Did you look that up? How retrieving from smartphones affects memory for source

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RESEARCH ARTICLE

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Did you look that up? How retrieving from smartphones affects memory for source

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Abstract

It is difficult to monitor whether information was originally retrieved internally, from our own memory, or externally, from another person or a device. We report two experiments that examined whether people were more likely to confuse prior access to information on a smartphone with accessing their own knowledge. Participants were experimentally assigned to either attempt to answer questions from memory or with a smartphone. One week later, we tested memory for the answers and source memory for the modality of the original attempt to retrieve the answer. Participants exhibited poorer source memory for answers retrieved from a smartphone than for answers they initially attempted to retrieve from memory. Experiment 2 demonstrated that memory for the information was equivalent across conditions. These results demonstrate that we are prone to confusing information retrieved from internal and external memory stores, and we have a cognitive bias to appropriate external knowledge as our own.

KEYWORDS
extended cognition, internet, smartphones, source memory, transactive memory

1 | INTRODUCTION

As digital technology continues to diffuse rapidly into society, reliance on internet-connected devices has become an inconspicuous facet of thinking and remembering (Finley et al., 2018). The majority of American adults (85%), particularly young adults (96%), owns smartphones (Pew Research Center, 2021). The convenience of using these devices has changed our cognitive habits (Marsh & Rajaram, 2019). Working together with devices can reduce some of the cognitive burden of daily life but also raises the potential for new cognitive demands. We seek to determine whether the ubiquitous use of devices blurs the ability to differentiate between internally and externally sourced information. Given the fact that the ability to identify the source of remembered information is critical for a wide variety of cognitive tasks (Johnson et al., 1993), determining the influence of external search on source memory is important for understanding the cognitive consequences of technology use.

To make strategic decisions about our memory, we must accurately monitor and control our memory (Benjamin, 2007; Fiechter et al., 2016; Nelson & Narens, 1990). In this way, the net effect of a human-technology partnership depends in part on keeping track of our respective knowledge and contributions. If we can store more information than ever before but are unable to monitor how or where to access that information, it is of little use. Our metacognitive ability to remember the *source* of information (Johnson et al., 1993) is critical to a healthy human-technology partnership.

The ability to accurately monitor our cognitive environment is limited by our available knowledge and beliefs (i.e., biases; Schacter, 2002). Indeed, humans often form beliefs and make decisions—sometimes unknowingly and unconsciously—that are biased toward their personal experiences. *Egocentric bias* describes the class of errors that arise and captures the tendency for people to view their own contributions differently than they view the contribution of others. Such biases are well known in the social psychological literature and

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appear in memory reports in many forms, including difficulty judgments based on one's own experience (Kelley & Jacoby, 1996), miscommunication due to poor assessments of common ground with an interlocutor (Keysar, 2007), bias in collaborative memory (Jalbert et al. 2021), and self-referential encoding (Rogers et al., 1977). Yet, little is known about how source memory errors that arise from egocentrism arise while collaborating with technology. In these experiments, we find that source memory is more accurate for answers initially generated alone than for answers originally found using an internet-connected device (i.e., a smartphone), a result that suggests that the tendency to outsource processing demands to technology may make it more difficult to identify the source of our existing knowledge.

We begin by discussing characteristics of our digital thinker to better understand the biases and intuitions that guide memorial decision-making in a digital world. We then explore the ways in which the ability to monitor the source of original information influences our decisions about our own memory. Finally, we follow with a series of experiments to demonstrate how we are prone to confusing information retrieved from internal and external memory stores, and how we have a cognitive bias to appropriate external knowledge as our own.

2 | EXTENDED COGNITION IN A DIGITAL WORLD

Our knowledge and memory exist in a transactional relationship with our devices. These devices provide quick and easy access to vast stores of information, allowing them to act as external memory partners. Because we interact with our devices as a means of extending our cognitive capacities (Belk, 2013; Hamilton & Benjamin, 2019), technology users can only take full advantage of digitally-enabled strategies and techniques to the extent that they accurately monitor the state of information available "in the head" and information in their digital portfolio in pursuit of their various goals. Our choices to exploit advancements in information technology have begun to affect how we think about and use our own memory (for a review of cognitive offloading, see Risko & Gilbert, 2016). For example, we frequently choose to offload memory tasks to external devices, and this choice affects what we remember. Sparrow et al. (2011) had participants enter trivia statements on a computer and showed that they remembered facts less well when they believed the information was saved externally and would be accessible later. Similarly, Henkel (2014) demonstrated poorer memory for objects that were photographed than ones that were observed but not photographed. Additionally, decisions to offload information to external stores may leave us more susceptible to distortions to that information (Risko et al., 2019).

Yet the presence of offloaded information also serves to enhance our capabilities when we work jointly with a device. Offloading information to an external source is often strategic and adaptive—offloading some information allows us to reallocate limited processing and memory capacity to new information (Storm & Stone, 2015). And, even though people may exhibit worse memory for photographed objects than observed but unphotographed objects, Henkel (2014) demonstrated that, when cameras are used to "zoom in" on details of an object, later recognition of those objects was in fact unimpaired.

3 | SOURCE MONITORING IN HUMAN-TECHNOLOGY PARTNERSHIPS

Source monitoring influences several memory decisions (Johnson et al., 1993), such as where to look for information, how long to search, how to judge the reliability of information and whether to trust its accuracy, as well as whether to encode it and work to generalize from it. If people who use the internet are not able to accurately monitor sources, then they may overestimate their ability to access and use information and make poor decisions about what new information to encode. Cryptomnesia describes a particularly pernicious case of source memory failure, where the origin of information is forgotten and appropriated as one's own. Such memory failures can lead to ill-advised behavior like overclaiming (Paulhus & Harms, 2004) and unconscious plagiarism (Landau & Marsh, 1997). The phenomenon is prevalent when the ability to monitor sources is compromised (e.g., Macrae et al., 1999). The habitual use of cognitive technology to recall information may fuel a process by which technology users come to conflate online ideas, facts, and beliefs as original.

