THE EXTENDED ORGANISM: A FRAMEWORK FOR EXAMINING STRATEGIC MEDIA SKILL IN A DIGITAL ECOLOGY

BY

KRISTY ANN HAMILTON

DISSERTATION

Submitted in partial fulfillment of the requirements
for the degree of Doctor of Philosophy in Communications & Media
in the Graduate College of the
University of Illinois at Urbana-Champaign, 2020

Urbana, Illinois

Doctoral Committee:

Professor Mike Z. Yao, Chair
Professor Aaron S. Benjamin
Associate Professor Brittany R.L. Duff
Professor Kevin R. Wise

Abstract

This dissertation presents an extended organism framework that is directly applicable to the study of strategic media skill. The framework posits that it can be helpful in understanding the human cognizer's adaptiveness and success of memory in a digital ecology to consider the characteristics of digital memory—the body of rote knowledge and various features of digital technology—as part of the human-technology extended organism, rather than an external environment on which the cognizer acts. It proposes three major subprocesses of strategic media skill: strategic encoding, metacognition, and identifying technological biases. This paper applies the framework to the case of offloading cognition to external devices to demonstrate its applicability. The extended organism framework, as it stands now, provides a conceptual-theoretical lens for predicting and explaining findings about strategic media skill, especially from an effects tradition, and for asking questions about the cognitive processing underlying strategic media skill. Using this perspective and these approaches to empirical investigations, researchers should be able to better understand the successes and failures of memory and cognition in a digital ecology, currently characterized by near-constant access to external information via dynamic and changing digital media devices. The ability to do this will allow media users to know the cognitive consequences associated with different actions and strategies and to make better decisions about when and how to use digital media to accomplish their goals.

Acknowledgements

To the mentors that shaped me:

Erin Fratella who unearthed my passion for psychological inquiry,

Harry Wallace who taught me to trust myself and my work,

Paula Hertel who trained me to conduct research competently and ethically,

Carolyn Becker who taught me to lead with a steadfast purpose,

Bill Christ who persuaded me toward a career in media communication,

Adrian Ward who inspired my research,

Aaron Benjamin who helped hone my methodological and statistical intuitions,

Kevin Wise who made higher education feel like home,

Brittany Duff who helped me confront my inner saboteurs, and

Mike Yao who pushed me to shoot beyond the stars.

'Thank you' is not enough.

Table of Contents

Chapter 1

INTRODUCING STRATEGIC MEDIA SKILL AND THE PROBLEM DOMAIN

In a media ecology where our everyday actions are enabled, constrained, and altered by characteristics and affordances of the digital tools available to us at any given time, it is surprising that most of the literature on the cognitive consequences of digital media use focuses on monolithic claims about whether or not people should rely on these tools to accomplish daily tasks. While most researchers identify negative consequences for pervasive technology use on recall (Sparrow, Liu, & Wegner, 2011; Henkel, 2014), inhibitory control (Dong, DeVito, Du, & Cui, 2012), and metacognitive monitoring (Hamilton & Yao, 2018; Ferguson, McLean, & Risko, 2015; Siler, Hamilton, & Benjamin, 2018; Storm, Stone, & Benjamin, 2017; Stone & Storm, 2019; Ward, 2013), many aspects of digital media—near-constant internet access, near-limitless rote information storage, increasingly reliable connection to other users—can be employed strategically to successfully accommodate the demands of intellectual and behavioral goals. Indeed, the implications of digital media use can be paradoxical with simultaneous positive and negative aspects (van Zoonen & Rice, 2017). Reaping cognitive benefits from digital media depends on the media user's skill in selecting an effective and efficient strategy in different situations and their ability to monitor their own learning in pursuit of their goals.

Many features of technological tools—GPS, data storage, information retrieval—are used regularly to accomplish goals in daily life. In such a theoretical perspective, much of what we think of as "memory" or "mind" in a digital ecology is the product of an integrative system of internal (i.e., in the "brain") and external (i.e., outside the "brain") cognitive processes that are selected to meet the demands of a particular cognitive task. In light of this nuanced dynamic, there is an emerging issue of conceptualizing the cognition of this extended cognitive system so we are able to understand the inherent qualities or liabilities of human memory and cognition in a digital ecology.

The purpose of this dissertation is to present an "extended organism" perspective **(Chapter 2)** for the empirical study of strategic media skill and to offer an approach to studying each of three inter-related components that characterize strategic media skill. Using this perspective and these approaches to empirical investigations, researchers should be able to better understand the successes and failures of memory and cognition in a digital ecology, currently characterized by near-constant access to external information via dynamic and changing digital media devices. The ability to do this will allow media users to know the cognitive consequences associated with different actions and strategies and to make better decisions about when and how to use digital media to accomplish their goals. The roots for this perspective on strategic media skill lie in the memory-as-skilled-cognition tradition of cognitive psychology (Anderson & Milson, 1989; Benjamin, 2007; Bjork, Dunlosky, & Kornell, 2013) and is reminiscent of theories on transactive memory (Wegner, Giuliano, & Hertel, 1985). The applicability of this perspective is demonstrated through three experiments investigating the influence of cognitive offloading on three aspects of strategic media skill. Those are: understanding how various cognitive strategies and techniques made possible by digital media influence short- and long- term communicative and cognitive goals **(Chapter 3)**, knowing how media users monitor and control the state of information available "in the head" and information out in the world in pursuit of their various goals **(Chapter 4)**, and understanding how certain characteristics of technology can impair these monitoring and control processes **(Chapter 5)**. By studying these interactions, a major goal of this dissertation involves thinking about ways to conceptualize and study digitally-mediated cognitive processes and behaviors in increasingly complex media environments.

This push towards research on media skill is not revolutionary or unprecedented (see Hargittai, 2003; Steyaert, 2002; van Deursen & van Dijk, 2010). Given the internet's ubiquitous importance in all domains of life after reaching wide diffusion in the second part of the 1990s (Figure 1), communication science researchers have spent a great deal of effort understanding and explaining issues of access to and usage of digital media under the interdisciplinary research umbrella called the "digital divide." As the internet became a commonplace in the lives of more and more people, however, it became less and less useful to dichotomize those affected by unequal access to digital resources between those who have access to the internet and those who do not. Instead, researchers implored scholars to "...start looking at differences in how those who are online use the medium" (Hargittai, 2001, p. 1) and argued that "because of the growing amount of information on the internet and people's increasing dependence on information, internet skills should now be considered as vital assets (van Deursen & van Dijk, 2010, p. 894). The overarching message of this dissertation is that understanding the fundamental nature of digital media skill and reaching agreement on what are the primary questions that should be asked about this phenomenon will require the adoption of a particular theory of mediated communication.

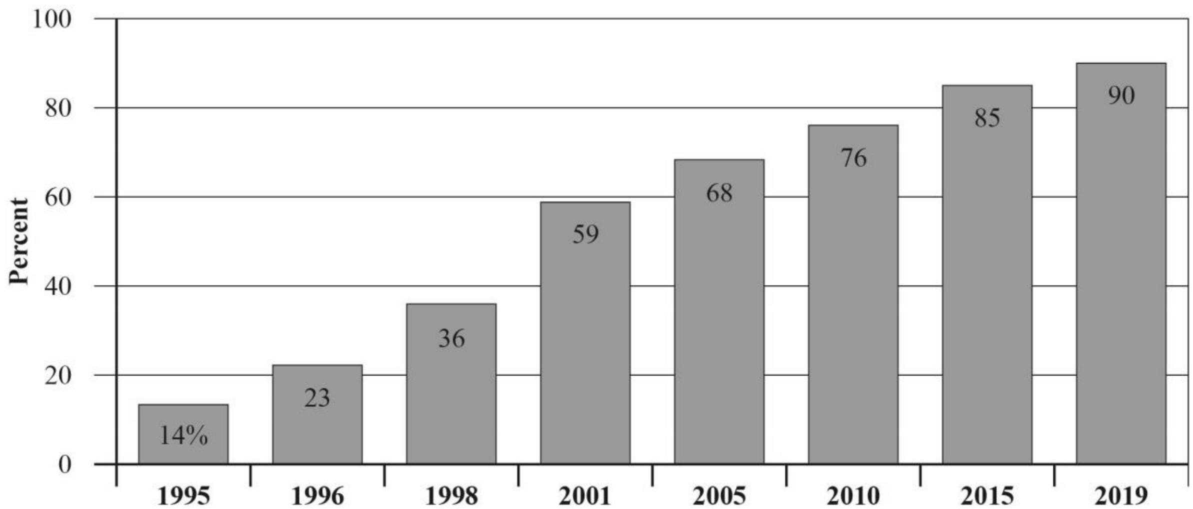

Figure 1. The percentage of the adult U.S. population using the internet over time, 1995-2019. Data source: Pew Research Center.

Strategic Media Skill: A Concept Explication

To use digital media effectively, we should do more than create monolithic practices surrounding our own media use. Ideas that the internet is ruining our brains or that the internet is an omniscient source of knowledge does no service for our ability to think critically and reflectively about the consequence of our media use (or non-use) in a given situation. Indeed, effective use of digital media is determined by the skillful action of higher-level decision making in service of intellectual and behavioral goals. In such a perspective, *strategic media skill* encompasses the myriad ways in which digital media can be strategically employed for the task at hand and the degree to which the outcome of these decisions satisfies present and future behavioral goals. Imagine, for example, that the goal is to become an expert birder. Because expertise and knowledge arise from the acquisition of facts and routines, a person cannot become an expert birder by having a hard drive full of bird photographs. Imagine, now, that the goal is to remember a friend's birthday. Making the strategic decision to set up a reminder on a frequently accessed device (like a personally-owned smartphone) allows this user to reliably accomplish their goal at little cognitive cost. These examples highlight the point that a digital media user needs to know strategies and their consequences to successfully accomplish their goals. Chapter 2 engages an explicit discussion of the characteristics of a truly skilled media user and these characteristics are further explicated in Chapters 3-5. Importantly, empirical research demonstrates that our ability to understand the consequences of our decisions about media use is highly imperfect. There is quite a lot that we, as humans, do not tend to know about how to assess and manage our own knowledge (Nelson & Narens, 1994) and, at the same time, people know too little about internet skill to realize they do not know a lot (Dunning, Johnson, Ehrlinger, & Kruger, 2003). To become a truly skilled media user it is necessary to learn the general principles and practices that can be applied while making decisions about when and how to use digital media to accomplish goals.

Planned use

Ultimately, we know too little about the strategic toolkit a digital media user must have to make effective use of digital media by one's own initiative (Stayaert, 2002; van Deursen & van Dijk, 2010). Strategic skill requires a level of digital media mastery beyond the operational and formal skills required to become a sophisticated media user, which cannot be gained from long or heavy media use (van Deursen & van Dijk, 2010). It is being progressively recognized that strategic information skills will become of paramount importance as it is as relevant in relation to traditional media (e.g., radio, television) as for new media (Stayaert, 2002). The purpose of this explication is to formalize the concept of strategic media skill to facilitate a more consistent approach to conceptualization and application of this research area and to make it useful for researchers to apply, explore, and build upon. With this goal in mind, there are a few boundary conditions of this explication of strategic media skill. First, this explanation is primarily intended for those who conduct (or intend to conduct) research on technological mediation, defined as behaviors "...mediated by contemporary technological tools in terms of the psychological, social, and behavioral mechanisms..." (Flanagin, 2020, p. 1). In other words, this research favors digitally-mediated experiences and behaviors as objects of study, rather than studies of the human mind or technological tools themselves. Researchers primarily focused on aspects of human cognition should refer to the wealth of research on memory skill (see Benjamin & Ross, 2008 for review), which gave foundation to the current notion of strategic media skill. Second, these arguments of the roles and responsibilities of human memory apply primarily to those who are immersed in a digital ecology characterized by frequent, pervasive, and inconspicuous media use. This research is not so applicable to those who do not need to rely on digital media to accomplish daily tasks, although the number of individuals for whom this discussion does not apply is quickly diminishing (Figure 2). The utility of this concept explication should be evaluated by its ability to facilitate growth of scientific knowledge that is generalizable from observations of media use or misuse and its ability to maintain a coherent reservoir of knowledge that is distinct from other types of media-related skills, such as skills related to the characteristics of the medium (e.g., operating a smartphone, navigating on the internet).

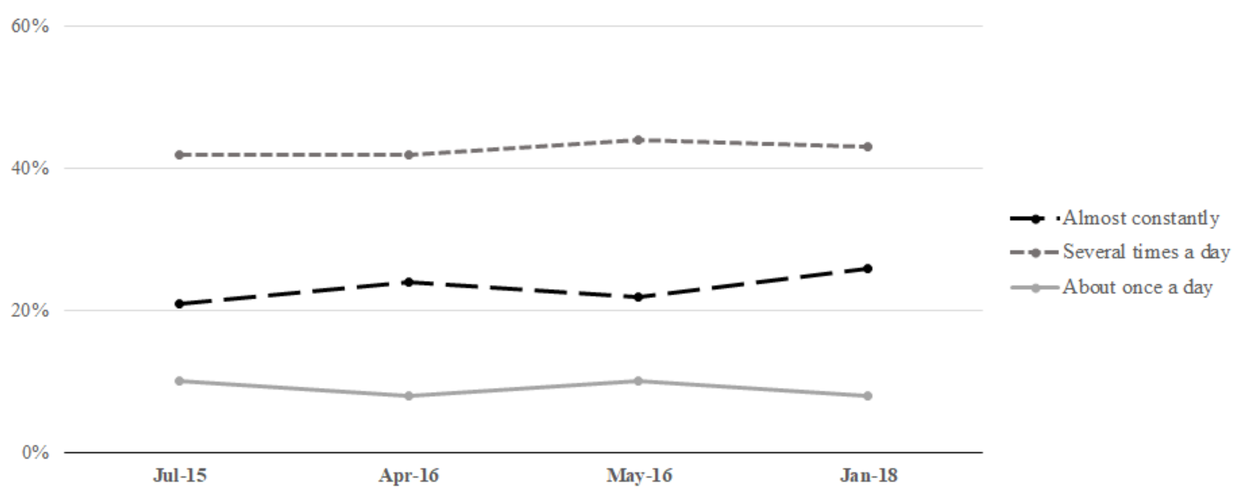

Figure 2. Frequency of internet usage over time in the adult U.S. population, 2015-2018. Data source: Pew Research Center.

Literature Review

Now that we have formalized the ideas of the concept of strategic media skill at a preliminary level, we can begin organizing the scholarly literature that deals with it. Below, I discuss three existing concepts that closely relate to strategic media skill. Those are: media literacy, memory skill, and internet skill. For each of these three concepts, I delineate the conceptual meanings assigned to them, their intended research purpose, and the confusions that ambiguities within the literature cause for the understanding and prediction of strategic media skill in contemporary human-technology interaction. The end goal for this review of literature is to offer an empirical description and modified conceptual definition of strategic media skill that alleviates the major constraints posed by prior conceptualizations of the concept.

Media literacy. One research domain that has been applied to study aspects of media skill is *media literacy.* Media literacy is defined generally as "the ability to access, analyze, evaluate and communicate messages in a wide variety of forms" (Aufderheide & Firestone, 1993) and emphasizes the skills that make use of multimedia features, such as language, moving images, music, and sound effects. Many media literacy scholars are concerned with educating media users out of a growing concern about potentially negative effects of media use. Media literacy scholarship has done a great deal to promote general education (Hobbs & Jensen, 2009; Jenkins, Purushotma, Robison, & Weigel, 2006; Kubey, 1998; Sholle & Denski, 1994) and to design interventions (Nathanson, 2001; Lawrence & Wozniak, 1989) to train people to avoid negative media effects.

The mega-concept of media literacy was developed to provide a heading for the discussion of the necessary skills and abilities required by the population at large to use present-day information and communication technologies safely. Reasonably so, literature on media literacy grew quickly in size with a wide range of scholarly backgrounds contributing to the discussion. As a result, it took on the role of a conceptual conglomerate entangled with a number of often unspecified concepts (Potter, 2010). Unpacking the meaning of media literacy and its intended research purpose became particularly challenging to researchers (see Potter, 2010 for a sampling of definitions). Potter (2010) posed three key issues that confront scholars who study media literacy, “What are the media? In terms of media literacy, we must clarify which media we mean… What do we mean by literacy? Again there is a wide range of thinking… [And] What should be the purpose of media literacy?” (pp. 679-680). Researchers have yet to reach consensus on these key issues. For example, Strömbeck (2008) defines media as newspapers, radio, and television; Hjarvard (2008) defines media as newspapers, radio, television, and interactive media; and Schultz (2004) has a similar list, but replaces interactive media with digital media. Some researchers argue that media literacy should be used to contemplate critical cultural issues (Alvarado & Boyd-Barrett, 1992), to stimulate media education (Houk & Bogart, 1974; Sholle & Denski, 1994), or as a topic for psychological inquiry (e.g., Sinatra, 1986; Scribner & Cole, 1981).

Within this literature, however, there is a broad theme concerning citizens’ participation in society. As Livingstone (2004) puts it,

> Debates over literacy are, in short, debates about the manner and purposes of public participation in society. Without a democratic and critical approach to media literacy, the public will be positioned merely as selective receivers, consumers of online information and communication. The promise of media literacy, surely, is that it can form part of a strategy to reposition the media user - from passive to active, from recipient to participant, from consumer to citizen. (pp. 18-20)

Media literacy has done a great deal to defend a person's right to participate in society at large and to equip people with the tools to do so effectively. Without a framework for negotiating the fundamental nature of the concepts under its expansive umbrella, for communicating the major questions, and for reaching consensus on the best research practices for giving answers to those questions, it is difficult to determine where and how progress will be made in this domain. The goal of this dissertation is to offer a formal framework for asking questions and evaluating answers about strategic media skill in a digitally-mediated environment.

