typed in 26-point, Times New Roman font, centered on the page, with each word appearing on its own line (single-spaced).

When participants entered the lab room they were seated at a low table across from the experimenter and invited to fill out a consent form and a brief demographics questionnaire (described in more detail below). An AmazonBasics 6-sheet cross-cut paper and credit card shredder was positioned on the table within arm's reach. After completing the questionnaire, participants were handed a plain manila folder and instructed to write their name on it. Next, they were told to pay close attention to the instructions, and were informed that during the experiment they should place word lists in their folder when they were instructed to "save" them, and place the lists in the shredder when they were instructed to "shred" them.

The experiment itself consisted of six trials. On each trial, participants were first handed one of the word lists (List A for that trial) and told they would have 20 seconds to study it in order to remember as many words as possible. After 20 seconds, depending on the trial, participants were instructed to either save or shred the list. Participants were then handed a second word list (List B) and were instructed to study it for 20 seconds before returning it to the experimenter. After studying List B, participants were told to count backwards by threes from 100 for 20 seconds. They were then handed a sheet of paper that included ten blank spaces and told to write down as many words as they could remember from List B. They were given 30 seconds to respond.

On Save trials, participants were then told to retrieve and re-study List A from their folder for 20 seconds, after which they were given another sheet of paper with ten blank spaces and given 30 seconds to write down as many words as they could remember from List A. On Shred trials, participants simply took a 20 second break after recalling the List B words before they were handed a new answer sheet and told to write down all of the List A words they could remember.

Participants completed the three Save and three Shred trials in an interleaved fashion, with half of the participants receiving a Save trial first and half receiving a Shred trial first. The order in which the 12 word lists were used across all six trials was counterbalanced so that each list would appear in a different position (1-12), trial type (Save vs. Shred), and list type (A vs. B) across participants.

The demographics questionnaire participants completed at the beginning of the study included gender, age, and year in school, as well as the following free response questions (coding schemes in parentheses): (1) Do you take notes in class during lectures? (yes/no/sometimes); (2) If so, what is your preferred method of taking notes (handwritten/typed); (3) Do you take notes on readings at home? (yes/no/sometimes); (4) If so, what is your preferred method of taking notes (handwritten/typed); (5) Do you think you remember information better when you write things by hand or type them out? (handwritten/typed). We also included one self-report memory ability question that participants rated on a 7-point scale: If you had to rate how good your memory is in general, what would you say? (1 = Very Weak, 7 = Very Strong). See Table 1 for a summary of responses to these questions.

Table 1. Summary of responses to demographics questionnaire

Variable	Total N = 50
Gender: Female, Male	74%, 26%
Age	*M* = 19.2 (*SD* = 1.0)
Do you take notes in class? [Yes, Sometimes, No]	88%, 6%, 6%
If so, preferred class note method: [Handwritten, typed]	82%, 18%
Do you take notes at home? [Yes, Sometimes, No]	38%, 32%, 30%
If so, preferred home note method: [Handwritten, typed]	78%, 22%
How do you remember better: [Handwritten, typed]	94%, 6%
Self-reported memory rating	*M* = 4.7 (*SD* = 0.9)

Results

We restricted our analysis to List B recall performance, as this is the key indicator of a Saving-Enhanced Memory Effect (Storm & Stone, 2015. Note that participants were able to re-study List A on Save, but not Shred trials, making a comparison of recall performance for List A words relatively uninformative). We computed the average number of words participants remembered correctly from the B lists on the three Save trials and the average number of words they remembered correctly from the B lists on the three Shred trials. Words "recalled" that did not appear on the list being tested (or any list at all) were considered errors and were excluded from analysis.

A paired-samples t-test revealed a statistically significant, medium-sized Saving-Enhanced Memory Effect, $t(49) = 3.35$, $p = 0.002$, $d = 0.47$, 95% CI [0.24 – 0.96]; On average, participants remembered about 18% more words on Save trials ($M = 3.89$, $SD = 1.59$) than on Shred trials ($M = 3.29$, $SD = 1.50$. See Figure 1).

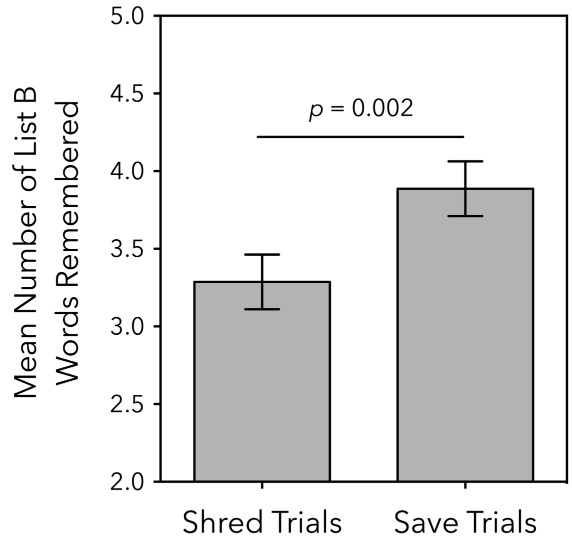

Figure 1. Mean number of List B words remembered on Shred and Save trials. Error bars represent within-subject 95% confidence intervals (Cousineau, 2005)