These metacognitive effects are already apparent in research on our sense of self and appraisal of our own abilities. It has been proposed that the pervasiveness of the internet and related devices contribute to an extended sense of self (Belk, 2013). This extension may lead us to falsely incorporate properties and processes of external devices into our metacognitive representation. For instance, frequent device use appears to lead to an inflated sense of competence in information management and retrieval. After using the internet to answer trivia questions, people showed an increase in cognitive self-esteem—a measure that reflects confidence in one's own ability to remember information and answer future questions (Ward, 2021). Likewise, searching for information on the internet led to an inflated sense of internal knowledge—that is, people mistook access to information as understanding (Fisher et al., 2015). People are more likely to use the internet to seek answers to questions when they have recently done so, even if they can access that information from their own memory (Storm et al., 2017). In a survey about their attitudes and beliefs about external memory, Finley et al. (2018) found that 63% of people consider their external memories to be part of themselves. Stone and Storm (2019) have shown that people erroneously use internet search time as a predictor of how well they will recall that information later. The tendency to attribute externally obtained information to the self may be amplified when we use our own devices. When people use their personal devices to access information on the internet, they report higher evaluations of their cognitive abilities compared to those who used devices provided by researchers (Hamilton & Yao, 2018). Together these studies demonstrate how device use may exaggerate the disparity between our perceived knowledge and capabilities and our actual knowledge and capabilities.

4 | PRESENT RESEARCH

It is often difficult to monitor whether information was retrieved internally, from our own memory, or externally, as from another person or a device. Additionally, there may be an inclination to attribute externally obtained information to the self, and this tendency may be exaggerated with the increased prominence of personalized technology. Here we explore a fundamental question about our relationship with technology: how well do we monitor the origin of a remembered piece of information? Are we prone to taking credit for remembering when we draw that knowledge from a digital device? These first two experiments examined source memory for the modality of the original attempt to retrieve the answer and recall accuracy for the answer that was either searched for in memory or with a smartphone. In our experiments, memory conditions reflect the scenario in which a person initially chooses to retrieve answers from internal memory (without the assistance of an external memory source). The smartphone conditions reflect the scenario in which a person chooses to directly access technology. In this way, we suspect that our data are generalizable to many circumstances in which a person chooses to outsource retrieval to a readily accessible and reliable digital source.

In line with previous research, we would expect poorer source memory for the modality of the original attempt to retrieve the answer when the information is sourced from the internet via smartphone (versus when the information is originally sourced from memory). We also predict poorer source memory after having used one's own phone (versus another phone). Secondarily, we expect memory for the information itself to suffer from device use. We expect lower recall accuracy for information originally retrieved from a phone, as seen in offloading studies (e.g., Henkel, 2014; Sparrow et al., 2011; Storm & Stone, 2015). We expect higher recall accuracy for information that was originally attempted to be retrieved from memory, through benefits comparable to generation and retrieval practice (e.g., Benjamin & Pashler, 2015; Roediger & Karpicke, 2006; Slamecka & Graf, 1978).

5 | EXPERIMENTS 1A AND 1B

In these first two experiments, we examined the following research questions: Do people make more source memory errors for information retrieved from their own smartphone? Is long-term memory better for information that people initially attempted to retrieve from memory compared to information initially retrieved from a phone?

5.1 | Method

5.1.1 | Participants

For all experiments, the plan was to analyze data via Bayesian inference methods, given the known advantages over traditional null hypothesis significance testing (for an overview, see Wagenmakers et al., 2018). One of the main benefits of Bayesian methods is that they allow for direct comparison of the null and alternative hypotheses. A Bayes factor represents the ratio of evidence favoring either hypothesis. All Bayes factors herein are reported in terms of evidence favoring the alternative—any values over 1 reflect support for the alternative and under 1 reflect support for the null.

An a priori power analysis was conducted to determine an appropriate sample size. The plan was to collect data until a Bayes factor of 3 (or 0.33) was reached ($\sim$150 participants for Experiment 1a and $\sim$100 for Experiment 1b). This estimate was based on the contrast based on phone ownership (own or control), discussed below. According to Jeffreys (1961), Bayes factors under 3 (and above 0.33) constitute ambiguous evidence.

A total of 304 participants ($n_{1a} = 166$; $n_{1b} = 138$) were recruited through the Department of Advertising at a large midwestern university. This group was comprised of undergraduate students in introductory advertising courses between the ages of 18 and 24 ($M = 19.83$, $SD = 1.11$), and the majority of this group identified as female (220 female, 72 male, 1 nonbinary, 1 agender, 10 did not provide an answer). Participants received partial course credit for participation in this study. Participation in Experiment 1a took place during the Fall 2017 semester, and participation in Experiment 1b took place during the Spring 2018 and Fall 2018 semesters. All participants were required to be 18 or older and own a smartphone to participate. Informed consent was provided by each participant at the start of each experimental session. Participants in both Experiments 1a and 1b were overwhelmingly iPhone users (iPhone = 91.11%, Android/other = 8.89%). Data from an additional 34 participants were eliminated from analysis due to technical problems ($n = 3$) or failure to complete part 2 of the experiment ($n = 31$).

5.1.2 | Design

In these experiments, participants answered trivia questions with or without the help of a smartphone in a 2×2 mixed design. Question modality (memory or phone) and phone ownership (own or control) were manipulated. The way participants initially attempted to retrieve answers to the trivia questions (question modality) was manipulated within subjects, and the phone used (phone ownership) was manipulated between subjects.