Memory skill. The memory-as-skilled-cognition perspective from cognitive psychology holds that beyond the action and interaction of internal memory systems, memory capacity reflects the action of higher-level decision making on the inputs to and the outputs from memory stores (Benjamin & Ross, 2008). At its core, the notion of memory skill emphasizes the important role that strategies and control processes play in memory performance. Benjamin (2007) defines memory skill as, "the degree to which people use their strategies to effectively allow them to achieve their intellectual goals" (p. 209). A good target on which memory skill researchers can focus is, "explaining (and eventually improving) the mnemonic behavior of a college student who is studying for and taking an examination" (Nelson & Narens, 1994, p. 6). Research on memory skill covers how we choose strategies for a given cognitive task (e.g., Goldsmith, Koriat, & Weinberg-Eliezer, 2002), how we successfully regulate and control memory in pursuit of a memory goal (e.g., Benjamin & Bird, 2006; Koriat & Goldsmith, 1996), how sophisticated encoding and retrieval strategies can moderate memory deficits (e.g., Dunlosky & Hertzog, 2000), and how we effectively monitor our outcomes in order to satisfy situational demands (e.g., Thiede, 1999).

The interest in memory skill has led to a greater emphasis on the functions of memory in real-life contexts, such as eyewitness testimony, preparing for an exam, and reconstructive memory. Rather than treating individuals as passive processors, memory skill points to the active role of the cognizer in putting memory to use in service of personal goals. Although the concept of memory skill plays an important role in progressing a scientific agenda that emphasizes real-world scenarios, it does less for forwarding questions regarding processes of cognitive and communicative change to which technologies are closely linked. Whereas memory skill scholars study basic cognitive processes that drive action, media skill scholars emphasize technology-enabled processes and attributes that demonstrate cause. Whereas memory scholars build theories about a relatively stable—yet vastly complex—human memory systems, media scholars must first build theories that are able to accommodate rapid technological change and an ever-changing object of study. If we are to study the skilled use of media, we will need to incorporate a framework that is sensitive to the complex and variable nature of media change.

Strategic internet skill. As the internet continues to play a large and increasing role in our daily routine, the importance of internet skills for participation in labor, education, and social contacts has also increased (Steyaert, 2002). In response, van Deursen and van Dijk (2010) proposed a four-component framework for the systematic study of technical and content aspects of internet skill. Technical skills consist of operational skills, which include the basic skills to operate an internet browser, and formal skills, which include the ability to navigate and orient oneself with the internet's hypermedia structure. Content skills consist of information skills, which include the ability to search, select, and evaluate online information, and strategic skills, which include the capacity to use the internet to achieve a particular goal (van Deursen & van Dijk, 2010).

Strategic internet skill, the most relevant component to the explication of strategic media skill, is described as a process concept that consists of four steps in making effective use of the internet. The procedure begins with goal orientation and the final step is obtaining the benefits of making the optimal decision. Van Deursen and van Dijk (2010) empirically define strategic internet skills as:

Taking advantage of the Internet by,

- developing an orientation towards a particular goal,
- taking the right action to reach this goal,
- making the right decision to reach this goal, and
- gaining the benefits resulting from this goal. (pp. 898-899)

The definition of strategic internet skill is derived from traditional decision-making approaches that emphasize procedures through which optimal solutions are reached (Miller, 2008). Because selecting an optimal decision requires a base of knowledge accumulated through years of complex learning (van Deursen & van Dijk, 2015), levels of strategic internet skills leave much room for improvement. A longitudinal analysis conducted among the Dutch population indicate that while levels of operational and formal internet skills are increasing, likely due to policy initiatives aimed at improving basic skills among specific target populations like the elderly (van Deursen & van Dijk, 2015), levels of information and strategic skills have seen only a very small increase. Of the variables that influence these skills, education is the most important (van Deursen & van Diepen, 2013). Unlike formal and operational skills that can be acquired by simply using the internet, information and strategic skills put greater stress on one's cognitive abilities, and therefore, are a greater challenge for training programmes (van Deursen & van Dijk, 2015). Indeed, strategic internet skill incorporates aspects of operational, formal, and information skill as means to reach a particular personal or professional goal by one's own initiative.

This concept of strategic internet skill is well-suited for driving empirical questions related to technical mediation, at least as it relates to the internet, and for harboring the accumulated knowledge on strategic skill that is unique from other distinct components of the internet skill framework. Still, posing a boundary condition around the internet, limits its applicability to experiences that are cross-mediated—by this, I mean experiences that cannot be simply associated with a given medium, such as the internet. Just like we no longer have to go to our television set to watch live video, we no longer have to turn on our computer to access internet information. Our smartphones and smartwatches can provide us internet content nearly anytime and anywhere; and smart speakers and chatbots continuously update their knowledge to offer assistance fine-tuned to our daily lives. These devices are multi-purpose platforms that provide a variety of media and communication experiences, and critically, a high propensity for modifications and other changes over time. Going forth, media researchers will need to shift their focus from novel platforms of communication to novel processes of communicative change that are entangled within a complex digital ecology.

Modified Conceptualization

Based on the literature review, it is clear that operational definitions of strategic media skill revolve around measuring the extent to which optimal solutions are reached. Strategic media skill involves taking the *right action* in service of intellectual and behavioral goals in the face of technology-related biases that can impair judgments.

In the current view of strategic media skill, decision-making is an entirely rational process. The basic operational procedures are as follows. First, media users identify an intellectual or behavioral goal that necessitates a decision. The media user then considers all characteristics of their environment which might be relevant to their decision (e.g., which technologies are available? How could they serve me?). Next, the media user develops a set of strategy options and evaluates them according to a set of criteria for decision effectiveness. The process concludes when the media user identifies an optimal decision and can begin implementation. Entangled within these general procedures are a host of processes and biases produced by a multi-faceted relational structure between technologies and the user, which enable and constrain potential outcomes. The argument here is that unraveling those technology-produced processes and biases will bring users one step closer toward becoming maximally effective as digital media users.

Empirical description. Consider, as an empirical example, the case of a journalist completing a news report to be published online. Their short-term goal is to write a report so that all of the facts are correct. Now that a goal has been identified, we can consider characteristics of the environment that might be relevant to goal completion. Assume in this scenario that the journalist's reliability in verifying the veracity of factual information is 90.00% (they catch 9 of 10 errors). The reliability of the information that this journalist uses to write the report is 70.00% (7 of 10 facts are correct). Therefore, the overall reliability of this article will likely be 97.00%. A fact-checking software is installed on the journalist's computer with a reliability of 80%. The assumption is that it will catch 8 out of 10 errors that the journalist fails to catch. So, the reliability of the article should now be 99.40%.

Now, the journalist can develop a set of strategy options, such as using the software to periodically check facts (saving time and cognitive energy) or writing the article while self-checking facts and then running the fact-checking software at the end (using more time and cognitive energy).

Ideally, this would lead to a profitable trade off. If the journalist has the goal of producing reports with near perfect accuracy, then adding this software would allow the journalist to optimize their goal of writing a factual report. Instead, after the journalist made a decision about how to write the report the reliability of the article dropped to 94.00%. Why? This is because the journalist decided to offload responsibility for fact checking to what they considered a reliable software. From this scenario, we see that one benefit of offloading responsibility is that it allows the opportunity for humans to increase access to useful information (e.g., relatively correct facts) while decreasing the cost of doing so (e.g., time spent fact-checking). Still, the journalist can only take advantage of the technologies available to them if they understand and overcome new biases of technology use. Unfortunately, the journalist did not make optimal decisions to accomplish their goal because they incorrectly inferred that it is not necessary for them to fact-check while the computer does not have the inferencing abilities to surmount the journalist's role. Optimally, the journalist would have appropriate knowledge of what the machine was good at (e.g., comparing content from a vast number of online sources) and then use fact-checking strategies that were outside the scope of the machine's abilities (e.g., considering the subtext of the article). This scenario provides context for understanding prominent questions that need answers in this domain. For example: which decisions about encoding would have led to a more profitable trade-off? What factors constrained this media user's ability to make a better decision about their media use? (See Appendix A for two complete strategic media skill scenarios).

Conceptual Definition

So far, it has been demonstrated that conceptions of strategic media skill have different roots, which have all made valuable improvements in this topic domain. The goal here is to present a conceptual definition of strategic media skill that alleviates some of the major constraints posed by adjacent concepts in this empirical domain. Based on the literature review, a definition of strategic media skill should include the following major dimensions: focus on optimal decisions, central to a mediated environment, conducive to empirical exploration in media scholarship.

Strategic media skill is a process concept describing the higher-level decisions a media user makes about when and how to use digital media in pursuit of their intellectual and behavioral goals. Put plainly, strategic media skill is *"the careful action of high-level decision making about simple or complex media use employed in service of intellectual or behavioral goals."*

To say that media skill is *strategic* means we are interested in goal attainment. This point is key to understanding the major purpose of strategic media skill research. Not all research that involves cognitive aspects of media fall under the umbrella of strategic media skill. Instead, researchers who might contribute to strategic media skill are those who seek to understand how a person can effectively use digital media to accomplish their personal goals and are privy to the particular nature of these digitally-mediated interactions that threaten effective use of these tools. In this sense, strategic skills are flexible and changing with respect to contexts and goals. Educating media users on simply how to use tools does no service to dynamic, flexible, and changing modes of use. What if there is a system update? What if connection is lost? A strategic media user is one who is able to reflect upon the material features available to them, their personal intellectual and technical abilities, and the situated nature of use to understand the best course of action for accomplishing their goals. To say that strategic skill involves digital *media*, means we are interested in cognitive tasks of people in a mediated environment. It does not mean that it is necessary to employ technologies in every context where they are available. Indeed, there are several cases where the appropriate decision is to rely on non-digital tools or internal capacities alone. But, using the term strategic *media* skill is to acknowledge that these cognitive decisions are made with respect to a dynamic media environment. To say that we are interested in *skill* is to say that we are interested in the ability to carry out a task with determined results. This requires a level of reflexivity on the part of the media user that may often feel unnatural, but nonetheless, is critical to the skilled use of media in today's complex digital environment.

As will be demonstrated later in this dissertation, the terms that are used to operationalize and empirically describe strategic media skill—internal and external memory, strategic encoding and retrieval, metacognition, technological biases—are relative to an individual human, which is the conventional unit of analysis in social science. Although we cannot test the process that strategic media skill depicts directly, theorized processes may be tested (McLeod & Pan, 2005). The following chapter poses a lens for understanding the ontological nature of strategic media skill and for developing operational procedures to examine processes and concepts most relevant to the skilled use of digital media.

Chapter 2

THE EXTENDED ORGANISM PERSPECTIVE

This chapter is adapted from a journal article published as:

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.

How should researchers investigate strategic media skill? This chapter constitutes one answer to that question.

The ready availability of digital media means that our knowledge and memory exist in a transactional relationship with our devices. Given that many strategies for accomplishing a personal goal involve integrated use of external and internal cognitive processes, media users face a new coordination demand of discerning when and how to use external resources to accomplish their personal goals. Although digital media offer a way to extend the faculties of our human cognitive capacities, it introduces into our affairs novel and unfamiliar phenomena. Whereas our internal memory system has enormous capacities to self-organize and reorganize (Hunt & McDaniel, 1993), for example, our external memory systems require a media user to adopt new strategies and routines that will allow external information to be rendered available in the future. As digital media continue to play a large and increasing role in supporting human memory, concepts and theories in the field of mediated communication have opportunities to play an instrumental part in unraveling the fundamental nature of technology-mediated cognition.

Shortcomings of Prior Media Research

There are three shortcomings of previous media research that, under this current view, constrain scientific progress on strategic media skill. These shortcomings are interrelated and each tends to give rise to the next. What follows this discussion of shortcomings of prior media research is an approach to conceptualizing and studying aspects of strategic media skill that alleviates constraints posed by these shortcomings. I argue that researchers investigating aspects of strategic media skill should assess the extent to which any guiding theory upholds these shortcomings before applying the theory to the study of strategic media skill.

First Shortcoming: Investigating medium X on outcome Y. Within the practice of theorizing of media, particularly the effects tradition, our major theories in media research have been strongly influenced by the media—as in, technological objects or outlets used to store and deliver information—of the era. The advent of the television gave us theories such as agenda-setting and cultivation theory. The advent of the computer gave us the field of computer-mediated communication (CMC) and human-computer interactions. The advent of the internet and social networking sites are currently raising new and important questions within the field. The constant shift in our objects of study reflect a major limitation of our dominant paradigm. In articulating the major dilemmas within the field of computer-mediated communication, Walther (2011) explains, “New CMC platforms and applications force us to ask how well the theories and approaches we know can cover rapid developments and significant changes in technological attributes. Questions are frequently raised about the utility of theories that were developed when CMC was just plain text, now that variants include free video conferencing and multimodal social networking sites…”

When media researchers segment their thoughts around specific media or design studies wherein the object is treated, and subsequently studied, as a whole (e.g., effects of internet on outcome Y), we limit our understanding of the empirical reality of complex media phenomena. Because our inferences in a traditional media effects paradigm are limited to our tested samples, investigations concerned with the effects of medium X on outcome Y inevitably constrain their generalizations to that particular medium. In other words, the dilemma here is that researchers study media as agents of change, but use a general notion of medium, which is inevitably limited to the empirical context. This appears to be in part due to the fact that practices are processes of media use and that when the researcher tries to theorize this involves reification of the process, freezing it into a particular context. This presents a particular dilemma for a field whose guiding questions are driven by understanding the fundamental nature of change with a technological cause. If media researchers continue to generate typologies without rooting them in a broader context of media use, it will be difficult for our research to keep up with routine technological improvements and innovations. A guiding framework for studying strategic media skill will need to provide a solution that alleviates constraints posed by our rapidly changing object of study (i.e., media).

Second Shortcoming: Overemphasis on Independent Systems. Traditionally, research on strategic media skill involves an analysis of the qualities of some medium (e.g., the internet, smartphones): examining the various ways that technology features enable, constrain, and alter memory behavior. Henkel (2014), for example, showed that individuals who took photos of objects during a museum tour, remembered fewer objects and fewer details about the objects than when they observed objects without taking pictures of them. Sparrow and colleagues (2011) found that people have lower rates of recall for information they believed would be accessible in the future compared to information they believe would be erased—a phenomenon coined the *Google Effect*. In both of these examples, we see an assumption being made that treats humans and the tools they use to accomplish their personal goals as separable, whereby the cognitive consequences of technology on human cognition are evaluated when individuals unknowingly lose access to their tools, which occurs much less frequently in our current digital ecology.

Understanding the individual constituents of human-technology partnerships is insufficient to understand fully the processes and behaviors of the cognizer in a digital ecology. Treating human and technology as independent systems denies two important facts about the partnership. First is the fact that the ready availability of technology changes, and should change, exactly what humans feel they need to know in order to reach their goals effectively. For example, if we have reliable access to the internet, why *should* we try to remember birthdays or directions? Certainly, it can do better than we can, and what is gained by keeping that information in our own heads? Second, it denies the fact that *many* qualities of present-day humans and technologies are shaped by the other. Outsourcing rote knowledge to the internet does not, despite popular opinion, make humans stupid. And the internet is not in any sense "omniscient." Certainly, it is a record of known facts, queries, objects, and writings. But it is also a collection of our misgivings, biases, secrets, and attempts to distort. The internet does not seek to establish coherence across its knowledge base, making it vulnerable to gaps and biases in our knowledge (e.g., Vanian, 2018) and to attempts to weaponize the appearance of fact in service of political, social, or personal goals (e.g., Boffey, 2018). In contrast, because human cognition prioritizes inference over information, it seeks coherence and suffers from poor memory for rote knowledge as a consequence. A guiding framework for studying strategic media skill will need to take a stance on how to approach the complex dynamic between humans and their devices that reflects ecologically valid contexts of use.

Third Shortcoming: Neglecting the Paradoxes of Transactive Media Use. Neglecting the transactive nature of our relationship with our media devices is to neglect the empirical reality of our time. To study strategic media skill, researchers must appreciate, if not acknowledge, two assumptions. First is the assumption that strategic media users must commit to an ongoing process to understand, manage, make sense of, cope with, and use one or more digital media. Second, is the assumption that digital media, in turn, come to manage, control, and affect media users and their decisions (Rice, Hagen, & Zamanzadeh, 2018). For example, users can take advantage of reliable information storage services (e.g., Cloud-based services) to the extent that the information is retrievable. What if internet connection is lost when you need some digitally-stored information? What if you cannot recall where you placed external information within your digital organizational structure? The more we choose to store information on our personal digital devices, the more we come to rely on our devices to complete future tasks. We cannot truly understand human decisions and actions until we understand how the simple use of digital media alters subsequent decision-making processes. A guiding framework for studying strategic media skill will need to accommodate the transactive qualities of human-technology partnerships.

Extended Organism Framework: Philosophy Overview

I start from the position that part of using memory effectively involves knowing how to increase access to useful information, while decreasing the cost of doing so (Anderson & Milson, 1989; Benjamin, 2007; Oaksford & Chater, 2007; Simon, 1996). Many technology-enabled offloading strategies, like storing contacts, finding directions, and searching the internet, are regularly employed in service of more efficient memory. Much of what we think of as human memory, or more broadly of mind, in a digital ecology is in fact the product of an integrative system of internal (i.e., “inside” the brain) and external (i.e., “outside” the brain) cognitive processes that are selected to meet the demands of a particular cognitive task. In such a theoretical perspective, the ability to effectively integrate internal and external processes to guide decisions is the critical feature of a successful cognitive agent.

High-tech external memory devices (e.g., computers, smartphones, internet) are able to perform some cognitive tasks that once could only be accomplished by humans. Certain features of these external devices, like their vastness, depth, and longevity, unequivocally outperform human memory, which is fallible in many ways (Schacter, 2001). As a consequence, the use of technology has become a habit of daily life. In a recent survey study, Finley, Naaz, and Goh (2018) summarized the ways in which external memory is seen as augmenting human capability in the early twenty-first century. Notably, 74% of participants indicated that external memory works better for semantic purposes, such as storing passwords, phone numbers, dates, appointments, email addresses, physical addresses, directions, "stone-cold facts," quotes, names, recipes, financial information, numbers, formulas, and lists. This is especially the case for information that is infrequently used, complex, boring, or vast. For such information, technology plays a large and increasing role in supporting human cognition.