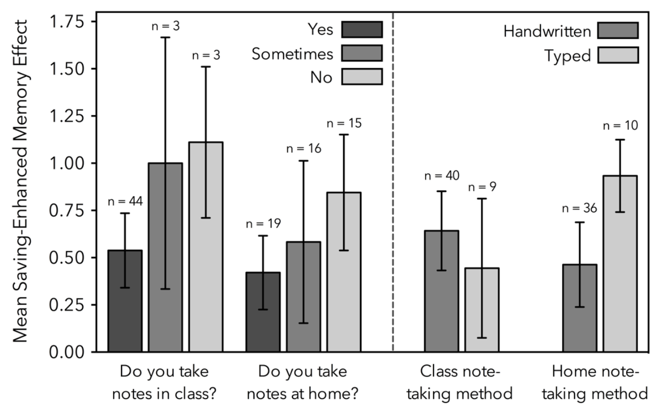

Figure 2. Mean Saving-Enhanced Memory Effect (mean number of List B words remembered on save trials minus shred trials), broken down by how participants responded to the note-taking demographics questions. Error bars represent SEMs

We also conducted a series of exploratory analyses to determine whether individual differences in self-reported memory abilities or preferred note-taking methods—which we reasoned would be one of the predominant forms of memory offloading in our student sample—moderated the Saving-Enhanced Memory Effect. In fact, none of these variables seemed to matter. A series of repeated-measures ANOVAs that included trial type (Save vs. Shred) as a within-subjects factor and each of the four key demographics variables (whether participants took notes in class; their preferred class note-taking medium; whether participants took notes on readings at home; their preferred at-home note-taking medium) as a between-subjects factor revealed that none of these demographics variables were reliable predictors of memory performance (all p's > 0.3). Importantly, the effect of trial type remained significant in each case, and there were no significant interactions between any of the demographics variables and trial type (see Figure 2). In addition, there was no relationship between self-reported memory ability and the magnitude of an individual's Saving-Enhanced Memory Effect (mean number of Save trial words remembered minus mean number of Shred trial words remembered), $r(48) = 0.2$, $p = 0.16$.

Discussion

One reason human behaviour is so sophisticated is that people are adept at offloading cognitive tasks onto the environment, making them easier to accomplish and amplifying the ability to get things done. Offloading memories represents one common strategy: by storing the information we wish to recall in a readily accessible format on a computer or smartphone, people can exponentially increase their capacity to accumulate and accurately retrieve memories. While some research suggests that memory offloading reduces people's ability to recall the stored information for themselves (Henkel, 2014; Sparrow, Liu, & Wegner, 2011), other studies have shown that it can free up cognitive resources, leading to an increased ability to learn new information (i.e., the "Saving-Enhanced Memory Effect"; Storm & Stone, 2015).

In the present study, we tested whether the Saving-Enhanced Memory Effect would replicate beyond the digital realm. Participants completed a series of six trials where they had to study two printed lists of words before being tested on their memory for both lists. On half the trials, participants destroyed the first word list in a paper shredder before attempting to learn the second list. On the remaining trials, they saved the first word list in a folder before learning the second list. Results revealed a robust, albeit moderately-sized Saving-Enhanced Memory Effect ($d = 0.47$); people remembered more words on average from the second list when they had saved the initial word list in a folder. Though the magnitude of this effect is somewhat smaller than what Storm and Stone (2015) observed for memory storage on the computer, a reduced effect size is a common occurrence in replication research (Aarts et al., 2015). Therefore, these findings appear to suggest that the effects of offloading memories onto the external world are similar for information stored in digital and physical formats.

We also conducted a series of exploratory analyses to examine whether individual differences in note-taking habits moderated the Saving-Enhanced Memory Effect. We reasoned that for our undergraduate participants, note-taking during lecture or while completing course readings at home represents a common and recurrent form of memory offloading. Therefore, these analyses enabled us to test whether the consequences of externally storing to-be-remembered information depends on habitual experience using a specific information storage medium. We found that all groups of participants showed a similarly-sized Saving-Enhanced Memory Effect, whether or not they regularly took notes during class or while doing reading assignments, and whether they relied on handwriting or typing their notes. This provides some additional evidence that the Saving-Enhanced Memory Effect reflects a generic cognitive response to expectations of (reliable) future information access and that individual experience using a specific offloading format does not really matter.

That said, there are several limitations which prevent strong conclusions from being drawn from these exploratory analyses. First, the self-report questions we used may have been too coarse to yield an accurate measure of the memory offloading strategies our participants favor in daily life. In addition, our sample size was likely too small to observe subtle differences between sub-groups of participants, especially since a large proportion reported a preference for handwritten notes. Indeed, a vast majority of participants (94%) indicated they learned better from handwriting (as compared to typing) their notes—a claim that is actually supported by recent empirical studies (e.g., Mueller & Oppenheimer, 2014). This lack of heterogeneity makes it difficult to assess the effects of personal experience with memory offloading on the Saving-Enhanced Memory Effect. Future research that seeks to explore the relationship between individual differences in memory offloading and the cognitive consequences of such offloading should include larger samples sizes and perhaps employ a within-subjects design that requires participants to complete both digital and physical information storage trials.

Taken together, however, the results of the present study clearly demonstrate that the Saving-Enhanced Memory Effect replicates beyond the digital realm. This work provides evidence that the cognitive consequences of memory offloading are the result of general expectations of reliable future information access and are not format-specific in nature.

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