For memory (M) questions, participants were instructed to answer each question as best they could from their own memory. For phone (P) questions, participants were instructed to use Google on the smartphone (own or control) to answer each question, regardless of whether they knew the answer themselves. In both conditions, participants were provided with the correct answer after they submitted their response. Figure 1 provides an example of how the trivia questions were presented across memory and phone rounds.

For each participant, questions were randomly assigned to question modality and split evenly across four rounds. The order of these rounds was counterbalanced, and participants were randomly assigned to one of two ordering conditions: MPMP or PMPM.

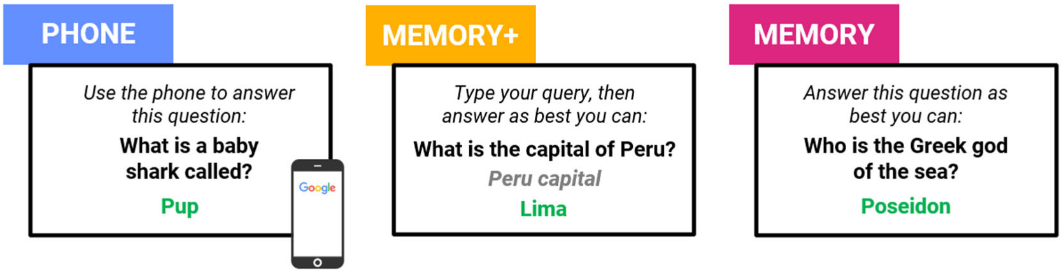

FIGURE 1 An illustration of how trivia questions were presented in experiments 1a, 1b, and 2. The memory+ condition was only included in experiment 2. Correct answer feedback was provided following the participant response.

Participants assigned to the own phone condition ($n_{1a} = 85$; $n_{1b} = 69$) used their personal smartphone to answer phone questions. Participants assigned to the control phone condition ($n_{1a} = 81$; $n_{1b} = 69$) used a smartphone provided by the lab to answer phone questions. This variable was included to examine the moderating effects of phone ownership, as has been demonstrated in prior work (Hamilton & Yao, 2018), but this effect was not apparent in the data and will not be discussed at length here.

5.1.3 | Materials

Sixty moderately difficult general-information questions were gathered from Ward (2021). These questions were evaluated to ensure they are easily "Google-able", that is, that the answer to each question could be found on the first page of search results. Questions were presented as free-response and participants typed their responses. Answers to all trivia questions were typically one or two words long. Fifteen questions were randomly assigned to each of four rounds for each participant.

Many of the same questions from Experiment 1a were used in 1b, but a few of the more difficult questions were exchanged for easier ones. In part 1 of Experiment 1a, participants answered the memory questions correctly less than one-third of the time ($M = 0.27$). This high level of difficulty may have discouraged participants from putting effort into attempts to retrieve answers from memory, as well as into learning the correct answers when they were provided.

Participants assigned to the control phone condition used an Apple iPhone 4s in Experiment 1a and a Google Nexus 5 phone in Experiment 1b. The search history on the control phone was deleted between participants. The control phone was switched to an Android phone in Experiment 1b because most participants were iPhone users. Since the control phone in Experiment 1a was also an iPhone, participants assigned to the control phone condition were using a phone much like their own. Therefore, the control phone condition in Experiment 1a was unintentionally very similar to the own phone condition.

5.1.4 | Procedure

These experiments were conducted in a university laboratory and consisted of two parts, separated by 1 week. In part 1, participants answered a series of trivia questions under the four conditions dictated by the experimental design. In part 2, source memory, recall accuracy, and confidence (only in Experiment 1a) for the answers to the trivia questions was assessed.

At the start of the experiment, participants were instructed to leave their personal smartphone with the experimenter and were seated at a computer station in a separate room. Those assigned to the control phone condition were briefly instructed on how to use Google on that phone.

At the beginning of part 1, participants were told they would answer trivia questions on topics like history, geography, and popular culture across four rounds. For two of those rounds they used a smartphone to answer those questions; for the other two they answered the questions from memory as best as they could. For each round, participants were given specific instructions on how they would be answering the questions and were directed to either return or retrieve the phone (own or control) from the experimenter before the round began.

Participants proceeded to answer the 15 questions per round and were given the correct answer as feedback after each question, regardless of question modality or whether their initial response was correct.

Participants returned 1 week later to complete part 2, in which they were re-tested on the same 60 trivia questions from part 1. Part 2 consisted of a cued-recall test that assessed source memory for each question, and Experiment 1a also solicited confidence in their responses. Participants were not allowed to use a phone to answer any questions in part 2 and no feedback was provided. The 60 questions were presented in random order. For each question, participants first had to provide the answer and were then asked whether they used a phone to look up that answer in part 1. In Experiment 1a, after providing the answer to the trivia question, participants rated their confidence in their response on a scale of 0–100 (0 = *not at all confident*, 100 = *extremely confident*). If the correct answer to a trivia question could not be recalled, participants were permitted to provide a "do not know" response, then proceeded to make their source judgment.

5.2 | Results

Given the near-complete overlap in design between Experiments 1a and 1b, analyses were performed on the combined dataset ($n = 304$; 154 participants used their own phone, 150 participants used the control phone). Experiment (a or b) was included as a factor to affirm that this combined analysis was justified. The only differences between experiments emerged in the recall data ($BF_{10} = 11.74$). As expected due to the intended difference in question set difficulty, average cued-recall accuracy was slightly higher in Experiment 1b ($M_{1a} = 0.57$, $M_{1b} = 0.61$). There were no effects of order (MPMP or PMPM). The combined analysis provides substantial power to evaluate claims about source memory and recall.