The ecological strengths of human cognition, on the other hand, are related to the ability to effortlessly draw inferences from data. This includes the development of categories: humans easily and spontaneously learn natural categories like "dogs" and social categories like "friends" from experience. In contrast, only recently have advances in machine learning progressed to the point where machines can classify complex stimuli that humans do routinely (in tasks like speech perception and object recognition; LeCun, Bengio, & Hinton, 2015). Humans also communicate, manipulate, and conceptualize problems with symbols—a strength that underlies our ability to solve complex problems (Anderson & Bower, 1973). Unlike machines, people are able to apply abstract rules in novel but appropriate situations (e.g., Smith, Langston, & Nisbett, 1992), understand and learn complex language (e.g., Kim, Pinker, Prince, & Prasada, 1991), and express and use metacognitive knowledge to one another in service of identifying individuals suited towards solving those problems (Bennett, Benjamin, Mistry, & Steyvers, 2014). The uniquely human capability to go beyond the information presented to *infer* what is “true” of the world is our strength in a digital ecology.

Extended Organism Metaphor

It can be helpful in understanding the human cognizer’s adaptiveness and success of memory in a digital ecology to consider the characteristics of digital memory—the body of rote knowledge and various features of digital technology—as part of the human-technology extended organism, rather than an external environment on which the cognizer acts. Similar to the idea of swarm cognition in termites (Turner, 2011). In essence, cognition itself is viewed as a communicative phenomenon, whereby the basic units of the social system (e.g., technological features, human abilities, context of use) are viewed together as a single entity: a superorganism. The extended organism contains a dynamic body of knowledge that reacts and self-regulates in a changing environment and with changing goals. Our access to digital memory shapes the manner in which we achieve our intellectual goals and, simultaneously, our queries and contributions to digital memory shape the nature of the information it possesses and provides to others.

To understand how humans achieve intellectual goals in a digital world, one has to understand the process and abilities of the human-technology extended organism within its broader environment. A good working analogy is swarm cognition in termites. It can be helpful in understanding the termite’s adaptiveness and success in a variety of environments to consider the structure and geometry of the termite mound—tunnels made of varying materials and food caches—as part of the extended termite, rather than an external environment on which the termite acts (Turner, 2011). The termite mound is a dynamic body of knowledge that reacts and self-regulates in a changing environment and with changing goals. The complex behaviors of this extended organism emerge from its simple constituents, yet understanding these constituents alone does not suffice to understand the swarm's cognitive abilities.

The extended organism metaphor is reminiscent of studies on transactive memory systems. The psychological theory of transactive memory explains how a person can become dependent on others to make the process of storing and retrieving information more efficient (Wegner, 1987). In a problem-solving task, Wegner, Giuliano, and Hertel (1985) showed that close dyads tend to adopt an integrated strategy for resolving discrepancies between individual responses. These results support the notion that transactive communication processes tend to develop among close dyads, which form a unique "group-mind." In general, theories of transactive memory allow us to understand aspects of the unique group-mind that develops in various systems (Wegner, 1987). Like theories of transactive memory, the extended organism metaphor is intended to allow researchers and media users to understand aspects of the unique group-mind that develops within human-technology relational structures. Adopting an extended organism perspective is to acknowledge that in order to understand the full cognitive consequences of living in today's digitally-mediated environment, we should understand the human and their digital media together as an extended organism that has capacities and risks beyond the reach of either alone.

If the concept of an extended organism in human-technology interactions has validity, we should expect this unit to perform cognitive tasks at the "superorganismal" scale. Indeed, the cognitive powers of the extended organism has been demonstrated in empirical settings. When learners are told that to-be-learned information will be stored on a computer for later, they show lower rates of recall for that information (Sparrow, Liu, & Wegner, 2011). One might draw the conclusion that Google is changing the way we think—and not for the better. Yet, if we consider the cognitive context in which this memory behavior is situated and evaluate memory as an optimization to the information-retrieval task that the human-technology extended organism faces, we see that in fact the decision to outsource (some) memory is an adaptive one. If we trust that semantic information will be accessible in the future and unlikely to be needed under circumstances in which the internet is not available, there is no need to fully encode it into our internal memory, which is limited in capacity and precision. In experiments in which users have access to information saved in external memory devices, they outperform users who are forced to rely on their own memory (e.g., Storm & Stone, 2014). Here we see that the complex behaviors of this extended organism emerge from its simple constituents, yet understanding these constituents alone does not suffice to understand the organism's cognitive abilities and the vulnerabilities that threaten the successful use of memory.

Toward a Theory of Strategic Media Skill

Thus far, we have discussed the fundamental nature of our human-technology interactions under contexts relevant to strategic media skill and proposed the extended organism perspective as a specific way of observing the digital world. The purpose of this section is to reach shared agreement on what are the primary questions that should be asked about our topic domain of strategic media skill. To do so, I refer back to our modified definition of strategic media skill, which is "the careful action of high-level decision making about simple or complex media use employed in service of intellectual or behavioral goals." Humans making decisions about technology use in an extended cognitive system must not only know how to operate the tools in their extended system, but they must also know whether their decision is appropriate for the demands of the task. Indeed, knowing how to manage one's own extended cognitive system has become an important survival tool. This general notion that our complex and rapidly evolving digital environment poses a new demand on a person to self-initiate and self-manage learning is readily apparent in cognitive science research, yet "for reasons that are not entirely clear, our intuitions and introspections appear to be unreliable as a guide to how we should manage our own learning activities" (Bjork et al., 2013, p. 419). Similar to strategic media skill, intuitions about our own learning does not come naturally and it is necessary to develop principles and practices to guide more effective decision-making surrounding our learning activities.

The following principles that describe the fundamental components of strategic media skill are adapted from cognitive psychology research regarding how to become sophisticated as a learner (Bjork et al., 2013), which is based on decades of learning literature. These general principles detailing what a person would need to know in order to become truly skilled as a media user can be used to guide important empirical questions on strategic media skill.

Becoming Skilled as a Media User

Becoming truly effective as a digital media user in an extended cognitive system entails, (a) recognizing key aspects of the functional architecture that characterizes the symbiosis between humans and digital media; (b) understanding how various cognitive strategies and techniques made possible by digital media influence short- and long- term communicative and cognitive goals; (c) knowing how media users monitor and control the state of information available "in the head" and information out in the world in pursuit of their various goals; and (d) understanding how certain characteristics of technology can impair these monitoring and control processes.

Strategic media skill, in this framework, is conceived of as a set of simultaneously occurring subprocesses that people perform and that determine sophisticated media use. This framework proposes three major subprocesses of strategic media skill: strategic encoding (Principle B), metacognition (Principle C), and identifying technological biases (Principle D), which serve two critical purposes. First, it serves as a means to present variables that represent strategic media skill in ways that are observable and measurable. Although the process of strategic media skill cannot be directly tested, hypotheses about the specific outcomes derived from a theoretical process can be tested (McLeod & Pan, 2005). Second, taking an approach that emphasizes core processes of interest over particular tasks, tools, or features that exhibit such processes facilitate the identification and development of research that emphasizes aspects of technology-mediated human behavior enduring across technologies (Flanagin, 2020) and also should serve as a bridge between memory research and research in attention and perception (Jacoby, 1991) and research in decision making (Nelson & Narens, 1994). This will hopefully allow future researchers to evaluate strategic media skill using a systematic approach to provide unique insight that will contribute to broader theories.

Still, before an individual can employ these subprocesses for more efficient media use, they must first understand the major peculiarities of the functional nature of human cognition, digital media, and their interactions (Principle A). This involves understanding the key ways that humans and technology differ. It is helpful to know, for example, that while certain features of technology like its vastness and longevity easily outperform human memory, our devices are currently unable perform the uniquely human feat of going beyond the information presented to infer what is "true" of the world, such as forgetting out-of-date information or solving complex problems. It is also helpful to know using the internet as a repository of our memories prevents us from using adaptive qualities of our memory, such as those that inoculate us against misinformation (e.g., Johnson & Raye, 1981) or allow us to develop expertise. A central premise of this paper has been that the strength of human cognition is the ability to draw inferences from data and solve problems that are beyond the capabilities of digital memory. Ironically, the ability for cognizers to accomplish the uniquely human feat of developing expertise, exercising creativity, synthesizing information, and generating new ideas is dependent upon having available the facts and routines that underlie these enterprises. One cannot become an expert birder by having a hard drive full of bird photographs. Generalization comes from internalized knowledge. Although organization is a key factor for effective memory in an extended cognitive system, knowing simply how to access external information does not support the generalization of knowledge and development of expertise in the same way. A critical role of the cognizer in a digital ecology is the ability to make careful decisions about when we are best served by storing information internally for future inference, even when that storage is error-prone or difficult. Again, we see how the consequences of outsourcing retrieval are beyond the understanding of simple constituents. To be maximally effective as a media user necessitates a commitment to understanding these important peculiarities of our human-technology cognitive architecture.

An Example: Cognitive Offloading

The aforementioned process-oriented approach lends itself to studying many other aspects of strategic media skill—to do so requires only that the research conceptualizes their variables in terms of one of three major subprocesses. In the following chapters, I specifically apply the extended organism framework of strategic media skill to the case of offloading cognition to an external device. Although offloading strategies have existed for centuries (e.g., reading encyclopedias, writing with pen and paper, finger counting), the concept was not formalized until 2016 when cognitive scientists Risko and Gilbert defined cognitive offloading as “the use of physical action to alter the information processing requirements of a task so as to reduce cognitive demand” (p. 676). Examples of offloading include writing information on a sticky note, using a GPS to find directions, or searching for information online. In this sense, *cognitive offloading* is an encoding strategy where people choose to share responsibility for a cognitive task with some external source in order to decrease effort and increase memory performance.

I explore and empirically demonstrate the three major subprocesses that characterize strategic media skill—strategic encoding, metacognition, and technological biases—within the experimental context of offloading cognition by searching for answers to general-information trivia questions. According to Chaffee (1996), “a theory should presumably produce reliable results in the real world, or we should not have much use for it” (p. 17). Google processes over 40,000 search queries every second, which translates to over 3.5 billion searches per day (Internet Live Stats, 2020). Recent empirical research has noted several behavioral outcomes associated with internet search. For example, Storm, Stone, and Benjamin (2017) found that having unfettered access to the internet increases future use of the internet to access other information, and Ferguson and colleagues (2015) found that using the internet can decrease our willingness to rely on internal memory. We are increasingly facing situations that allow us to offload internal cognition, which may have downstream effects on our subsequent memory and metacognitions (Risko & Gilbert, 2016).

Each chapter that follows includes an explication and an experiment that demonstrates each of the three subprocesses that characterizes strategic media skill under an extended organism perspective. The extended organism framework, as it stands now, provides a conceptual-theoretical lens for predicting and explaining findings about strategic media skill, especially from an effects tradition, and for asking questions about the cognitive processing underlying strategic media skill. Conceptualizing components of strategic media skill in terms of (a) encoding strategies that influence behavioral goals, (b) monitoring and controlling of learning, and (c) identifying technological biases should prove useful both to researchers and media users by increasing our understanding of the major determinants of sophisticated media use. Questions about cognitive offloading, while prominent in our current literature, only illustrate one type of question to be explored in this domain. In the conclusion section, I summarize some other questions that would benefit from further investigation.

Chapter 3

STRATEGIC ENCODING

This empirical study in this chapter is an experiment for a journal article to be published as:

Hamilton, K. A.*, Siler, S.* & Benjamin, A. S. (In Progress). Have you tried Googling it? When internet search enhances memory.

Strategic Encoding: A Concept Explication

The first subprocess associated with more sophisticated media use is knowing how various cognitive strategies and techniques made possible by digital media influence short- and long- term communicative and cognitive goals.

People cannot possibly store all perceivable information in mind and must make several decisions, such as how to limit their intake of material and how to store information to meet the demands of present or future memory goals. During this general process of encoding, the observer engages in a number of operations, such as perceiving, attending to, and working with internal and external events, with the ultimate goal of converting useful information into a construct that can later be used to adaptively guide behavior (Davachi & Dobbins, 2008). *Strategic encoding* refers to the skillful selection of an encoding strategy. The number of encoding strategies available in a given context of memory use are diverse and varied.

Generally, when we think of the strategies we use to encode information, we think of strategies that will help convert information that can be stored within the brain (internal memory). For example, you might think of the time you came up with a useful mnemonic to memorize a definition, or the time you visualized numbers in your head to memorize a password. However, encoding strategies can also be those that help convert information to be stored outside the brain (external memory). For example, you might use a password manager on your personal device to store passwords that are important but infrequently used, or you might bookmark webpages you think might be useful in the future. All of these examples reveal the way people efficiently and effectively employ encoding strategies to enhance memory by selecting strategies that are appropriate to the demands of the material (e.g., you probably wouldn't want to memorize a URL) and the goal at hand (e.g., you probably don't need to store passwords used on a daily basis). There are other situations, however, that reveal failures to encode effectively. For example, when preparing for a test, you may choose to read your notes line-by-line, assess your familiarity with the material as an indication that the information is known, and then find that you are not able to recall that content at the time of the test (Fischhoff & Beyth, 1975). You might prepare for a presentation by writing important points to cover in the notes section of your slides and then find that the projector you must use can only mirror content on your screen. We can see from these examples that our ability to accomplish intellectual goals like taking tests or giving presentations are not always based on a general capacity to remember, but rather, are a product of the strategic decisions we make during encoding.

There are limiting conditions on this generality, however. For example, Mueller and Oppenheimer (2014) found that students who took notes on laptops performed worse when tested on their conceptual knowledge of the information than students who took notes longhand. Structural features of media such as those related to the way information is displayed to the user or the way in which can be used play a role in how and how well that information is remembered. Similarly, in an ad viewing task, Sundar, Narayan, Obregon, and Uppal (1998) found that advertisements displayed in print format were better recognized than advertisements displayed in online format. Searching the Internet has also been associated with lower accuracy in recalling information as compared to traditional book searching (Dong & Potenza, 2015).

Such aspects of media also influence downstream judgments and decisions related to the information. For example, Yang and Roskos-Ewoldsen (2007) found that the way that products are placed within a movie not only influence recognition of the target brand, but also reported attitudes toward the brand. The important lesson from this combined evidence is that one media user may be more likely to recall information when needed compared to another media user because of their ability to select appropriate encoding strategies for the task at hand, rather than because they have superior memory; but also, features and affordances of the media while making decisions about encoding will influence how and how well information is encoded.

Many strategic encoding experiments evaluate cognitive offloading in the context of a search manipulation. This manipulation often consists of an orienting instruction of internal search (memory retrieval) versus external search (internet/computer retrieval). The intent is to induce a difference in encoding procedures to evaluate the degree to which memory, usually measured as proportion correct on a final test, reflects that difference. The general expectation is that memory for previously viewed information will be worse in the external memory than internal memory conditions. This finding reflects a prominent learning theory that self-produced information is better remembered than information that is presented and passively read (Jacoby, 1978; McKinley, Brown-Schmidt, & Benjamin, 2017; Slamecka & Graf, 1978).

The experiment presented in this chapter is a concrete application of empirical research on strategic encoding that is evaluated through an extended organism perspective. Specifically, I test the hypothesis that using an internet search engine to search for answers to general-information questions will lead to better recall of those answers compared to memory retrieval. Contrary to prior research, I start from the position that the use of technology requires considerable cognitive planning and may in some cases have beneficial consequences for memory. Many characteristics of effective learning—deep encoding, cognitive elaboration, and error generation—are employed in the generation of effective cues for searching the Internet. In addition, the evaluation processes involved in selecting among the literally millions of outcomes of an Internet search are also known to promote learning (Watanabe, 2001). This conceptualization turns conventional understanding on its head: searching the Internet may, under certain conditions, set the stage for excellent memory for searched information. The overarching goal is to demonstrate how an extended organism lens allows researchers to predict and explain contradictory findings relevant to strategic media skill.

Hamilton*, Siler*, & Benjamin: Memory Performance

For the current study, we designed a within-subjects experiment to explore the hypothesis that the task of generating a search query for searching the Internet imbues a memorial advantage over generating an answer from memory. We included three conditions to test the idea that the act of generating a search query is the critical act that serves to enhance memory. Those are: memory (i.e., attempting to retrieve answers from memory), search (i.e., using a smartphone to search for answers), and memory+ (i.e., generating a search query for each question as if they would use Google, then attempting to retrieve the answer from memory). Participants completed a cued-recall test for all questions one week later and recall accuracy was measured as the proportion of questions that they answered correctly.

Our primary hypothesis concerned differences between Search and Memory conditions on recall accuracy (H_0: Evidence for Search = Memory and H_1: Evidence for Search $\neq$ Memory). Based on our previous observations (Siler, Hamilton, & Benjamin, 2018), we predicted:

H1: Using a phone to search for an answer to a general-information question leads to higher recall accuracy one week after the initial test than attempting to retrieve the answer from memory (Hypothesis 1: Search > Memory).

Such a result would support the idea that there are memory benefits to information retrieval via internet search. We address the effect of query generation on recall accuracy by comparing the Memory condition to the Memory+ (H_0: Evidence for Memory = Memory+ and H_1: Evidence for Memory ≠ Memory+). We predict:

H2: Generating a search query and attempting to retrieve the answer from memory leads to higher recall accuracy one week after the initial test than only attempting to retrieve the answer from memory (Hypothesis 2: Memory+ > Memory).

Such a result would suggest that the act of generating a search query has beneficial consequences for memory beyond the benefits of self-generating answers. Finally, we compare differences between Search and Memory+ conditions on recall accuracy (H_0: Evidence for Search = Memory+ and H_1: Evidence for Search ≠ Memory+). We predict:

H3: Generating a search query and attempting to retrieve the answer from memory during the initial test will not show differences in recall accuracy over using a phone to search for answers (Hypothesis 3: Memory+ = Search).