5.2.1 | Part 1

Participants answered the phone questions correctly a majority of the time ($M = 0.91$). Participants may have gotten some items incorrect because they selected an incorrect answer from the search results or because they searched for the answer inappropriately (i.e., they may have chosen a poor search query). Participants answered the memory questions correctly approximately one third of the time ($M = 0.32$). The median time it took to answer a memory question was 9.17 s, and to answer a phone question was 22.46 s.

5.2.2 | Source memory

For each trivia question, participants were asked if they originally used a phone to retrieve the answer in part 1. Their yes/no responses were used to calculate their source memory accuracy (where chance performance is 0.5). Source memory was compared across phone ownership (own or control) and question modality (memory or phone) in a 2 × 2 Bayesian ANOVA.[1] There was moderate evidence for no difference between own and control phone conditions ($BF_{10} = 0.23$), and strong evidence of a difference between memory and phone items ($BF_{10} = 22.67$). As shown in Figure 1, source memory was higher for questions previously answered by memory than questions previously answered via phone. There was no evidence for interaction effects ($BF_{10} = 0.21$).

5.2.3 | Conditional source memory

Being able to correctly recall the answer to a question may impact one's ability to accurately remember the source. It is common in investigations of source memory to take this contingency into account by examining source memory selectively for items that were successfully recalled. We did this by conducting a 2 × 2 (question modality × phone ownership) Bayesian ANOVA only for those items that were correctly recalled during part 2. Evidence for any difference between own and control conditions was ambiguous ($BF_{10} = 0.40$), but there was again strong evidence of a difference between memory and phone items ($BF_{10} > 1000$). There were no interaction effects ($BF_{10} = 0.12$). The right panel of Figure 2 shows that the central finding of an effect on source memory persisted even after conditionalizing on recall accuracy.

5.2.4 | Recall

Responses on the cued-recall test were coded as "correct" if they very closely matched the correct answer. Minor misspellings and conceptual matches were considered correct (e.g., "Portugeese" = "Portuguese", "Everest" = "Mount Everest", "100" = "one hundred"). These judgments were made by research assistants blind to condition and to experimental hypotheses. The following analyses were conducted on data that included these adjustments.

The proportion of questions answered correctly in part 2 was measured and a 2 × 2 (question modality × phone ownership) Bayesian ANOVA was conducted. There was moderate evidence for no difference between own and control phone conditions ($BF_{10} = 0.11$), and good evidence of a difference between memory and phone items ($BF_{10} = 4.40$). There were no interaction effects ($BF_{10} = 0.14$). As shown in Figure 3, answers to phone questions were better remembered than answers to memory questions after collapsing across both experiments.

5.2.5 | Confidence

Participants were asked to rate confidence in their responses on a scale of 0–100 after each trivia question in Experiment 1a. Confidence scores were compared across phone ownership and question modality in a 2 × 2 Bayesian ANOVA. No differences were found in confidence for phone ownership ($BF_{10} = 0.32$), question modality ($BF_{10} = 0.13$), and no interaction effects ($BF_{10} = 0.16$). For this reason, the confidence measure is not discussed further here and was dropped in Experiment 1b.

5.3 | Discussion

Source memory for the modality of the original attempt to retrieve the answer was considerably better for memory items than for phone items. After a week delay, participants were better at identifying that memory items were ones they had initially attempted to recall than they were at identifying phone items as ones they retrieved from the phone. That is, participants made more source memory errors for phone items, which means they were more likely to attribute phone items to retrieval from their own memory. This finding is in line with the claim that technology use inflates appraisal of our own cognitive abilities (Fisher et al., 2015; Ward, 2021). Contrary to our prediction, no effects of phone ownership emerged in these two experiments. For both recall and source memory, it did not appear to matter whether the phone used was the participant's personal smartphone or one provided by the lab.

The primary goal of these experiments was to assess the biases in memory for whether information was originally attempted to retrieve from our own memory, or instead looked up externally on a smartphone. Across Experiments 1a and 1b, the data strongly support the view that we are prone to appropriate information retrieved from

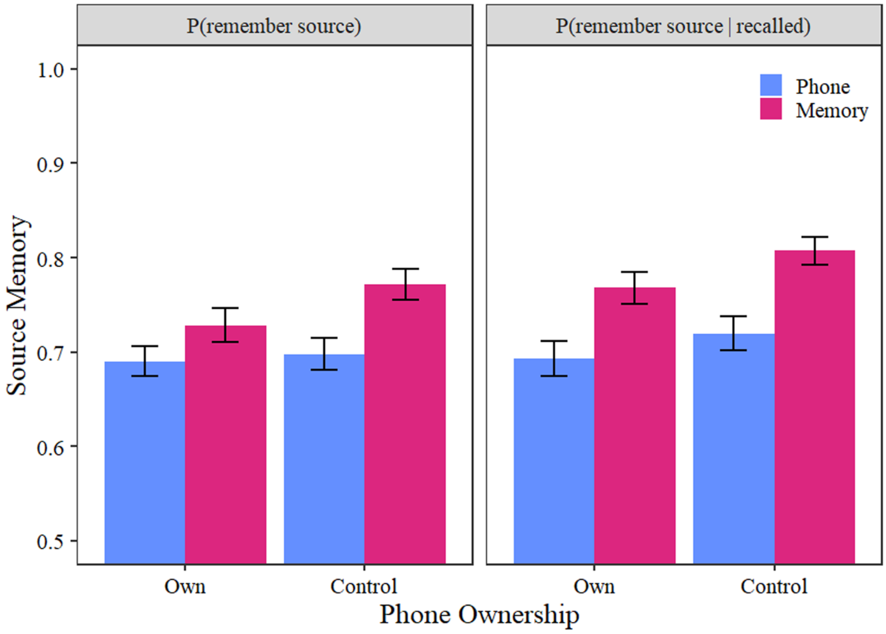

FIGURE 2 Source memory accuracy (left) and conditional source memory accuracy (right) collapsed across both experiments 1a and 1b. Error bars show one standard error of the mean.