Such a result suggests that Search and Memory+ conditions invite similar encoding processes. This finding would provide evidence in favor of the notion that the act of generating search queries during internet search predicts beneficial consequences for memory.

Method

Methods, procedures, target sample size, exclusion rules, and analysis plan were pre-registered before we started data collection for this experiment (https://osf.io/zvja6/).

Participants

Results from a previous experiment showed that participants better remembered the answers to questions originally looked up on a phone than questions they originally tried to answer from memory (Cohen's d = 0.256). We conducted an a priori power analysis using G*Power 3.9.2 to determine the sample size needed to detect an effect of at least d = 0.256 with 90% power. We deemed 90% power appropriate because the effect in our previous experiment was not predicted, and therefore likely exaggerated. We planned to first recruit a sample of 131 participants, or further until a Bayes Factor of over 3 (or under 0.33) is achieved. According to Jeffreys (1961), Bayes Factors under 3 (and above 0.33) do not constitute much evidence for one hypothesis over another. Participants were recruited through the undergraduate course credit subject pool in the Department of Advertising at a large midwestern university. The final sample contained 139 participants (75.5% women, M_{age}=19.94, SD_{age}=1.33, range = 18-27).

Design

This experiment consisted of a manipulation of query generation method, resulting in a three-level within-subjects design (query generation method: search, memory, memory+).

Materials

Our stimuli consisted of 60 general-information questions on topics like history, geography, and pop culture gathered from Ward (2013). These questions range from easy to moderate difficulty. All questions are "Google-able" such that answers to each question can be found in a knowledge graph (i.e., a textbox at the top of the search results that contains a concise answer with a link to the reference source (e.g., What is a baby kangaroo called? *Answer: Joey*). Appendix B presents the questions and answers used in this experiment.

For the Search condition, participants used either an Apple iPhone 4s or a Google Nexus 5 provided by the lab depending on whether participants owned a smartphone with an iPhone or Android operating system, respectively.

Procedure

All participants completed the same general methodology: a manipulation (study) phase and a recall phase taking place after one-week delay. In the first phase, we manipulated how participants answered 60 general-information questions. In the second phase, we measured recall accuracy through a cued-recall test on all 60 questions.

Manipulation (study) phase. During the manipulation phase, participants answered 10 randomly selected general-information questions presented one at a time across six rounds. Before each round, participants were instructed on how they would be answering the questions. These instructions serve as the main within-subjects manipulation. *Search* condition: "Use Google on the phone to answer these questions. Even if you think you might know the answer to a trivia question, please use the phone to find ALL the answers." *Memory* condition: "Answer these questions as best you can." *Memory+* condition: "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." Participants received corrective feedback after each provided answer on the computer screen directly under their answer text (i.e., right/wrong + correct answer), regardless of condition.

Final cued-recall phase (one-week delay). Participants returned to the lab exactly one-week later to complete the recall phase. During the recall phase, the same 60 general-information questions were presented one at a time in random order. All participants were told that they would be shown the same set of trivia questions and they should answer each question as best they can from their own memory. Participants did not receive corrective feedback after providing an answer to each question. Once they completed this final test, participants answered demographic questions and were debriefed and thanked for their time.

Measures

Cued-Recall. Responses on the cued-recall test were counted as “correct” if they very closely match the correct answer (i.e., slight misspellings or conceptual matches will still count as “correct”). These judgments were made by a research assistant blind to condition and experimental hypotheses.

Reaction Time (RT). RT was recorded for each answer provided measured as the interval of time in seconds (s) between the presentation of the trivia question to the submission of an answer.

Results

All data are available on the Open Science Framework (https://osf.io/zvja6/). Data were analyzed using Bayesian inferences to allow for evaluations in favor of both the null and alternative hypotheses. Specifically, these Bayesian analyses evaluated the likelihood of a point null hypothesis (i.e., Cohen’s $d = 0$) to that of a JZS alternative prior. Following recommendations by Jeffreys (1961), Bayes factors greater than 3 and less than 0.33 are interpreted as the minimum criteria for evidence in favor of the alternative or null, respectively. Comparable analyses using null hypothesis significance testing are included at a false positive rate of 5% for heuristic value.

Cued-Recall

Figure 3 depicts mean accuracy scores across conditions in both phases of the experiment.

An analysis of condition on mean accuracy during the manipulation phase yielded strong evidence in favor of the alternative model, $F(2, 138) = 556.2$, BF_{10}= 1.13E+114, $p < .001$. Differences in mean accuracy between groups were evaluated by conducting pairwise comparisons by Bayesian t-tests for Memory vs. Search, Memory vs. Memory+, and Search vs. Memory+. As expected, mean accuracy during the manipulation phase was higher for items in the Search condition ($M = .867$, $SD = .11$) than the Memory condition ($M = .370$, $SD = .15$, BF_{10}= 2.25E+91, $p < 0.001$) and Memory+ condition ($M = .370$, $SD = .15$, BF_{10}= 2.25E+91, $p < 0.001$). Mean accuracy scores in the Memory condition were about the same as the Memory+ condition (BF_{10}= .144, $p = 0.878$).

An analysis of condition on mean accuracy during the final cued-recall phase yielded strong evidence in favor of the null model, $F(2, 138) = .694$, BF_{10}= 0.05, $p = 0.500$. Mean accuracy scores were about the same between Memory ($M = .624$, $SD = .17$) and Memory+ ($M = .600$, $SD = .17$, BF_{10}= .252, $p = .467$), Memory and Search ($M = .613$, $SD = .17$, BF_{10}= .151, $p = .854$), and Memory+ and Search (BF_{10}= .161, $p = 0.797$).

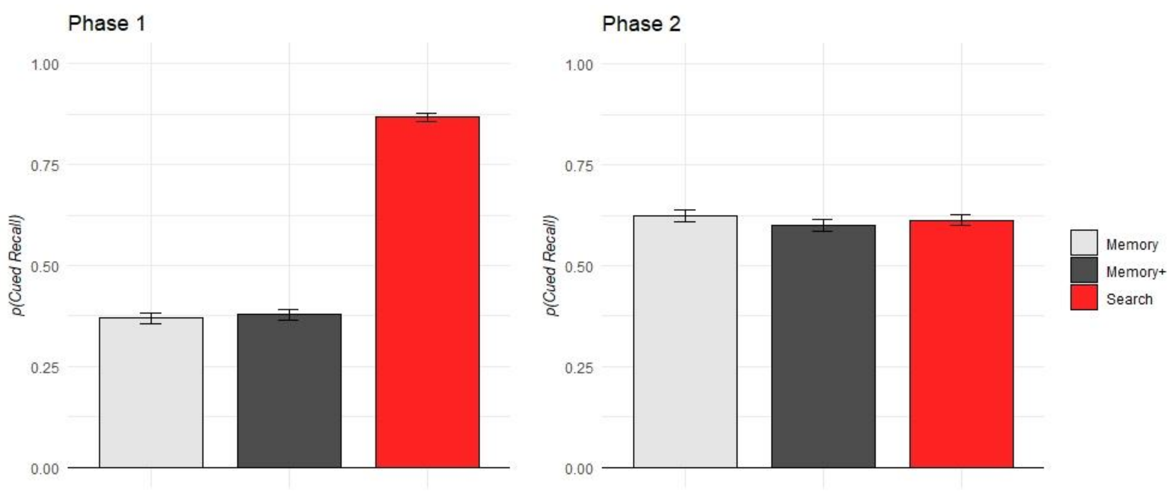

Figure 3. Recall accuracy measured as proportion correct on a cued-recall test during the manipulation phase (1) and the final cued-recall phase (2) collapsed across condition. Error bars represent standard error.

RT

Figure 4 depicts mean RT scores across conditions in both phases of the experiment.

An analysis of condition on mean RT during the manipulation phase yielded strong evidence in favor of the alternative model, $F(2, 138) = 168.3$, $BF_{10} = 4.58E+50$, $p < .001$. Mean RT during the manipulation phase was higher for items in the Memory condition ($M = 10.3$, $SD = 4.38$) than the Search condition ($M = 21.0$, $SD = 5.76$, $BF_{10} = 1.12E+46$, $p < 0.001$) and Memory+ condition ($M = 20.8$, $SD = 4.89$, $BF_{10} = 1.83E+38$, $p < 0.001$). Mean RT scores in the Search condition were about the same as the Memory+ condition ($BF_{10} = .138$, $p = 0.938$).

An analysis of condition on mean RT during the final cued-recall phase yielded strong evidence in favor of the null model, $F(2, 138) = .363$, $BF_{10} = 0.038$, $p = 0.500$. Mean RT scores were about the same between Memory ($M = 7.68$, $SD = 2.90$) and Memory+ ($M = 7.60$, $SD = 3.27$, $BF_{10} = .137$, $p = .955$), Memory and Search ($M = 7.84$, $SD = 3.71$, $BF_{10} = .152$, $p = .846$), and Memory+ and Search ($BF_{10} = .181$, $p = 0.679$).

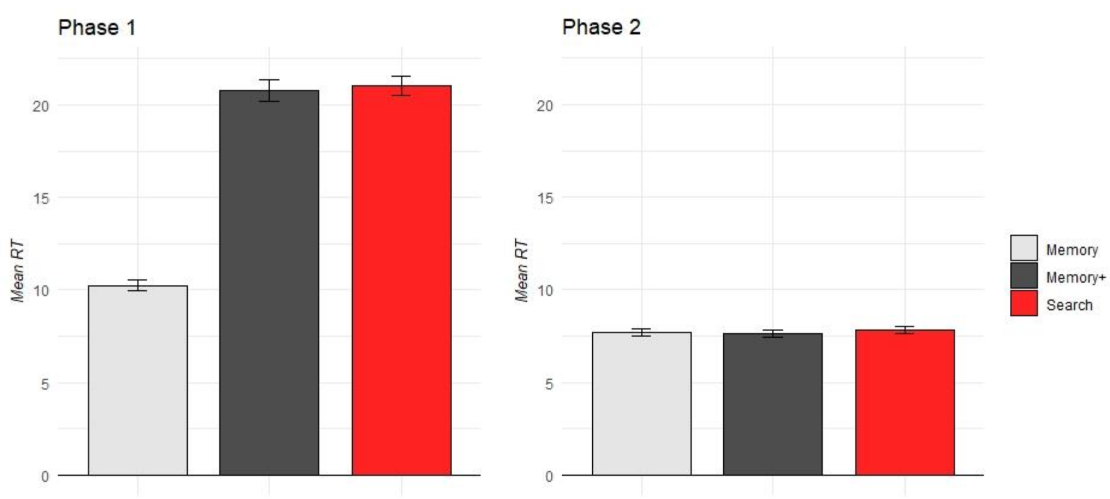

Figure 4. RT measured as the average interval of time in seconds between the presentation of a trivia question to the submission of an answer on a cued-recall test during the manipulation phase (1) and the final cued-recall phase (2) collapsed across condition. Error bars represent standard error.

Discussion

The primary goal of this experiment was to present an empirical example of research that seeks to provide answers regarding the various encoding strategies available to media users and their consequences on the ability to accomplish a particular cognitive goal. In this case, this experiment tests the influence of using a search engine or memory to retrieve information on memory performance under the pretense that query generation is a component of internet search driving the observed effect.

The addition of the Memory+ condition, generating a search query and then answering from memory, allows for a shift in focus from the features of tools that exhibit the capacity for core processes of interest (e.g., using a search tool) to mechanisms underlying those object-outcome links. As noted previously, past investigations of cognitive offloading on performance assumed a one-to-one mapping of the task (i.e., offloading information) and the processes underlying the task. In this way, researchers operated under an assumption that the task of offloading cognition (e.g., saving a file) was process-pure with respect to the type of processing media users undergo during an instance of offloading.

In fact, our research team has previously committed this error while predicting the outcome of a similar experiment that tested the effect of searching on memory performance. In our previous experiment, we had assumed that using a phone to search the Internet would be a passive task, equivalent to a ‘read only’ condition in a generation experiment. Yet, because participants viewed general-information questions on a stationary lab computer, but using a smartphone to search for the answer, participants rarely transcribed the text from the screen to their handheld device verbatim. The act of generating a search query is one way that searching is not an entirely passive experience. An exploratory analysis revealed that participants on average spent much more time completing phone blocks (*M* = 10.147, *SD* = 3.139) than memory blocks (*M* = 25.411, *SD* = 7.789), B_{10} > 10000 (Siler, Hamilton, & Benjamin, 2018). The time spent searching for an answer on a phone may also have given participants more time to contemplate the answer to the query while completing the task. In fact, these findings mimic similar results from a vocabulary learning task reported by Metcalfe and Kornell (2007). In the first phase, participants studied definition–word pairs (e.g., Disdainful; characterized by haughty scorn: *Supercilious*), and then freely-generated targets, were forced to generate targets, or read the targets in a second phase (with and without feedback). In a third phase, participants tried to produce the word corresponding to each of the definitions (cued recall). To the experimenters' surprise, the generation conditions did not result in superior memory performance compared to the read-only conditions. In follow-up experiments in which learners were only able to *passively* read the materials, a large generation effect was observed. These findings indicate that self-generation does not in and of itself produce superior memory compared to internet search, and instead, evidence of improved recall has more to do with the encoding processes that those strategies tend to recruit. The outcome of this experiment motivated the current investigation concerning memory benefits to information retrieval via internet search. In the proposed study, we argued that the process of actively generating a search query during internet search potentiates superior recall of the searched content.

Using the extended organism framework, we can see how memory is not only a product of a general ability to remember, but also an ability to make strategic decisions about encoding. By viewing a media user's performance as the product of both external and internal cognitive processes, we are able to draw inferences from our data that more accurately reflect cognitive processes and outcomes that occur in human-technology interactions. One advantage of internet search, for example, is its capacity for “deep” processing, where greater *depth* implies more meaningful analysis (e.g., images, associations) of information; and subsequently, more elaborate, longer lasting memory traces (Craik & Lockhart, 1972). For example, after a question is presented (e.g., “What animal represents the astrological sign of Cancer?”) the internet searcher often adapts the query by selecting keywords and ignoring irrelevant syntax (e.g., “astrology cancer symbol”) in a way that minimizes effort and maximizes the expected signal-to-noise ratio of the search. This act of information reduction guarantees a considerable degree of active engagement by the user on the query. An effective user will make decisions about which terms are likely to lead to an overabundance of information and modify or eliminate such terms. Yet another opportunity for deep processing during internet search occurs when a response to the query has been returned by the system. Internet search provides the user with a snippet of each potential response’s content, allowing the user to narrow down the search set further before committing to an in-depth examination of a particular piece of content.

However, research has only begun to evaluate the memory consequences of internet search, and has paid little attention to the underlying cognitive processes that are responsible for memory effects. To date, researchers have mostly directed their attention to the negative consequences of internet search on memory (e.g., Barr, Pennycook, Stolz, & Fugelsang, 2015; Dong & Potenza, 2015; Sparrow, Liu, & Wegner, 2011). Research by Sparrow and colleagues (2011) has shown that people have lower rates of recall for information they believed would be accessible in the future compared to information they believe would be erased—a phenomenon coined the *Google Effect*. Searching the Internet has also been associated with lower accuracy in recalling information as compared to traditional book searching (Dong & Potenza, 2015). These findings stand with a popular notion that Google is changing the way we think—and not for the better (Carr, 2008).

The results of previous studies that point to negative effects of internet search on memory tend to tacitly promote the idea that searching the Internet is a passive activity. For instance, it makes sense that erased information is better remembered than saved information because there is no need to fully encode information that you are told will be available on demand at a later date. It also makes sense that finding answers to questions through the use of a printed encyclopedia leads to better recall of those answers than through an internet search engine because the time spent to find an answer in an encyclopedia requires a considerable degree of active engagement by the user on the task—so much engagement that, in an era when it was the only option for information search, it was avoided by all by the most curious and studious learners. Although these findings appear to indicate that internet search has negative consequences for memory, our starting point is the same as theirs: that more sustained cognitive involvement in the processes underlying search cue generation and outcome evaluation will lead to better memory. The cognitive benefits of internet search will depend on the degree to which the search task allows for such involvement, not whether the Internet is involved in the retrieval process.

Now, we can use this evidence to evaluate the contexts during which each of these two encoding strategies are suitable for the task at hand. As discussed in Chapter 2, what constitutes optimal memory behavior involves knowing how to increase access to useful information, while decreasing the cost of doing so. Necessarily, the cognitive consequences of employing either encoding strategy depends on the demands of the task and the end goal. For example, if the goal is to learn answers to questions (i.e., retain information internally long-term), then our evidence suggests that either encoding strategy would be suitable. If the goal were simply to answer those questions as accurately as possible, then evidence of superior accuracy in the Search condition than the Memory condition during Phase 1 suggests that online search would be a more appropriate decision. If the goal were to answer questions as quickly as possible, regardless of accuracy, then evidence of smaller RT in the Memory condition than the Search condition during Phase 1 suggests memory retrieval would be a more appropriate decision.

In a technology-rich environment, where the information we seek is accessible at any time and everywhere, the overarching message of this research is theoretically significant—a full understanding of cognition in the digital age should not view cognitive technology (e.g., internet search engines) as supplanting human memory, but rather as *diversifying* memory. In doing so, it poses new coordination demands on the user that warrant empirical attention.

Chapter 4

METACOGNITION

Metacognition: A Concept Explication

The second subprocess associated with more sophisticated media use is understanding how media users monitor and control the state of information available "in the head" and information out in the world in pursuit of their various goals.

Metacognition is the ability to monitor the state of one's own knowledge, or simply a person's knowledge about their knowledge. The study of metacognition is driven by the understanding that the ability for a person to monitor their own knowledge underlies the ability to make appropriate decisions about encoding (Nelson & Narens, 1994). When a person chooses to offload responsibility, they enter a transactional relationship with the information source. In other words, the "knowledge" required to complete the task is external to the person. Therefore, the ability to complete the task is contingent on their ability to access the external information later on.