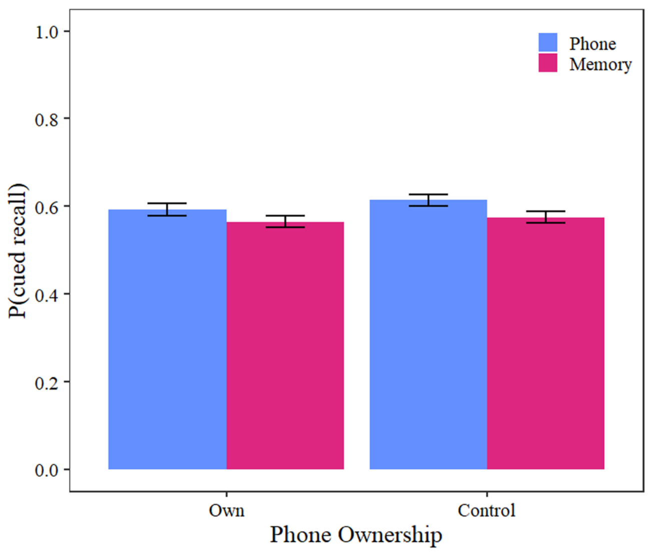

FIGURE 3 Recall accuracy collapsed across both experiments. Error bars show one standard error of the mean.

a digital counterpart as information retrieved from memory. In addition to our primary prediction, we preregistered a secondary prediction that participants would have higher recall accuracy for answers that were initially retrieved from memory than from a smartphone. We expected the recall data to mirror findings from the generation and testing effect literature (e.g., Roediger & Karpicke, 2006; Slamecka & Graf, 1978). More specifically, we expected answers to questions in the phone condition to act like passive 'read-only' or 'restudy' items which are not encoded as deeply as items that were tested or self-generated. We expected the act of attempting to retrieve from memory, whether successfully or not (as in Kornell et al., 2009), would benefit memory. We were surprised to observe that memory for information initially retrieved from a phone was better than for information attempted to be retrieved from memory. This result might indicate that there was more effortful processing involved in constructing search queries for a search on the phone than we had originally anticipated. Experiment 2 was specifically designed to provide an opportunity to evaluate the replicability of this unexpected effect on recall from Experiment 1 and to address this question about the contribution of effortful processing in search query generation.

6 | EXPERIMENT 2

Experiments 1a and 1b showed an unexpected effect on recall accuracy such that answers to phone questions were better remembered than answers to memory questions. One possible explanation could be the difference in the time taken to initiate search between phone and memory trials. Participants spent approximately twice as much time answering phone questions compared to memory ($Mdn_{phone} = 22.46$ s, $Mdn_{memory} = 9.17$ s). Spending more time with the to-be-remembered material could contribute to the observed memory benefit. An alternative hypothesis is that the effect may be due to more effortful processing in the phone condition. The act of searching for an answer on a smartphone may be a more active cognitive enterprise than we initially thought. When presented with a trivia question, participants must craft a search query, enter it, then evaluate the search output for a candidate response. This series of processes may have beneficial consequences for memory, similar to generation. Experiment 2 followed up on this finding to see if it is the act of generating a search query that benefits memory.

6.1 | Method

6.1.1 | Participants

An a priori power analysis was conducted to determine the sample size. The plan was to collect data from approximately 131 participants, or further until a Bayes factor of >3 was achieved. This estimate was based on the effect size of the question modality manipulation in Experiments 1a and 1b.

A total of 138 participants were recruited through the Department of Advertising at a large midwestern university. This group was composed of participants between the ages of 18 and 27 ($M = 19.93$, $SD = 1.34$), the majority of which identified as female (104 female, 28 male, 6 did not provide an answer). Participants received partial course credit for participation in this study. Participation in Experiment 2 took place during the Spring 2019 and Fall 2019 semesters. As in Experiments 1a and 1b, it was required that all participants be 18 or older and own a smartphone to participate. Informed consent was provided by each participant at the start of each experimental session. Data from an additional 23 participants were eliminated from analysis due to technical problems ($n = 3$), not following instructions ($n = 1$), or failure to complete part 2 of the experiment ($n = 19$).

6.1.2 | Design

As in the previous experiments, participants answered trivia questions with or without the help of a smartphone, but now in a within-subjects design with three conditions. We manipulated how participants retrieved answers to general-information questions in the first part of the experiment. The memory (M) and phone (P) conditions were presented just as before—participants either attempted to answer trivia questions from their own memory (M) or used Google on the phone to answer trivia questions (P). In the additional memory+ (M+) condition, participants first generated a search query for each trivia question (as if they would use Google), then they answered as best they could from their own memory (see Figure 1). Feedback was provided after each trivia question, regardless of condition.

One-third of the questions were randomly assigned to each condition for each participant. The order of these conditions was counterbalanced, and participants were randomly assigned to one of the following ordering conditions: MPM + MPM+, PM + MPM + M, or M + MPM + MP.