Still, how people think about and monitor their own performance is highly imperfect (Soderstrom & Bjork, 2015). Because people can only make judgments based on subjective cues that are available at the time the judgment is made, there are countless ways in which a media user may misinterpret, or completely miss, metacognitive cues related to the task. Recent research suggests having unfettered access to the world's knowledge via an internet-connected device makes the decision to offload even more tempting in the future. For example, Storm and colleagues (2017) showed that participants who searched Google for answers to difficult trivia questions were more likely to rely on Google to answer easier trivia questions compared to participants who initially answered difficult trivia questions from memory. These findings suggest that relying on Google for outsourced knowledge influences the propensity to use Google in the future, even though this future use may not be necessary. In a similar vein, Ferguson and colleagues (2015) showed that people who relied on Google for answers to trivia questions were less willing to provide their own answers to questions. This suggests that the tendency to rely on external sources may influence the metacognitive processes that govern our beliefs about what we know or don't know and our subsequent decisions about the extent to which we should rely on outsourced knowledge to support cognition. Although cognitive offloading *can* be adaptive in certain contexts, it requires accurate metacognitive monitoring (e.g., do I know this?) and metacognitive control (e.g., should I search?).

The fundamental purpose of metacognitive experiments is to evaluate how well metacognition reflects memory (Benjamin & Diaz, 2008). Metacognitive judgments are considered to be accurate when individuals show some sort of a calibrated assessment of their memory's failings and successes. Metacognitive accuracy can be difficult for a media user to achieve given that various features and affordances of media may influence metacognition in ways that are currently unknown to the user. Several researchers have begun to investigate the influence of cognitive offloading on metacognition. For example, Dunn, Gaspar, McLean, Koehler, & Risko (2018) found that people's ability to accurately monitor their performance was worse during situations where an external aid was used. Siler, Hamilton, and Benjamin (2018) found support for their claim in a related study—memory for the original source of information (external vs. internal) was worse for information searched online compared to information retrieved from memory. The tendency to offload responsibility for information to digital source may negatively influence metacognitive accuracy. The goal of the current experiment is to determine whether the act of offloading cognitive responsibility to technology leads to poorer metacognitive accuracy under the assumption that sharing cognitive responsibility with technology may make it more difficult to differentiate between attributes of technology and the self.

Hamilton & Benjamin: Metacognitive Accuracy

This experiment investigates the effect of various offloading tendencies on calibration of future metacognitive monitoring. When a person chooses to offload responsibility for information to a digital counterpart, the ability to make use of this information in the future is contingent on their ability to accurately assess where information is located within their extended cognitive system. This is where metacognitive accuracy plays an important role. Metacognitive judgments are considered to be accurate when individuals show some sort of a calibrated prediction of future failures and successes. Previous research suggests that sharing responsibility for information with the internet leads to undue confidence in internal cognitive abilities (Fisher, Goddu, & Keil, 2015; Ward, 2013). However, less is known about how this inflated sense of confidence influences the *calibration* and *resolution* of media users' judgments. Therefore, the goal of Experiment 1 was to determine whether the act of offloading cognitive responsibility to technology leads to poorer metacognitive accuracy, under the assumption that sharing cognitive responsibility with technology makes it more difficult to differentiate between attributes of technology and the self (H_0: Evidence for Constant search = Memory = Baseline and H_1: Evidence for Constant search ≠ Memory ≠ Baseline).

If search induces overconfidence, we can expect participants in the Constant search condition to report more confident metacognitive judgments compared to participants in the Memory condition and for scores to be independent of recall.

H1. Participants in Constant search will have higher metacognitive judgments compared to Memory and Baseline conditions (Hypothesis 1: Constant search > Memory & Baseline).

Additionally, metacognitive accuracy will be compared between all 3 conditions by conducting pairwise comparisons by Bayesian t-tests for Constant search/Memory, Constant search/Baseline, and Memory/Baseline (using a JZS prior). We predict:

H2. Participants in Constant search will have worse metacognitive accuracy (calibration) compared to Memory and Baseline conditions (Hypothesis 2: Constant search < Memory & Baseline).

If participants in the Constant search condition have worse metacognitive accuracy than Memory and Baseline conditions, it can be suggested that the act of searching may contribute to poorer monitoring. If participants in the Constant search condition have higher metacognitive accuracy than memory and baseline conditions, it can be suggested that the act of searching may be important to more accurate monitoring of the extended cognitive system.

Method

Participants

An a priori power analysis using G*Power 3.1.9.4 indicated that about 82 participants per condition would provide sufficient power (greater than 80%) to detect an effect of at least d = .2 at a false positive rate of 5%. The original sampling plan was to first recruit a sample of 250 participants, or further until a Bayes Factor of over 3 (or under 0.33) is achieved. According to Jeffreys (1961), Bayes Factors under 3 (and above 0.33) do not constitute much evidence for one hypothesis over another. Participants were recruited through the undergraduate course credit subject pool in the Department of Advertising at a large midwestern university. In response to the COVID-19 pandemic, the university suspended face-to-face instructions for the rest of the spring 2020 semester and the Department of Advertising Sona System suspended all in-person data collection. As a result, the reported sample contains 90 participants.

Design

This experiment consisted of a manipulation of retrieval method during the first of three rounds, resulting in a three-level between-subjects design (retrieval method: memory, constant search, baseline).

Materials

Our stimuli consisted of 60 general-information questions on topics like history, geography, and pop culture. All questions contain answers with a numerical value (e.g., What year did the first person land on the moon? *Answer: 1969*). Appendix C presents the questions and answers used in this experiment.

Procedure

All participants completed the same general methodology: a manipulation phase, a prediction phase, and a recall phase.

Manipulation phase. During the manipulation phase, 20 general-information questions were randomly selected and presented one at a time. In the *Memory* condition, participants viewed a trivia question and answered the best they could from their own memory by typing their answer. In the *Constant Search* condition, participants viewed a trivia question and pressed a search icon on their screen to view the answer. Once they saw the answer, participants typed their answer. In the *No Search* condition, participants completed a filler arithmetic problem set of equivalent length.

Prediction phase. During the metacognitive judgment phase, 40 new general-information questions were selected and presented one at a time. All participants were told that they would be shown a new set of trivia questions and would be asked to predict whether or not they would need to search for the answer in about 10 minutes. They were also told that each question would be presented on the screen for a duration of 6 seconds and they should try to make their predictions as quickly and as accurately as possible. The response scale ranged from 1 (*I am SURE I need to SEARCH the answer*) to 4 (*I am SURE I KNOW the answer*).

Recall phase. During the recall phase, the same 40 general-information questions were presented one at a time in the same order as the prediction phase. All participants were told that they would be shown the same set of trivia questions and they should answer each question as best they can from their own memory. Once they completed this final test, participants answered demographic questions and were debriefed and thanked for their time.

Measures

Metacognitive judgment. A single item measured metacognitive judgment ratings after each question was presented during the prediction phase. Responses were prompted by the text, "You have 6s to predict the probability of recalling the answer to this question." Responses were recorded on a 1 to 4 interval scale in which higher prediction ratings indicate more confidence in personal knowledge [1=I am SURE I need to SEARCH the answer, 2= I MIGHT need to SEARCH the answer, 3=I MIGHT KNOW the answer, 4=I am SURE I KNOW the answer].

Cued-Recall. Responses on the cued-recall test (i.e., recall phase) were counted as "correct" if they were within 10 years of the correct answer.

Metacognitive accuracy. Metacognitive accuracy was measured in terms of a calibration curve and the Goodman-Kruskal gamma correlation (Nelson, 1986).

Results

All data will be available on the Open Science Framework (https://osf.io/ebj3h/). Data were analyzed using Bayesian inferences to allow for evaluations in favor of both the null and alternative hypotheses. Comparable analyses using null hypothesis significance testing are included at a false positive rate of 5% for heuristic value.

Metacognitive judgments

Figure 5 depicts mean judgment responses across conditions. An analysis of condition on mean judgments ratings yielded evidence in favor of the null model, $F(2, 94) = .559$, $BF_{10} = 0.13$, $p = 0.705$. Differences in mean judgments between groups were evaluated by conducting pairwise comparisons by Bayesian t-tests for Memory vs. Baseline, Constant Search vs. Baseline, and Memory vs. Constant Search (using a JZS prior). Mean metacognitive judgment in the Memory condition ($M = 1.82$, $SD = .45$) was about the same as the Constant Search condition ($M = 1.85$, $SD = .46$, $BF_{10} = 0.06$, $p = 0.967$) and Baseline condition ($M = 1.74$, $SD = .40$, $BF_{10} = 0.28$, $p = 0.573$). We did not have enough evidence to evaluate differences between Constant Search and Baseline conditions ($BF_{10} = 0.93$, $p = 0.594$).

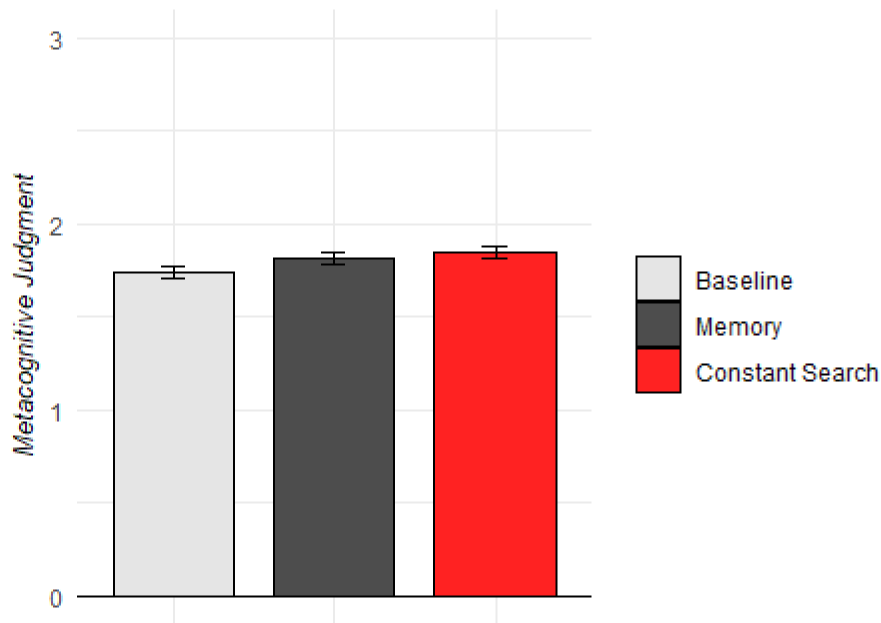

Figure 5. Mean metacognitive judgment ratings collapsed across condition (1=I am sure I need to SEARCH the answer to 4= I am sure I KNOW the answer). Error bars represent standard error.

Relative Calibration

As a measure of relative accuracy (i.e., one item relative to another), a Goodman-Kruskal gamma correlation (γ) was computed between metacognitive judgments and subsequent recall with one γ computed for each subject. Figure 6 depicts mean γ scores across conditions. An analysis of condition on mean γ correlations yielded evidence in favor of the null model, $F(2, 94) = .401$, $BF_{10} = 0.13$, $p = 0.671$. Mean γ correlations in the Memory condition ($M = 1.82$, $SD = .45$) was about the same as the Constant Search condition ($M = 1.85$, $SD = .46$, $BF_{10} = 0.27$, $p = 0.992$) and Baseline condition ($M = 1.74$, $SD = .40$, $BF_{10} = 0.32$, $p = 0.745$). We did not have enough evidence to evaluate differences between Constant Search and Baseline conditions ($BF_{10} = 0.34$, $p = 0.712$).

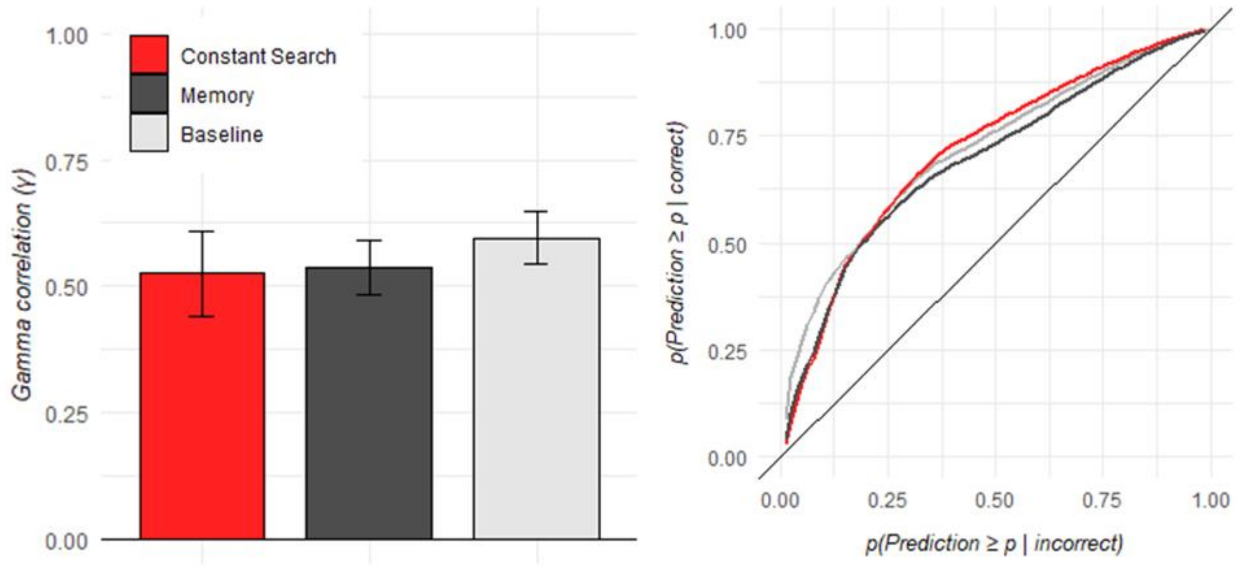

Figure 6. Relation between metacognitive judgments and cued-recall performance as operationalized by the value of the Goodman-Kruskal gamma correlation (γ) as a function of the search manipulation (Constant Search vs. Memory vs. Baseline; left). An estimate of the isosensitivity function from data as operationalized by the cumulative proportions across the rating scale from right to left, such that the fourth level (i.e., "I am sure I KNOW") contains the proportion of all four responses (right). The sensitivity of the ratings can be evaluated by the distance of the isosensitivity function from chance performance indicated by the diagonal line.

Absolute Calibration

The primary focus on metacognitive accuracy was in terms of relative calibration, in which the association between performance and judgments is evaluated. An analysis of metacognition in terms of the absolute calibration, in which mean performance and mean judgments collapsed across judgment ratings and conditions, was also conducted to summarize the degree to which rating values accurately estimate performance. Figure 7 depicts the proportion of correct responses collapsed across condition at each level of metacognitive judgement rating (1=I am sure I need to SEARCH the answer to 4= I am sure I KNOW the answer).

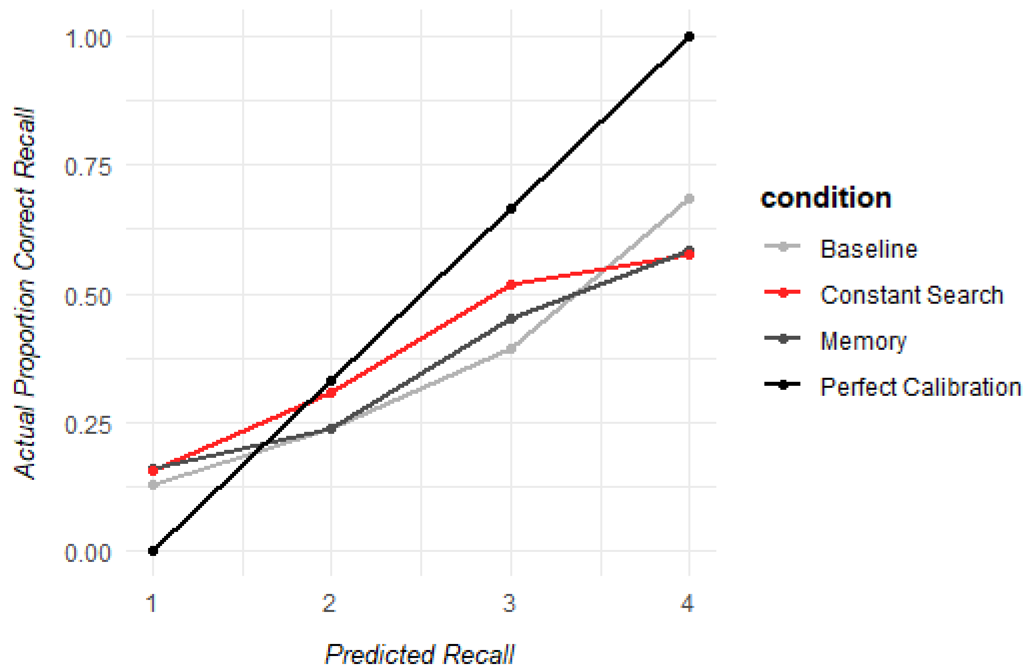

Figure 7. Calibration curve representing mean proportion of recall at each level of predicted recall by condition. Metacognitive accuracy as a function of the search manipulation can be evaluated by the degree to which lines resemble the main diagonal of perfect calibration. 1 = I am sure I need to SEARCH the answer, 2 = I might need to SEARCH the answer, 3 = I might KNOW the answer, 4 = I am sure I KNOW the answer.

An analysis by Bayesian t-test was conducted to assess differences in recall performance between conditions on predicted recall at the end points of the absolute accuracy function. Proportion correct for questions participants were certain they would need to search was about the same across all three group comparisons: Memory–Constant Search (BF_{10}= 0.269, p = 0.997), Memory–Baseline (BF_{10}= 0.280, p = 0.825), and Constant Search–Baseline (BF_{10}= 0.305, p = 0.819). Proportion correct for questions participants were certain they would know was inconclusive across all group comparisons, except between Memory and Constant Search conditions, which yielded evidence in favor of the null model: Memory–Constant Search (BF_{10}= 0.317, p = 0.999), Memory–Baseline (BF_{10}= 0.423, p = 0.575), and Constant Search–Baseline (BF_{10}= 0.430, p = 0.638). See Table 1 for means and standard deviations.