6.1.3 | Materials

The same 60 trivia questions used in Experiment 1b were used here. Ten questions were randomly assigned to each of the six rounds for each participant. Participants were provided with either an Apple iPhone 4s or a Google Nexus 5 smartphone to answer the phone questions. Unlike Experiments 1a and 1b, phone ownership was not a

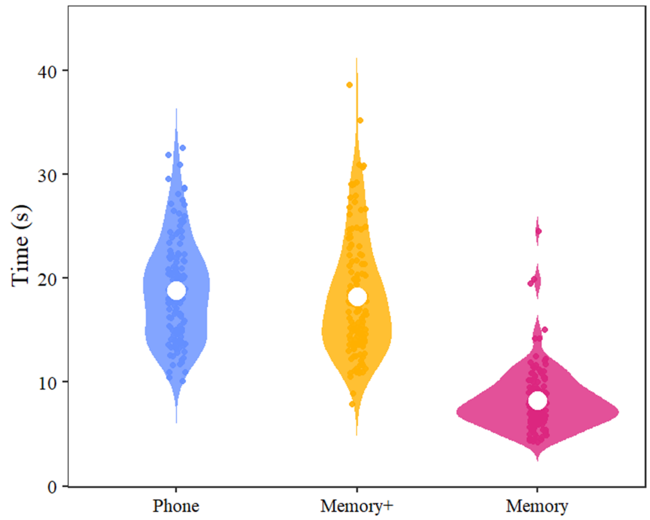

FIGURE 4 Median time spent answering questions in each condition. The "holes" of each violin represent the means, the colored dots represent individual participants, and the shape of each violin represents how the data are distributed.

manipulated variable in Experiment 2, essentially all participants use a "control phone" to answer the trivia questions during the phone rounds. Therefore, type of smartphone used was not included as a factor in final analyses.

6.1.4 | Procedure

The procedure for Experiment 2 closely matched that of Experiments 1a and 1b. In part 1, participants answered trivia questions either from memory (M), by using Google on a phone (P), or by generating a search query then answering from memory (M+). The instructions for memory and phone rounds were identical to the previous experiments. For the M+ rounds, participants were instructed, "Imagine you have to use the phone to answer this question, how would you search for it? Type in what you would enter into Google, then answer the question as best you can."

One-week later participants returned to complete part 2, in which recall accuracy for the trivia questions was assessed. Trivia questions were presented in a random order, no phone use was permitted, and no feedback was provided.

6.2 | Results

6.2.1 | Part 1

Following the pattern of previous experiments, phone questions were answered correctly most of the time ($M_P = 0.87$), and the memory and memory+ questions were answered correctly far less ($M_M = 0.37$ and $M_{M+} = 0.38$). There was strong evidence of no difference in accuracy between the memory and memory+ conditions ($BF_{10} = 0.11$),

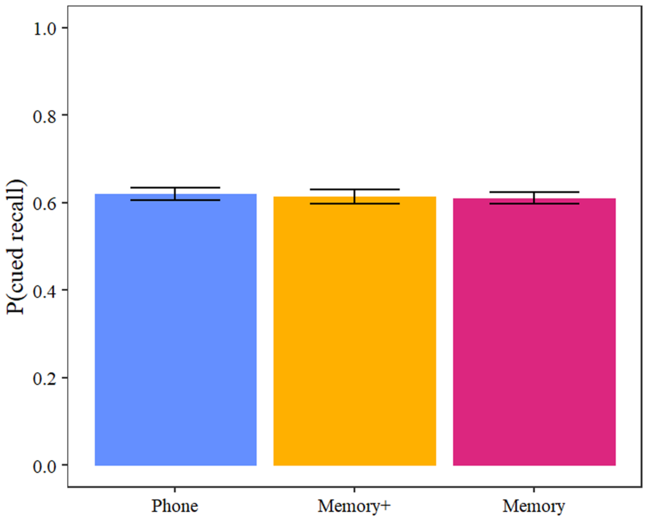

FIGURE 5 Recall accuracy. Error bars show one standard error of the mean.

and, of course, very strong evidence of differences between phone/memory (BF_{10} > 1000) and phone/memory+ (BF_{10} > 1000).

The median time it took to answer phone, memory, and memory+ questions was 18.55, 7.62, and 17.46 s, respectively. There was very strong evidence of a difference between time take to answer phone and memory questions (BF_{10} > 1000), and ambiguous evidence of a timing difference between memory and memory+ questions ($BF_{10} = 1.91$). Importantly, there was good evidence of no meaningful timing differences between phone and memory+ conditions ($BF_{10} = 0.33$). This pattern is depicted in Figure 4.

6.2.2 | Recall

Responses on the cued-recall tests were again coded by research assistants blind to condition and experimental hypotheses. Proportion of questions answered correctly in part 2 was compared across question modality in a one-way Bayesian ANOVA. There was very strong evidence of no difference in recall accuracy across the three conditions ($BF_{10} = 0.032$), as seen in Figure 5.

6.3 | Discussion

A concern from the recall finding of Experiments 1a and 1b was the timing difference between conditions in part 1. Experiment 2 addressed that concern with the inclusion of the memory+ condition. Participants spent roughly the same amount of time with the to-be-remembered material in the phone and memory+ conditions, but considerably less time in the memory condition. The recall finding that emerged in Experiments 1a and 1b was not replicated here; instead, all conditions led to equivalent levels of memory 1 week later. Based on evidence in Experiment 2, we refrain from drawing conclusions on recall data we observed in Experiment 1a. Though we did not observe better memory in the phone condition, the equivalent memory performance observed in Experiment 2 does support the claim that there is not a memory deficit to searching for information online compared to retrieving information from memory.

7 | GENERAL DISCUSSION

The experiments herein examined item and source memory for material that was either initially searched for in memory or on a smartphone. From Experiments 1a and 1b, participants exhibited better memory for the answers retrieved via smartphone but poorer source memory for that information. Experiment 2 was conducted to clarify the recall finding and found evidence of no difference for question modality. This finding is interesting and suggests that, though there are no additional benefits to looking up information, there is also not a cost compared to initially trying to retrieve information on your own. This finding contrasts with the broad claims in the literature that retrieval of knowledge from one's own memory is the best means of enhancing later memory for that information (e.g., Benjamin & Pashler, 2015). Perhaps a more direct test of these possible memory benefits would include an extremely passive condition, similar to restudy conditions in the testing effect literature.

Source memory results revealed that people were less likely to remember the source of the information they retrieved when they had originally used a phone to access the information. Stated differently, people were more likely to take credit for retrieving information from memory after having truly accessed that information on a phone than vice-versa. Consistent with prior work (Fisher et al., 2015; Ward, 2021), this effect reveals that we are likely to appropriate external knowledge as our own. This effect was not exacerbated when subjects used their own phones, as had been shown in prior work (Hamilton & Yao, 2018). In this task, information was accessed from the internet via the device, the information was not locally stored on the device itself. Therefore, whether the device was personally owned may have been inconsequential.

The source memory finding supports the claim that we tend to incorporate features of external technological devices into our sense of self. Personal phones and computers are ubiquitous in many of our lives and grant access to information readily, making them ideal partners from whom to appropriate credit. We have shown here one consequence of such a bias—a memory bias inflating one's own prior contributions to a human-device partnership. Downstream ramifications are likely and probably more concerning. If our sense of knowledge is inflated by appropriation from a device, it may influence later judgments about what we need to learn and how much effort we should put into mastering a body of knowledge (cf. Dunlosky & Rawson, 2012).

There are several possible origins for the observed effect. First, research on egocentric bias reveals a general tendency to encode memories from an egocentric perspective and to assume that others' memories are more like our own than they really are. As a result of the fact that encoding includes personalized information about the self and about the experience, people have better memory for self-relevant information (Rogers et al., 1977) and information generated actively rather than passively (Roediger & Karpicke, 2006; Slamecka & Graf, 1978). In a collaborative remembering task, people are more likely to "steal" memories (i.e., misattribute a partner's knowledge to the self) than to "give away" memories (i.e., misattribute one's own knowledge to a partner; Jalbert et al., 2021). In the presence of uncertainty about the true origin of information, people are more likely to take credit than to give credit away. In this way, the habitual tendency to outsource processing demands to technology may lead to encoding outcomes that are not anticipated by the user. In these experiments, participants overestimated the amount of information that they had initially attempted to retrieve.

The egocentric bias demonstrated here also aligns with the "Google effect" (Sparrow et al., 2011; Ward, 2021). This categorical instantiation of egocentric bias highlights the tendency to forget information that is readily available through search engines like Google. In a question-answering task, participants were more likely to attribute information to the self when found using Google than Lycos (an infrequently used search engine; Ward, 2021). Perpetual and convenient access to the repository of knowledge on the internet can lead us to overestimate our own unaided abilities to understand, find, and retain information (Fisher et al., 2015; Hamilton & Yao, 2018; Stone & Storm, 2019; Ward, 2021).

Lastly, we wish to clarify possible limitations of our experimental design. The purpose of our experiments is to investigate the consequence of offloading cognitive responsibility to our digital devices on source memory. While the memory condition reflects the scenario in which a person sources the answer to questions from memory, the description does not fully capture our participants' performance. For questions in this condition, participants first attempted to answer from internal memory. Subjects failed in this pursuit often and only learned the true answer when feedback was provided. Approximately, one-third of the knowledge in this condition was actually generated internally, and the other two-thirds are delivered by an external source (although not a smartphone). It is a common design feature in experiments investigating the effects of retrieval on memory to provide corrective feedback when subjects are unsuccessful; we did so here to ensure that the two conditions did not have differing amounts of material to remember and be tested on. Notably, such attempts at retrieval can actually enhance memory for the feedback itself, an effect that may also feed into the bias we report.

Taken together, these experiments demonstrate that we are prone to confusing information that we attempt to retrieve from memory and information we access on our smartphone. In the face of this confusion, a cognitive bias to appropriate external knowledge as our own manifests. An environment in which people carry and use smartphones for daily tasks is one in which we are more prone than ever to overestimations of our knowledge, ability, and memory. As information technology like smartphones become more routine, sharing memory responsibilities with devices means that it can be harder to assign credit to who or what is actually doing the remembering. In this technological age, our world has become more blended and the bounds between devices and the self are obscured.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

All experiments were preregistered, and the materials and data from each can be found on the following OSF project pages (Experiments 1a and b: https://osf.io/tjkrv/; Experiment 2: https://osf.io/zvja6/).

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ENDNOTE

[1] Note: For many results, our preregistrations planned simple Bayesian *t*-tests. We later decided to conduct Bayesian ANOVAs throughout to reduce the number of tests.

REFERENCES

Belk, R. W. (2013). Extended self in a digital world. *Journal of Consumer Research*, *40*(3), 477–500. https://doi.org/10.1086/671052

Benjamin, A. S. (2007). Memory is more than just remembering: Strategic control of encoding, accessing memory, and making decisions. *Psychology of Learning and Motivation*, *48*, 175–223. https://doi.org/10.1016/s0079-7421(07)48005-7

Benjamin, A. S., & Pashler, H. (2015). The value of standardized testing: A perspective from cognitive psychology. *Policy Insights From the Behavioral and Brain Sciences*, *2*(1), 13–23. https://doi.org/10.1177/2372732215601116

Dunlosky, J., & Rawson, K. A. (2012). Overconfidence produces underachievement: Inaccurate self evaluations undermine students' learning and retention. *Learning and Instruction*, *22*(4), 271–280. https://doi.org/10.1016/j.learninstruc.2011.08.003

Fiechter, J. L., Benjamin, A. S., & Unsworth, N. (2016). The metacognitive foundations of effective remembering. In J. Dunlosky & S. K. Tauber (Eds.), *The Oxford handbook of metamemory* (pp. 307–324). Oxford University Press. https://doi.org/10.1093/oxfordhb/9780199336746.013.24

Finley, J. R., Naaz, F., & Goh, F. W. (2018). *Memory and technology*. Springer. https://doi.org/10.1007/978-3-319-99169-6