	P(Correct|SURE-SEARCH)		P(Correct|SURE-KNOW)	
	M	*SD*	*M*	*SD*
Memory	.155	.110	.623	.363
Constant Search	.158	.104	.618	.360
Baseline	.138	.149	.724	.375

Table 1. Descriptive statistics for mean conditional probabilities of correct responses on the final recall test at endpoints of the absolute calibration function.

Discussion

The primary goal of this experiment was to present an empirical example of research that seeks to provide answers regarding the influence of various encoding strategies on metacognition. Specifically, this experiment tests the influence of using a search engine or memory to retrieve information on metacognitive accuracy, which evaluates how well judgments reflect performance.

Making smart decisions about encoding depends on the media user's ability to monitor the state of their own knowledge and monitor the capacity of their external environment to successfully accommodate a cognitive goal. Relying on a digital device to hold on to nonessential or infrequently used information like addresses and birthdates may be adaptive, but the adaptiveness of this decision depends on whether the offloader is reasonably confident that it is not essential for this information to be internally encoded and that they will have access to their digital device when this information is needed. Due to COVID-19, results from this experiment are based on data from 90 participants, approximately one-third of the sample size needed to achieve adequate power based on an a priori power analysis. Results from an analysis of condition on mean judgments ratings yielded evidence in favor of the null model, suggesting that using digital means to constantly search for answers to general-information trivia questions does not induce a search-induced overconfidence demonstrated in prior research (e.g., Fisher, Goddu, & Keil, 2015; Hamilton & Yao, 2018; Ward, 2013). Similarly, results from an analysis of condition on mean gamma (γ) correlations yielded evidence in favor of the null model. Contrary to prior work, constant internet search does not appear to have consequences for the ability to accurately assess personal knowledge. However, we hesitate to draw inferences upon these data until our planned sample size (N= at least 250) is achieved. Figure 8 illustrating metacognitive calibration at each judgment option allows for the heuristic assessment of whether individuals' judgments of knowledge reflect actual memory performance or match a pattern of under confidence or overconfidence. Data from our model suggest a general trend of overconfidence across condition such that participants tend to overestimate their ability to answer general-information trivia questions from their own memory. Interestingly, evidence seems to suggest that participants who either constantly searched or constantly relied on their own memory demonstrate worse metacognitive accuracy than those in the baseline condition at extreme ends of the judgment scale (i.e., I am SURE…), but not at middle ranges of the judgment scale (i.e., I MIGHT…). Understanding strategic memory skill in terms of relative and absolute calibration directs the researcher's evaluation of findings toward understanding a person's ability to take appropriate action in pursuit of goals, rather than understanding simply a person's perceptions under the influence of technology.

Given the transactive nature of digital media use, we can expect digital media to continue to become a pervasive aspect of daily life. That said, we can use evidence from this experiment to better understand the influence of pervasive media on the ability to make appropriate decisions about when digital media are needed for help accomplishing our cognitive goals. If we find that the act of constant search produces poorer metacognitive accuracy than both memory retrieval and baseline, we will have evidence to suggest immersion in a mediated environment will pose negative consequences for metacognition. If we find that both the act of constant search and memory retrieval produces poorer metacognitive accuracy, we will have evidence to suggest that relying on memory alone does not allow the media user to develop the metacognitive intuition to make appropriate decisions about when to search.

Chapter 5

TECHNOLOGICAL BIASES

The empirical study in this chapter is Experiment 2 for a journal article published as:

Hamilton, K. A., & Yao, M. Z. (2018). Blurring boundaries: effects of device features on metacognitive evaluations. *Computers in Human Behavior, 89*, 213-220.

Technological Biases: A Concept Explication

The third subprocess associated with more sophisticated media use is understanding how certain characteristics of technology can impair monitoring and control processes.

Media are playing a large and increasing role in supporting human cognition. The availability of new technology-enabled encoding strategies place responsibility on the media user to select encoding strategies that are appropriate to the demands of a given cognitive task. Doing so requires that the media user has a fairly sophisticated understanding of the limits of their own knowledge and the strengths and weaknesses of offloading information to a digital source. Becoming proficient in monitoring and controlling one's media use is particularly difficult in the face of technological biases that can misinform a person's metacognitive perceptions, often resulting in feelings of overconfidence, or mislead their beliefs about the effectiveness of certain digitally-enabled strategies. *Technological biases* are systematic errors in thinking enabled by aspects of digital media that affect the decisions and judgments media users make. These biases are often a result of the mind's attempt to simplify information at the time of encoding or retrieval. Technologies that augment cognition influence metacognition by imbuing the sense of familiarity or fluency in encoding or retrieving information and other invalid measures of knowledge and performance, which pose consequences for sophisticated media use.

An area of research that illustrates this dynamic between metacognition and media use is related to the concept of processing fluency. According to a review by Alter and Oppenheimer (2009), individuals often rely on the fluency or ease with which information comes to mind as a basis for their metacognitive judgments. Schwarz et al. (1991), for example, showed that the feeling of fluency a person experiences during a cognitive task predicts their metacognitive judgments independently of observable performance. This metacognitive error has also been studied within the context of media use. Ryffel and Wirth (2018) found that individuals who experienced fluency while watching television reports overestimated their knowledge about the issue depicted in the report. Because attributes of media often increase the ease of information retrieval, certain contexts of media use may make it difficult for users to make accurate metacognitive judgments. Hamilton, McIntyre, and Hertel (2016) found that people's ratings of their own job knowledge differed as a function of whether they reported using automatic search functions to find information versus searching manually. For people who reported having more organized files, manual search was associated with higher ratings of knowledge than if they searched with automated functions. The way in which one searches information may draw more or less attention to what one does and does not know.

Technologies that expand the capacity of human cognition, while maintaining an illusion of non-mediation may have particularly powerful effects on perceptions of self (Sparrow & Chatman, 2013; Nestojko, Finley, & Roediger, 2013). Ward (2013) found that individuals who are able to use the internet to search for answers to trivia questions score significantly higher on a survey of Cognitive Self-Esteem (CSE), indicating that they are more confident in their ability to think about, remember, and locate information. Searching the internet may create an illusion that makes it difficult for individuals to distinguish the extent to which they rely on outsourced knowledge. Hamilton and Yao (2018) extended this line of research by pointing out that the unique features of the device used to offload cognition may contribute to metacognitive evaluations. When all participants could use the internet to search for information, people who used their personally-owned device reported higher CSE compared to people who used a control (lab) device. This suggests that features and affordances embedded within a human-technology dynamic play an important role in enabling or constraining inflated cognitive evaluations. More recently, Hamilton, Ward, and Yao (2019) investigated the cognitive consequences of accessing information through voice-activated digital assistants, which may simultaneously reduce friction and introduce another mind into the mix. In a wine selection task, participants who used a digital assistant imbued with human-like features reported lower CSE than participants who used a nonhuman-like digital assistant. Transforming our digital interactions into interpersonal experiences may be one way to calibrate our understanding of our own knowledge when we access information online.

Differences in self-assessed knowledge have often been studied through a manipulation of some material feature of a technological medium, generally the specific features a given medium embodies (e.g., Digital assistants [voice vs. no voice]; Smartphones [owned vs. non-owned]; Search engines [typed search vs. non-typed search]). For example, Fisher et al. (2015) found that people who clicked on a link to find answers to questions reported lower self-assessed knowledge than people who actively searched for answers. The findings generate insight by pinpointing the technology-driven variables that bias media users’ perceptions of their personal knowledge and imply negative consequences for decision-making.

The present investigation provides an empirical example of research that seeks to identify technological biases that threaten effective use of media. The goal of this demonstration is to illuminate a possible way of isolating the psychological effects of key technological variables and then to use an extended organism perspective to speculate the effectiveness of this approach with respect to the major shortcomings of media research. In doing so, hopefully researchers will begin to pursue new directions in unraveling the technological biases that can impair monitoring and control processes.

Hamilton & Yao: Ownership and Modality Biases

This experiment directly examines whether differences in the type of device participants used to retrieve information could predict CSE, while holding internet use constant. The main technological attributes of interest were ownership (H_0: Evidence for Owned = Not Owned and H_1: Evidence for Owned ≠ Not Owned) and modality (H_0: Evidence for Smartphone = Laptop and H_1: Evidence for Smartphone ≠ Laptop), which were manipulated in a 2 × 2 between-subjects design. To manipulate ownership, participants either used their own device or a control device (i.e., an unfamiliar device supplied by the lab) to complete a 10-item trivia quiz. To manipulate modality, participants either used a smartphone or a laptop to complete the trivia quiz. At the end of the experiment, participants were asked to complete the CSE scale and report their familiarity with the device used to complete the experiment.

Based on evidence for routine use of a device as a moderator of the effect, we expected that a personally-owned device (compared to an unfamiliar control device) and a mobile device (compared to a stationary device) would be more likely to influence cognitive evaluations. Consequently, we proposed:

H1a: Retrieving answers to trivia questions from a personal (owned) device would result in higher cognitive evaluations compared to retrieving answers from a control device (Hypothesis 1a: Owned > Not Owned).

H1b: Retrieving answers to trivia questions from a smartphone results in higher cognitive evaluations compared to retrieving answers from a laptop (Hypothesis 1b: Smartphone > Laptop).

Method

Participants

We aimed to recruit about 30 participants per cell (total 120 participants) based on the minimum suggested power (80%) used to detect differences between groups (Cohen, 1988; VanVoorhis & Morgan, 2007).[3] During the experiment session, we recruited 147 undergraduate students from advertising classes at a large midwestern university in the United States. Participants completed the study in exchange for extra credit. 32 participants indicated that they did not use Google to search for answers to all ten trivia questions (i.e., searched < 10), and therefore, were excluded from the study. The final sample contained 115 individuals (21 men, 94 women). Ages ranged from 18 to 25 years old (M = 19.63, SD = 1.17). Participants indicated being either "extremely familiar" (n = 112) or "moderately familiar" (n = 3) with Google as a search engine for finding answers. Informed consent was obtained from all participants.

Design

Participants were randomly assigned to one of four conditions—owned smartphone, owned laptop, control smartphone, or control laptop. Participants received an email prior to their lab session with instructions about what they needed to bring to complete the experimental task. During the lab session, each participant was instructed to use the device assigned to them to complete the ten-item trivia quiz and questionnaire that followed (experiment used the same questions from Experiment 1). Before beginning the trivia quiz, all participants were reminded to use their device to find all their answers ("Even if you already know the answer to a question, please use [your personal mobile device/ your personal laptop/ our lab's mobile device/ our lab's laptop] to confirm your answer"). Participants who did not follow the instructions were removed from the study.

Measures

Response accuracy. Responses to the ten-item trivia quiz were scored such that participants received one point for each correct response. Responses were counted as "correct" if they very closely or exactly match the correct answers (slight misspellings or conceptual matches were counted as "correct"). Responses were coded by a research assistant blind to condition and experimental hypotheses.

Cognitive evaluations. Immediately after completing the 10-item trivia quiz, participants completed the Cognitive Self-Esteem Scale (CSE; Ward, 2013). This 14-item scale measures participants' beliefs about their cognitive abilities. The CSE scale contains three sub-components that assess confidence in the ability to think (e.g., "I am good at thinking"), to remember (e.g., "I have a better memory than most people"), and to locate information (e.g., "When I don't know the answer to a question right away, I know where to find it"). Responses were coded on a 7-point scale (1 = strongly disagree to 7 = strongly agree), such that higher ratings would indicate higher levels of CSE. The CSE scale demonstrated good reliability ($\alpha = .93$).

Time spent. Time spent was measured by recording the number of seconds participants spent answering the trivia questions from when the page loaded to when the "Next" button was selected.

Results

Data were analyzed using null hypothesis significance testing at a false positive rate of 5%. Comparable analyses using Bayesian inferences are included where possible for heuristic value.

Operational Familiarity. A single-item question assessed the extent to which participants felt familiar with the basic features of the device they used to complete the trivia quiz (from 1 = not at all familiar to 100 = extremely familiar).

Inclusion of Device in the Self (IDS) Scale. The IDS scale is adapted from the Inclusion of Other in the Self (IOS) scale measuring interpersonal interconnectedness characterized by a lessened self/other distinction (Aron et al., 1992). In the IDS Scale, respondents select the picture that best describes their relationship from a set of seven Venn-like diagrams each representing different degrees of overlap of two circles representing "Self" and "Device."

Frequency of Use. This question assessed the extent to which participants used their device as part of their daily routine (from 1 = strongly disagree to 5 = strongly agree).

Device Attachment. This measure asks participants to indicate their agreement with 11-items related to their device use (e.g., "If I did not have my device with me, I would be uncomfortable because I could not stay up-to-date with social media and online networks"). Responses were coded on a 7-point scale (1 = strongly disagree to 7 = strongly agree), such that higher ratings would indicate higher levels of attachment. This measure was adapted from a nomophobia questionnaire (Yildirim, 2014), which measured the fear of not being able to use a device and/or the services it offers. Participants responded to the questionnaire for their attachment to their smartphone and laptop computer separately. The device attachment scale demonstrated good reliability ($\alpha = .95$).

Hypothesis 1: Effect of Ownership and Modality conditions on CSE

A two-way ANCOVA was conducted to evaluate the effect of Ownership (own versus control) and Modality (smartphone versus laptop) on CSE ratings while controlling for response accuracy to the ten-item trivia quiz.[1] In support of the main prediction, results indicate a significant main effect of Ownership, such that participants had higher overall CSE scores when they used their own device (M = 5.21 SD = .74) compared to participants who used a control device (M = 4.93, SD = .90) to complete the experiment, $F(1, 115) = 4.07$, $p = .046$, $\eta^2_{partial}$ = .036. Also in support of our main prediction, results indicate a significant main effect of Modality, such that participants had higher overall CSE scores when they used a smartphone (M = 5.30, SD = .86) compared to participants who use a laptop (M = 4.82, SD = .74) to complete the experiment, $F(1, 115) = 8.43$, $p = .004$, $\eta^2_{partial}$= .071 (Figure 8). The interaction effect of Ownership and Modality on CSE was not significant (p = .934).

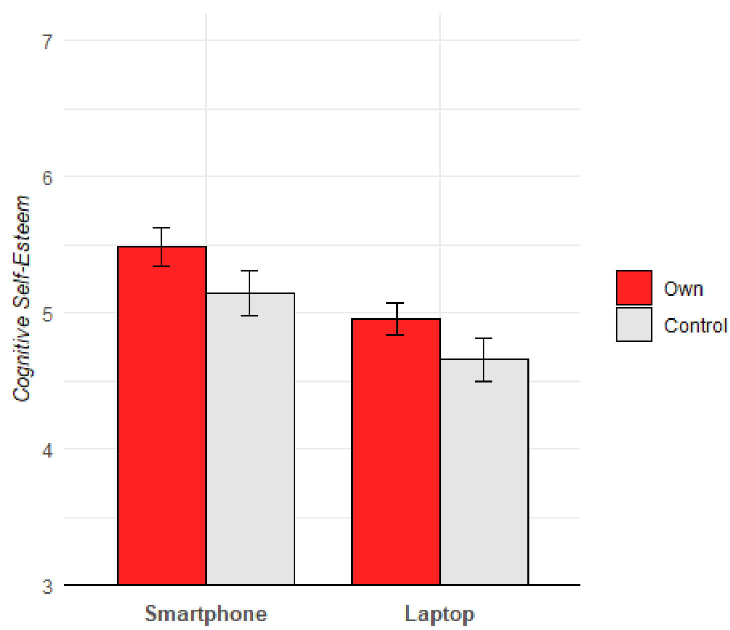

Figure 8. Effect of ownership and modality manipulations on Cognitive Self-Esteem (CSE) scores (n=115). Error bars represent standard error.

[1] The original manuscript did not control for response accuracy.

Exploratory Mediation Analysis: CSE TM Mediates the Effect of Modality on CSE Thinking

The hypothesized process was tested by mediation analysis using the PROCESS macro (Hayes, 2018) with 5,000 bootstrapped samples to test whether the relationship between modality and heightened confidence in internal knowledge can be explained by confidence in the ability to use digital tools to accomplish intellectual goals. The model predicts mean responses to the CSE thinking sub-component (e.g., "I am smart") with modality as the independent factor (0 = smartphone, 1 = laptop) and mean responses to the CSE transactive memory (TM) sub-component (e.g., "I have a knack for tracking down information") as the mediator. Consistent with H1, the regression of modality on CSE thinking was significant (β = -.47, *SE* = .17, *p* = .048). Step 2 showed that using a smartphone to answer general-information questions produced significantly higher scores on the CSE TM sub-component than using a laptop (β = -.36, *SE* = .16, *p* = .032). Furthermore, scores on the CSE thinking sub-component were significantly and positively related to scores on the CSE TM sub-component (β = .57, *SE* = .08, $p < .001$). In Step 3, the model indicated a significant indirect effect of modality condition on CSE thinking via CSE transactive memory (β = -.21, *SE* = .10) because bootstrapping analysis with 5,000 interactions did not include 0 ([-.43, -.02]). The direct effect of modality condition on the CSE thinking sub-component, controlling for the influence of responses to the CSE TM sub-component was not significant (β = -.27, *SE* = .14, *p* = .055). These observations support the prediction that CSE TM mediates the effect of modality condition on CSE thinking. A comparable mediation analysis was conducted to test whether the relationship between ownership and heightened confidence in knowledge can be explained by confidence in the ability to use digital tools to accomplish intellectual goals, however the regression of ownership on CSE thinking (Step 1) was not significant (p = .059).

Exploratory Multiple Regression Analysis: Relationship between Device Familiarity, Attachment, IDS, and Frequency of Use on CSE-TM

Data were analyzed by multiple linear regression to develop a model for predicting the transactive memory sub-component from aspects of familiarity. Basic descriptive statistics and regression coefficients are shown in Table 2. The four predictor variables accounted for 56.7% of the variance in CSE-TM, which assesses people's perceived ability to accomplish their intellectual goals with digital tools, $F(4, 110) = 13.05$, $p < .001$, $R^2 = .567$. Device familiarity (β = .024, SE = .004, p < .001) and attachment (β = .16, SE = .05, p = .002) were significant predictors of CSE-TM.

	Zero-Order *r*					β	*SE*	*p*
Predictor	CSE-TM	A	B	C	D			
Operational Familiarity[A]	.480*					.024	.004	.000
Device Attachment[B]	.218*	-.067				.162	.050	.002
IDS[C]	-.052	-.025	.181			-.065	.040	.107
Frequency of Use[D]	-.235*	-.216*	-.090	-.318*		-.267	.146	.071
M	5.38	88.38	17.99	4.00	1.24			
SD	.90	17.04	1.44	1.90	.52			

Table 2. Descriptive statistics, correlations, and multiple-regression statistics for the relationship between operational familiarity, attachment, IDS, and frequency of use on CSE-TM. N = 115, *p < .05.

Discussion

The goal of this experiment was to present a concrete example of research that seeks to identify the various technological biases that impair monitoring and control processes relevant to strategic decision-making about media use. In this case, this experiment examines the role of ownership and modality on perceptions of knowledge operationalized as cognitive self-esteem (Ward, 2013).

Being effective in assessing one's own knowledge, let alone their extended knowledge, demands the understanding that media users are subject to innumerable biases during the monitoring process. This experiment demonstrates that using a personally-owned or mobile device to offload cognition uniquely influences perceptions of personal knowledge. Indeed, feelings of confidence are likely to occur when the successful retrieval of information via digital means is judged as an indicator of internal knowledge when accessed through a device that is easily conflated as a natural extension of self.

Applying an extended organism lens to the evaluation of this study provides greater insight into the implications of these findings for the strategic selection of a media strategy. First, employing an approach that seeks to study technologies in terms of the specific variables they embody allows the researcher to isolate the effects of key technological variables on outcomes—in this case, knowledge confidence—relevant to strategic media use. Still, in a dynamic and constantly-evolving media environment where our actions are a product of the complex relational structure in human-technology partnerships, it is less useful to draw inferences from a manipulation of the material features of a device (e.g., smartphone vs. laptop) because it does not help us to explain the psychological and behavioral mechanisms that help to predict these outcomes in the long-term as outcomes emerge in the dynamic relation between the user, the material features, and the situated nature of use (Evans et al., 2017).

Nonetheless, until experiments are able to narrow in on the underlying phenomena that endure technological change, it is difficult to see how research will be able to spur a systematic study of novel technology-driven cognitive bias that threaten effective use of media at a broad level. Flanagin (2020) articulates potential solutions to this methodological problem, such as: (a) considering technologies only as manifestations of underlying phenomena, (b) focusing on the capacities of technologies that span across tools, and (c) emphasizing the development of theories that illuminate core processes that are inherently connected to technologies. The extended organism lens shows promise as an approach to facilitate development of such a solution as these aforementioned solutions are critical assumptions embedded within an extended organism approach, i.e., one that seeks to understand human behavior by understanding the process and abilities of the human-technology extended organism within its broader environment.

The strategy of exploring data to unravel underlying processes of search-induced overconfidence contrasts with the strategy of understanding the outcome of an object-centered manipulation of device and may provide one solution to the aforementioned problems. The results of an exploratory mediation analysis demonstrates that using a mobile smartphone (vs. a stationary laptop) increased participants' confidence in their ability to use digital tools strategically to accomplish their intellectual goals, which, in turn, increased confidence in their own (internal) knowledge. This supports the notion that search-induced overconfidence occurs through the process of conflating externally-accessible information as internally-produced. The results of an exploratory multiple regression analysis sheds light on the digitally-mediated factors that potentiate such outcomes. A model developed for predicting the transactive memory sub-component from aspects of familiarity accounted for 56.7% of the variance in CSE-TM scores, supporting that search-induced overconfidence are in part based on the application of a global heuristic of cue-familiarity and accessibility (Koriat & Levy-Sadot, 2001; Bhargave, Mantonakis, & White, 2016, Ward, 2013). Specifically, operational familiarity, measured as the ease of using the basic features of the device used to complete the question-answering task, and the degree to which users are attached to their personal devices accounted for a significant portion of the variance in CSE-TM scores. Participants who reported familiarity with basic features of the experimental device or who reported higher device attachment also reported higher evaluations of their own strategic medial skill. This aligns with the trend of the tendency for people to feel more confident in their performance when a task is fluent than when it is disfluent (Kelley & Lindsay, 1993; Koriat, 1993). Confidence in internal knowledge appears to be based in part on the subjective ease with which information comes to mind whether those means of retrieval are digital or not.

Chapter 6

CONCLUSION

Media users' effectiveness in accomplishing their intellectual and behavioral goals reflect their strategic approach to satisfying the variety of demands placed on them. Superior cognitive performance is determined by the nature of the media user's goals and motivations as well as the sophisticated use of digital tools available in a particular context. In this sense, media users are pressed with making appropriate decisions toward goal attainment in the face of various mediated and non-mediated factors that threaten effective decision-making. Ultimately, the role of a strategic media user is to navigate the costs and benefits of engaging technology-enabled strategies, starting with the simple decision to use technology and ending with more complex decisions about the nature of that use.

The goal of this research was to first outline the empirical domain of strategic media skill and then offer a perspective for observing the digital world and for answering questions about psychological processes and phenomena underlying truly skilled media use. We began this conversation with a description of the problem domain. Strategic media skill concerns a person's ability to take appropriate action in pursuit of personal goals in the face of technology-enabled biases that can impair judgments. The necessity for strategic skills surrounding media use is not new, as it is relevant to the effective use of traditional (radio, newspapers) and novel (digital assistants, smartphones) media. Still, swift technological change has contributed to a society that is indebted to the devices that were designed to serve them. In the coming years, strategic media skills will become of paramount importance.

This dissertation presents the extended organism perspective as a guiding framework for discussing the fundamental nature of our human-technology interactions under contexts relevant to the skilled selection of mediated or non-mediated cognitive strategies in pursuit of intellectual or behavioral goals. Specifically, this lens poses it can be helpful in understanding a person's adaptiveness and success in a variety a technology-mediated decision contexts to consider the characteristics of digital memory—the body of rote knowledge and various features of digital technology—as part of the human-technology extended organism, rather than an external environment on which the cognizer acts. Similar to the idea of swarm cognition in termites (Turner, 2011). The extended organism contains a dynamic body of knowledge that reacts and self-regulates in a changing environment and with changing goals. Our access to digital memory shapes the manner in which we achieve our intellectual goals and, simultaneously, our queries and contributions to digital memory shape the nature of the information it possesses and provides to others. Put more simply, choosing an extended organism perspective is to acknowledge that in order to understand the full cognitive consequences of living in today's digitally-mediated environment, we should understand the capacities and risks of the unique group-mind that manifests when we come to expect technology to facilitate the accomplishment of our daily goals. Adopting this perspective should allow the researcher to abstain from, or at least be attentive to, some major shortcomings in media research, such as the temptation to privilege new media devices as important objects of study, the tendency to view humans and the technologies that inform their decisions as separable, and neglecting to acknowledge the enduring effect of our transactions with technologies on subsequent perceptions and behaviors.

Through an extended organism lens, this approach also proposes critical questions that should be asked about strategic media skill, framed through the characterization of a truly sophisticated media user. Those characteristics are: (a) recognizing key aspects of the functional architecture that characterizes the symbiosis between humans and digital media; (b) understanding how various cognitive strategies and techniques made possible by digital media influence short- and long- term communicative and cognitive goals; (c) knowing how media users monitor and control the state of information available “in the head” and information out in the world in pursuit of their various goals; and (d) understanding how certain characteristics of technology can impair these monitoring and control processes. Chapters 3, 4, and 5 offer an explication of the critical concepts underlying each characteristic—strategic encoding, metacognition, and technological biases, respectively—as well as a concrete empirical example that seeks to examine each of the subprocesses underlying strategic media skill. The discussion section at the end of each of these chapters offers an example of how the extended organism perspective can be employed as a process-oriented approach to predict and explain findings relevant to strategic media skill.

Using a theoretical framework that focuses on processes rather than tasks or phenomenological features of digital media facilitates the identification and development of research that emphasizes aspects of technology-mediated human behavior enduring across technologies (Flanagin, 2020) and also serves as a bridge between memory research and research in attention and perception (Jacoby, 1991) and research in decision making (Nelson & Narens, 1994). This will hopefully allow future researchers to evaluate strategic media skill using a systematic approach to provide unique insight that will contribute to broader theories. For example, a central theme across strategic media use scenarios is the critical role of controlled processing underlying performance. The term ‘controlled processing’ here refers to a person’s intentions and is subject to capacity limitations (Lang, 2006). This term stands in contrast to ‘automatic processing’ which refers to an orienting response that occurs as a consequence of stimulation and requires neither intention nor awareness. Like controlled processes, automatic processes can manifest as a source of interference or as a source of facilitation. Further, theories of mediated (e.g., Lang, 2006) and non-mediated (Shiffrin & Schneider, 1977) attention point out that behavioral outcomes underlying our personal goals arise from controlled and automatic processes that co-occur, are embedded in, and enable one another. Adopting a process-oriented approach to the study of strategic media skill facilitates the development of broader theories in this relevant domain. Future work should continue to explore the distinct contributions of active, controlled processing and of passive, automatic processing on skilled media use to unravel the fundamental nature of our digitally-mediated actions and reactions.

The empirical research outlined in this dissertation contributes to a concrete application of the framework to the mediated context of offloading cognition to digital technology via online search. Cognitive offloading describes an encoding strategy where the user takes physical action to augment the information processing requirement of a task so as to reduce cognitive demand (Risko & Gilbert, 2016). Understanding the way that different technology-driven encoding strategies, like cognitive offloading, influence the ability to make appropriate decisions about media use contribute to a better understanding of the new roles and responsibilities of “thinkers” in today’s digital media environment. By that I mean an environment that is saturated by data sources and modes of information transmission that are diverse, complex, interconnected, and importantly, accessible anytime and everywhere. True, people have relied upon technologies to support memory and cognition for centuries with inventions such as the abaci, punch cards, and typewriters. But, only recently has the capacity to access and control enormous amounts of information become a pervasive and inconspicuous part of daily life. Not only do present-day cognizers have near-constant access to the world's body of knowledge (facts, perspectives, how-to's), but they also have access to several tools to help them accommodate the demands of intellectual goals (apps, software).

The availability of new technology-enabled encoding strategies place the responsibility on the media user to select encoding strategies that are appropriate to the demands of a given cognitive task. The experiment in Chapter 3 assessed whether using an internet search engine to find answers to general-information trivia questions influenced memory for those answers one week later than retrieving answers from memory. Answering this question provides media users insight into the memorial consequences of these distinct encoding strategies; doing so from an extended organism perspective allows the researcher to evaluate the consequences of such a finding from a lens that is sensitive to the nature of our digitally-mediated experiences. Performance measures can be used to measure the short- and long-term behavioral consequences associated with various mediated or non-mediated encoding strategies. A reliable indicator of an effective encoding strategy is higher recall or recognition. For instance, in a question-answering task, participants demonstrated equal memory performance for answers searched online and answers retrieved from memory one week after the initial test. Unsurprisingly, participants performed better on the cued-recall test when they were able to use a smartphone to search for their answers, yet participants completed the task much more quickly if they were able to answer from memory and then receive immediate corrective feedback. If we view optimal memory behavior as actions that increase access to useful information while decreasing the cost of doing so, we can infer the contexts during which either encoding strategy should be employed. If a person's goal is to complete the task quickly during phase 1 and perform competently during phase 2, then retrieving from memory should be more adaptive. If a person's goal is to perform competently during both phases, then using a search engine to facilitate task completion will likely be more adaptive. A major strength of an extended organism framework is its ability to provide a systematic lens for evaluating media use that shifts questions from whether or not to search online to when and how.

Still, making smart decisions about encoding depends on the media user's ability to monitor the state of their own knowledge and monitor the capacity of their external environment to successfully accommodate their cognitive goal. Relying on a digital device to hold on to nonessential or infrequently used information like addresses and birthdates may be adaptive, but the adaptiveness of this decision depends on whether the offloader is reasonably confident that they will have access to their digital device when this information is needed. The experiment in Chapter 4 assessed whether constantly searching for answers or constantly answering from memory (manifestations of the two encoding strategies evaluated in Chapter 3) influences the ability to make appropriate decisions about when to search. Answering this question provides media users insight into the consequences of their encoding decisions; doing so from an extended organism perspective allows the researcher to evaluate the consequences of such a finding from a lens that is privy to the transactive nature of our media use. Metacognitive accuracy can be used to measure the extent to which judgments about memory reflect actual memory. A reliable indicator of high metacognitive accuracy occurs when people show some sort of a calibrated understanding of their memory's performance that is independent of actual levels of memory performance. Heuristic evidence from the experiment in Chapter 4 suggests that constant search or constant memory retrieval have similar negative consequences for metacognitive accuracy as demonstrated by lower gamma correlations in memory and constant search conditions than baseline. Given that data collection is still on-going, I hesitate to draw conclusions from these data. However, such a finding would provide face validity for an extended organism model. If sophisticated use of media requires a person to learn principles that can be applied while making decisions about when and how to use digital media to accomplish goals, then invariability in the decision process will likely have negative consequences for the ability to make smart decisions about media use.

Metacognitive accuracy can be particularly difficult for a media user to achieve given that various features and affordances of media may influence metacognition in ways that are currently unknown to the user. The experiment in Chapter 5 investigated the effect of ownership and modality features on knowledge confidence. Answering this question provides media users insight into the technological biases that threaten strategic media skill. Specifically, data demonstrate that participants hold higher confidence in personal knowledge when completing a question-answering task with either a personally-owned or mobile device. Although this is a step toward identifying novel media-driven biases that threaten skilled media use, more work is needed to determine sound, systematic approaches for answering such questions that avoid shortcomings of prior media research.

Together, these findings illuminate practical ways that media users can strategically employ technology during the process of encoding to successfully accommodate the demands of their memory goals and also to discuss how those technology-driven encoding strategies may (ironically) influence the ability to make strategic encoding decisions in the future. Offloading cognition to a reliable device may provide unique opportunities to expand cognition to the extent that the decision to do so is appropriate given the functionality of the device and the nature of the memory goal. Features and affordances of new media offer new opportunities to support human memory, but also pose new coordination demands on the media user to strategically monitor and control the state of their memory.

Implications

The experiments offer evidence to suggest that offloading cognition to a digital source provides new opportunities to extend cognition given that the decision to offload is appropriate to the demands of the task. With near-constant and reliable access to media, there are several advantages to sharing cognitive responsibility with a digital partner. Certain features of these external devices, like their vastness, depth, and longevity, unequivocally outperform human memory, which is fallible in many ways (Schacter, 2001). Yet, as technology plays a large and increasing role in supporting human cognition, we are increasingly facing situations that require us to decide whether we should or should not offload cognition to technology. This decision requires accurate monitoring of one's own knowledge and reasonable understanding of how various offloading decisions influence short- and long-term goals.

In the wake of recent technological advancements, there has been a surge of interest in unraveling the various ways that technology affordances enable, constrain, and alter memory behavior (e.g., Barr, Pennycook, Stolz, & Fugelsang, 2015; Henkel, 2014; Sparrow, Liu, & Wegner, 2011; Storm & Stone, 2014). However, less is known about the possible ways to equip media users with the skill to utilize cognitive offloading to their advantage. If we want to be more productive in understanding and explaining the processes and behaviors of present-day cognizers, our guiding questions must be framed with a consideration of the dynamic ways in which cognizers can strategically engage encoding processes to successfully accommodate intellectual goals. Investigating psychological phenomena relevant to strategic media skill through an extended organism lens provides one solution to this problem.

In general, this research is meant to illuminate unique contexts of memory practice made possible by a new, complex media space; and hopefully, lead researchers toward asking new questions—not about *whether* memory should be extended, but rather—about how to offer new answers to old questions given that memory has been extended. For a full understanding of technology-mediated memory and cognition, we may consider viewing new media technology as diversifying human memory, rather than supplanting human memory. As unique and diverse technology-driven encoding strategies continue to develop, our ability to adaptively integrate internal with external processes, and our ability to monitor the decision to do so, will be increasingly predictive of what it means to be a successful cognitive agent in a digital media environment.

Novel Directions

The extended organism approach was illustrated and critiqued on the basis of cognitive offloading. This is one of many domains that may be of interest to those interested in studying strategic media skill. Here are others:

Cognition Under Surveillance

Data and metadata have become a legitimate currency for technology users to pay for their communication services and security. Masses of people naively or unwittingly trust their personal information—identifiers, interests, click behavior, search history—to corporate platforms often with little understanding of how these data points are used to strategically monitor and exploit users' decision-making processes. As data continue to transform our daily lives through their incorporation in the daily operations of Internet of Things devices, cyber-physical systems, and smart infrastructures, it will become increasingly important to consider unique opportunities for action through emerging technology that pose new consequences for the ability of technology users to make strategic decisions in service of their intellectual and behavioral goals.

One area of undeveloped research concerns a media user's best decision strategy while under surveillance by an observing agent that does not have their best interest in mind. As an example, consider an e-commerce setting where a consumer is interested in reserving a hotel room online. Initially, the consumer acts as a learning agent by searching the internet for relevant services and affordable deals. The consumer may do so by entering keywords on a search engine, clicking sponsored content, or using third-party platforms to determine which hotel room to reserve. As the consumer continues to learn about the options available to them, they simultaneously reveal information to the observing agent, in this case corporate advertisers, about their knowledge and intentions. Likewise, each action the consumer takes to learn more before reserving a hotel room can be used by corporate advertisers to strategically exploit the consumer. The above example is not artificial. When analyzing prices of products presented to shoppers online, Hannak and colleagues (2014) found Priceline alters hotel search results based on the user's history of clicks and purchases. Users who clicked on or reserved low-priced hotel rooms in the past received slightly different results in a much different order, compared to users who clicked on nothing, or clicked/reserved expensive hotel rooms. In general, the knowledge that their data are being monitored and potentially used against them, an intelligent technology user will strategically take actions in order to guide observing agents to incorrect beliefs and, consequently, maximize their utility when it comes to making a decision.