Fisher, M., Goddu, M. K., & Keil, F. C. (2015). Searching for explanations: How the internet inflates estimates of internal knowledge. *Journal of Experimental Psychology: General*, *144*(3), 674–687. https://doi.org/10.1037/xge0000070

Hamilton, K. A., & Benjamin, A. S. (2019). The human-machine extended organism: New roles and responsibilities of human cognition in a digital ecology. *Journal of Applied Research in Memory and Cognition*, *8*(1), 40–45. https://doi.org/10.1016/j.jarmac.2019.01.001

Hamilton, K. A., & Yao, M. Z. (2018). Blurring boundaries: Effects of device features on metacognitive evaluations. *Computers in Human Behavior*, *89*, 213–220. https://doi.org/10.1016/j.chb.2018.07.044

Henkel, L. A. (2014). Point-and-shoot memories: The influence of taking photos on memory for a museum tour. *Psychological Science*, *25*(2), 396–402. https://doi.org/10.1177/0956797613504438

Jalbert, M. C., Wulff, A. N., & Hyman, I. E., Jr. (2021). Stealing and sharing memories: Source monitoring biases following collaborative remembering. *Cognition*, *211*, 104656.

Jeffreys, H. (1961). *Theory of probability* (3rd ed.). Oxford University Press.

Johnson, M. K., Hashtroudi, S., & Lindsay, D. S. (1993). Source monitoring. *Psychological Bulletin*, *114*(1), 3–28. https://doi.org/10.1037/0033-2909.114.1.3

Kelley, C. M., & Jacoby, L. L. (1996). Adult egocentrism: Subjective experience versus analytic bases for judgment. *Journal of Memory and Language*, *35*(2), 157–175.

Keysar, B. (2007). Communication and miscommunication: The role of egocentric processes. *Intercultural Pragmatics*, *4*(1), 71–84.

Kornell, N., Hays, M. J., & Bjork, R. A. (2009). Unsuccessful retrieval attempts enhance subsequent learning. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *35*(4), 989–998. https://doi.org/10.1037/a0015729

Landau, J. D., & Marsh, R. L. (1997). Monitoring source in an unconscious plagiarism paradigm. *Psychonomic Bulletin & Review*, *4*(2), 265–270.

Macrae, C. N., Bodenhasen, G. V. & Calvini, G. (1999). Contexts of cryptomnesia: May the source be with you. *Social Cognition*, *17*, 273–297.

Marsh, E. J., & Rajaram, S. (2019). The digital expansion of the mind: Implications of internet usage for memory and cognition. *Journal of Applied Research in Memory and Cognition*, *8*(1), 1–14. https://doi.org/10.1016/j.jarmac.2018.11.001

Nelson, T. O., & Narens, L. (1990). Metamemory: A theoretical framework and new findings. *The Psychology of Learning and Motivation*, *26*, 125–173. https://doi.org/10.1016/s0079-7421(08)60053-5

Paulhus, D. L., & Harms, P. D. (2004). Measuring cognitive ability with the overclaiming technique. *Intelligence*, *32*(3), 297–314.

Pew Research Center. (2021, April 7). Mobile fact sheet. https://www.pewresearch.org/internet/fact-sheet/mobile/.

Risko, E. F., & Gilbert, S. J. (2016). Cognitive offloading. *Trends in Cognitive Sciences*, *20*(9), 676–688. https://doi.org/10.1016/j.tics.2016.07.002

Risko, E. F., Kelly, M. O., Patel, P., & Gaspar, C. (2019). Offloading memory leaves us vulnerable to memory manipulation. *Cognition*, *191*, 103954. https://doi.org/10.1016/j.cognition.2019.04.023

Roediger, H. L., III, & Karpicke, J. D. (2006). Test-enhanced learning: Taking memory tests improves long-term retention. *Psychological Science*, *17*(3), 249–255. https://doi.org/10.1111/j.1467-9280.2006.01693

Rogers, T. B., Kuiper, N. A., & Kirker, W. S. (1977). Self-reference and the encoding of personal information. *Journal of Personality and Social Psychology*, *35*(9), 677–688.

Schacter, D. L. (2002). *The seven sins of memory: How the mind forgets and remembers*. Houghton Mifflin Company.

Slamecka, N. J., & Graf, P. (1978). The generation effect: Delineation of a phenomenon. *Journal of Experimental Psychology: Human Learning and Memory*, 4(6), 592–604. https://doi.org/10.1037/0278-7393.4.6.592

Sparrow, B., Liu, J., & Wegner, D. M. (2011). Google effects on memory: Cognitive consequences of having information at our fingertips. *Science*, *333*(6043), 776–778. https://doi.org/10.1126/science.1207745

Stone, S. M., & Storm, B. C. (2019). Search fluency as a misleading measure of memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *47*(1), 53–64. https://doi.org/10.1037/xlm0000806

Storm, B. C., & Stone, S. M. (2015). Saving-enhanced memory: The benefits of saving on the learning and remembering of new information. *Psychological Science*, *26*(2), 182–188. https://doi.org/10.1177/0956797614559285

Storm, B. C., Stone, S. M., & Benjamin, A. S. (2017). Using the internet to access information inflates future use of the internet to access other information. *Memory*, *25*(6), 717–723. https://doi.org/10.1080/09658211.2016.1210171

Wagenmakers, E. J., Marsman, M., Jamil, T., Ly, A., Verhagen, J., Love, J., … Matzke, D. (2018). Bayesian inference for psychology. Part I: Theoretical advantages and practical ramifications. *Psychonomic Bulletin & Review*, *25*(1), 35–57. https://doi.org/10.3758/s13423-017-1343-3

Ward, A. F. (2021). People mistake the internet's knowledge for their own. *Proceedings of the National Academy of Sciences*, *118*(43). https://doi.org/10.1073/pnas.2105061118

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