Threats of Misinformation

In August 2016, three months before the US presidential election, an article in The Political Insider made the, shall we say, provocative claim that Democratic candidate Hillary

Clinton sold weapons to the militant group ISIS (Roberts, 2016).Although the election story was quickly verified as false, the "fake news" story generated 789,500 shares, reactions, and comments on Facebook before the news outlet removed the story from its site (Silverman, 2016).According to an article published by BuzzFeed Founding Editor Craig Silverman (2016), the 20 top-performing fake election stories accumulated over 8.7 million Facebook engagements in the final three months of the US presidential campaign. These points illustrate two important elements to consider about the human-machine extended organism. The first is that the internet is shaped by the people who use it. The vast and deep nature of the internet misleads many to treat the internet as an "omniscient" source of external memory. Indeed, several features of the internet, such as the diverse scope of information it covers, the speed at which it is able to access information, and its capacity to be continuously updated with new knowledge, distinguish the internet as a valuable knowledge source with expert information in an unfathomable number of domains.

Yet other features of the internet, such as its indifference toward accuracy and relative permanence, reflect important exceptions to this generality. The proliferation of misleading, oversimplified, or incomplete information leaves the extended organism vulnerable to unprecedented dangers that threaten the successful use of memory. Under these circumstances, the growing symbiosis between internal and external memory poses a new coordination demand on the user to monitor and verify the accuracy of information accessed on the internet. As we become increasingly reliant on the internet for outsourced knowledge, we become more deeply involved in a cognitive system that favors information that is immediate over comprehensive, provocative over substantiated, and affirmative over contravening.

Limitations

Generally, the goal of this research is to study strategic media skill in a broader theoretical context that commits to addressing a wider scope of issues related to access and skill. Specifically, this research uses experimental methods from cognitive and social psychology to help people learn how to access and manage their digital devices strategically within the constraints of their environment. By studying these interactions, a major goal of this research involves building theories about media skill that are flexible to a diverse range of individual contexts and goals. This highlights a critical limiting condition of this work. Although this research may best serve educationally or technological disadvantaged students who have not had the privilege to maintain reliable and secure internet access, this research is predominantly driven by studies represented by well-educated and frequent media users (e.g., university students). Indeed, research methods and ways of thinking in this area fail to consider the full range of experiences and skill levels of technology users, which have significant problems of validity particularly with respect to educationally disadvantaged students or students from culturally diverse groups. Future research will be needed to better understand the generalizability of this model across individuals.

Concluding Remarks

Many aspects of digital media—near-constant internet access, near-limitless rote information storage—can be employed strategically to help people accomplish daily tasks. That said, one’s level of digital media skill strongly influences effective use of these tools. The ability to participate in labor, earn an education, and maintain social contacts are determined by the ability to access and navigate information via digital devices.

To become a truly skilled media user it is necessary to learn the general principles and practices that can be applied while making decisions about when and how to use digital media to accomplish goals. The extended organism framework presents one solution to this problem by providing a concrete way of studying aspects of strategic media skill that better synchronizes the major concepts that give a voice to this research domain so that media researchers are better able to build on each other's work to answer fundamental questions about the mind under the influence of media. Adopting a more consistent stance on the fundamental nature of our human-technology interactions under contexts relevant to strategic media skill and reaching shared agreement on what are the primary questions that should be asked about our topic domain of strategic media skill means that theories can be verified, scrutinized, or extended in a manner that advances the field.

References

Alvarado, M., & Boyd-Barrett, O. (Eds.). (1992). *Media education: An introduction.* British Film Institute.

Anderson, J. R., & Bower, S. (1973). *G. H. Human associative memory*. Washington, DC: Winston & Sons.

Anderson, J. R., & Milson, R. (1989). Human memory: An adaptive perspective. *Psychological Review, 96*(4), 703.

Aufderheide, P., & Firestone, C. (1993). *Media Literacy: A Report of the National Leadership Conference on Media Literacy.* Conference report. Queenstown, MD: The Aspen Institute.

Barr, N., Pennycook, G., Stolz, J. A., & Fugelsang, J. A. (2015). The brain in your pocket: Evidence that Smartphones are used to supplant thinking. *Computers in Human Behavior, 48*, 473-480.

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.

Benjamin, A. S., & Bird, R. D. (2006). Metacognitive control of the spacing of study repetitions. *Journal of Memory and Language*, *55*(1), 126-137.

Benjamin, A. S., & Diaz, M. (2008). Measurement of relative metamnemonic accuracy. *Handbook of memory and metamemory*, 73-94.

Benjamin, A. S., & Ross, B. H. (2008). *Skill and strategy in memory use*. Elsevier Academic Press.

Bennett, S. T., Benjamin, A. S., Mistry, P. K., & Steyvers, M. (2018). Making a wiser crowd: Benefits of individual metacognitive control on crowd performance. *Computational Brain & Behavior, 1*(1), 90-99.

Bhargave, R., Mantonakis, A., & White, K. (2016). The cue-of-the-cloud effect: When reminders of online information availability increase purchase intentions and choice. *Journal of Marketing Research, 53*(5), 699-711.

Bjork, R. A., Dunlosky, J., & Kornell, N. (2013). Self-regulated learning: Beliefs, techniques, and illusions. *Annual review of psychology*, *64*, 417-444.

Boffey, D. (2018, December 10). *Russia 'paved way for Ukraine ship seizures with fake news drive'.* Retrieved from https://www.theguardian.com

Carr, N. (2008). Is Google making us stupid? *Atlantic 302*, 56.

Chaffee, S.H. (1996). Thinking about theory. In M.B. Salwen & D.W. Stacks (Eds.), *An integrated approach to communication theory and research* (pp. 15-32). Mahwah, NJ: LEA.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Erlbaum.

Craik, F. I., & Lockhart, R. S. (1972). Levels of processing: A framework for memory research. *Journal of verbal learning and verbal behavior*, *11*(6), 671-684.

Davachi, L., & Dobbins, I. G. (2008). Declarative memory. *Current directions in psychological science*, *17*(2), 112-118.

Dong, G., & Potenza, M. N. (2015). Behavioural and brain responses related to internet search and memory. *European Journal of Neuroscience, 42*(8), 2546-2554.

Dong, G., DeVito, E. E., Du, X., & Cui, Z. (2012). Impaired inhibitory control in 'internet addiction disorder': a functional magnetic resonance imaging study. *Psychiatry Research: Neuroimaging*, *203*(2-3), 153-158.

Dunlosky, J., & Hertzog, C. (2000). Updating knowledge about encoding strategies: A componential analysis of learning about strategy effectiveness from task experience. *Psychology and aging*, *15*(3), 462.

Dunn, T. L., Gaspar, C., McLean, D., Koehler, D. J., & Risko, E. F. (2018). Distributed Metacognition: Examining the Metacognitions Associated with Retrieval from Internal and External Stores.

Dunning, D., Johnson, K., Ehrlinger, J., & Kruger, J. (2003). Why people fail to recognize their own incompetence. *Current directions in psychological science*, *12*(3), 83-87.

Evans, S. K., Pearce, K. E., Vitak, J., & Treem, J. W. (2017). Explicating affordances: A conceptual framework for understanding affordances in communication research. *Journal of Computer-Mediated Communication*, *22*(1), 35-52.

Ferguson, A. M., McLean, D., & Risko, E. F. (2015). Answers at your fingertips: Access to the Internet influences willingness to answer questions. *Consciousness and Cognition*, *37*, 91-102.

Finley, J. R., Naaz, F., & Goh, F. W. (2018). *Memory and Technology*. Cham, Switzerland: Springer.

Fischhoff, B., & Beyth, R. (1975). I knew it would happen: Remembered probabilities of once—future things. *Organizational Behavior and Human Performance*, *13*(1), 1-16.

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.

Flanagin, A. J. (2020). The Conduct and Consequence of Research on Digital Communication. *Journal of Computer-Mediated Communication*, *25*(1), 23-31.

Goldsmith, M., Koriat, A., & Weinberg-Eliezer, A. (2002). Strategic regulation of grain size memory reporting. *Journal of Experimental Psychology: General*, *131*(1), 73.

Gonzales, A. (2016). The contemporary US digital divide: from initial access to technology maintenance. *Information, Communication & Society*, *19*(2), 234-248.

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.

Hamilton, K. A., McIntyre, K. P., & Hertel, P. T. (2016). Judging Knowledge in the Digital Age: The Role of External-Memory Organization. *Applied Cognitive Psychology*, *30*(6), 1080-1087.

Hamilton, K. A., & Yao, M. Z. (2018). Blurring boundaries: Effects of device features on metacognitive evaluations. *Computers in Human Behavior*, *89*, 213-220.

Hamilton, K.A., Ward, A.F., & Yao, M.Z. (2019). *Minds vs. Machines: Investigating the Role of Anthropomorphism on Knowledge Misattributions in Voice-Activated Consumer Search.* Paper presented at the 50th annual meeting of the Association for Consumer Research, Atlanta, Georgia.

Hannak, A., Soeller, G., Lazer, D., Mislove, A., & Wilson, C. (2014, November). Measuring price discrimination and steering on e-commerce web sites. In *Proceedings of the 2014 conference on internet measurement conference* (pp. 305-318). ACM.

Hargittai, E. (2003). The digital divide and what to do about it. *New economy handbook*, *2003*, 821-839.

Hargittai, E. (2001). Second-level digital divide: Mapping differences in people's online skills. *arXiv preprint cs/0109068*.

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.

Hjarvard, S. (2008). The mediatization of society. *Nordicom review*, *29*(2), 102-131.

Hobbs, R., & Jensen, A. (2009). The past, present, and future of media literacy education. *Journal of media literacy education*, *1*(1), 1.

Houk, A., & Bogart, C. (1974). Media Literacy: Thinking About.

Hunt, R. R., & McDaniel, M. A. (1993). The enigma of organization and distinctiveness. *Journal of Memory and Language*, *32*, 421–445.

Internet Live Stats (2020). Google Search Statistics. Retrieved from http://www.internetlivestats.com/google-search-statistics/.

Jacoby, L. L. (1991). A process dissociation framework: Separating automatic from intentional uses of memory. *Journal of memory and language, 30*(5), 513-541.

Jacoby, L. L. (1978). On interpreting the effects of repetition: Solving a problem versus remembering a solution. *Journal of verbal learning and verbal behavior*, *17*(6), 649-667.

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

Jenkins, H., Clinton, K., Purushotma, R., Robison, A. J., & Weigel, M. (2006). Confronting the challenges of participatory culture: Media education for the 21st century. MacArthur Foundation. *Retrieved on February*, *29*, 2008.

Johnson, M. K., & Raye, C. L. (1981). Reality monitoring. *Psychological Review*, *88*(1), 67.

Kelley, C. M., & Lindsay, D. S. (1993). Remembering mistaken for knowing: Ease of retrieval as a basis for confidence in answers to general knowledge questions. *Journal of Memory and Language*, *32*(1), 1-24.

Kim, J. J., Pinker, S., Prince, A., & Prasada, S. (1991). Why no mere mortal has ever flown out to center field. *Cognitive Science*, *15*(2), 173-218.

Koriat, A. (1993). How do we know that we know? The accessibility model of the feeling of knowing. *Psychological review*, *100*(4), 609.

Koriat, A., & Goldsmith, M. (1996). Monitoring and control processes in the strategic regulation of memory accuracy. *Psychological review*, *103*(3), 490.

Koriat, A., & Levy-Sadot, R. (2001). The combined contributions of the cue-familiarity and accessibility heuristics to feelings of knowing. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *27*(1), 34.

Kubey, R. (1998). Obstacles to the development of media education in the United States. *Journal of communication*, *48*(1), 58-69.

Lang, A. (2006). Using the limited capacity model of motivated mediated message processing to design effective cancer communication messages. *Journal of communication*, *56*, S57-S80.

Lang, A. (2000). The limited capacity model of mediated message processing. *Journal of communication*, *50*(1), 46-70.

Lawrence, F. C., & Wozniak, P. H. (1989). Children's television viewing with family members. *Psychological Reports*, *65*(2), 395-400.

LeCun, Y., Bengio, Y., & Hinton, G. (2015). Deep learning. *Nature, 521*(7553), 436.

Livingstone, S. (2004). Media literacy and the challenge of new information and communication technologies. *The communication review*, *7*(1), 3-14.

McKinley, G. L., Brown-Schmidt, S., & Benjamin, A. S. (2017). Memory for conversation and the development of common ground. *Memory & cognition*, *45*(8), 1281-1294.

McLeod, J. M., & Pan, Z. (2005). Concept explication and theory construction. *The evolution of key mass communication concepts: Honoring Jack M. McLeod*, 13-76.

Metcalfe, J., & Kornell, N. (2007). Principles of cognitive science in education: The effects of generation, errors, and feedback. *Psychonomic Bulletin & Review, 14*(2), 225-229.

Miller, K. I. (2008). Organizational communication. *The international encyclopedia of communication*.

Mueller, P. A., & Oppenheimer, D. M. (2014). The pen is mightier than the keyboard: Advantages of longhand over laptop note taking. *Psychological science*, *25*(6), 1159-1168.

Nathanson, A. I. (2001). Parents versus peers: Exploring the significance of peer mediation of antisocial television. *Communication Research*, *28*(3), 251-274.

Nelson, T. O., & Narens, L. (1994). Why investigate metacognition. *Metacognition: Knowing about knowing*, *13*, 1-25.

Nelson, T. O. (1986). BASIC programs for computation of the Goodman-Kruskal gamma coefficient. *Bulletin of the Psychonomic Society*, *24*(4), 281-283.

Nestojko, J. F., Finley, J. R., & Roediger III, H. L. (2013). Extending cognition to external agents. *Psychological Inquiry*, *24*(4), 321-325.

Oaksford, M., & Chater, N. (2007). *Bayesian Rationality: The Probabilistic Approach to Human Reasoning*. Oxford University Press.

Alter, A. L., & Oppenheimer, D. M. (2009). Uniting the tribes of fluency to form a metacognitive nation. *Personality and social psychology review*, *13*(3), 219-235.

Pew Research Center (2020). Internet Use Over Time. Retrieved from https://www.pewresearch.org/internet/chart/internet-use-over-time/.

Pew Research Center (2019). Frequency of Internet Use. Retrieved from https://www.pewresearch.org/wp-content/uploads/2019/07/FT_19.07.25_ConstantlyOnline_Topline_Methodology.pdf.

Potter, W. J. (2010). The state of media literacy. *Journal of Broadcasting & Electronic Media*, *54*(4), 675-696.

R Core Team (2018). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. https://www.R-project.org/.

Rice, R. E., Hagen, I., & Zamanzadeh, N. (2018). Media Mastery: Paradoxes in College Students' Use of Computers and Mobile Phones. *American Behavioral Scientist*, *62*(9), 1229-1250.

Risko, E. F., & Gilbert, S. J. (2016). Cognitive offloading. *Trends in cognitive sciences*, *20*(9), 676-688.

Roberts, H. (2016, November 17). *This is what fake news actually looks like — we ranked 11 election stories that went viral on Facebook.* Retrieved from https://www.businessinsider.com

Ryffel, F. A., & Wirth, W. (2018). How perceived processing fluency influences the illusion of knowing in learning from TV reports. *Journal of Media Psychology: Theories, Methods, and Applications*.

Schacter, D. L. (2001). *The Seven Sins of Memory: How the Mind Forgets and Remembers.* Boston, MA: Houghton Mifflin.

Schulz, W. (2004). Reconstructing mediatization as an analytical concept. *European journal of communication*, *19*(1), 87-101.

Schwarz, N., Bless, H., Strack, F., Klumpp, G., Rittenauer-Schatka, H., & Simons, A. (1991). Ease of retrieval as information: another look at the availability heuristic. *Journal of Personality and Social psychology*, *61*(2), 195.

Scribner, S., & Cole, M. (1981). Unpackaging literacy. *Writing: The nature, development, and teaching of written communication*, *1*, 71-87.

Shiffrin, R. M., & Schneider, W. (1977). Controlled and automatic human information processing: II. Perceptual learning, automatic attending and a general theory. *Psychological review*, *84*(2), 127.

Sholle, D., & Denski, S. (1994). *Media education and the (re) production of culture*. Praeger Publishers.

Siler, J., Hamilton, K.A., & Benjamin, A.S. (2018). *Did you look that up? Source memory for smartphones.* Paper presented at the 59th annual meeting of the Psychonomic Society, New Orleans, LA.

Silverman, C. (2016, November 16). *This Analysis Shows How Viral Fake Election News Stories Outperformed Real News On Facebook.* Retrieved from https://www.buzzfeednews.com

Simon, H. A. (1996). *The Sciences of the Artificial*. MIT press.

Sinatra, R. (1986). *Visual Literacy Connections to Thinking, Reading and Writing*. Charles C. Thomas, Publisher, 2600 South First St., PO Box 4709, Springfield, IL 62708-4709.

Slamecka, N. J., & Graf, P. (1978). The generation effect: Delineation of a phenomenon. *Journal of experimental Psychology: Human learning and Memory*, *4*(6), 592.

Smith, E. E., Langston, C., & Nisbett, R. E. (1992). The case for rules in reasoning. *Cognitive science*, *16*(1), 1-40.

Soderstrom, N. C., & Bjork, R. A. (2015). Learning versus performance: An integrative review. *Perspectives on Psychological Science*, *10*(2), 176-199.

Sparrow, B., & Chatman, L. (2013). Social cognition in the Internet age: Same as it ever was?. *Psychological Inquiry*, *24*(4), 273-292.

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

Steyaert, J. (2002). Inequality and the digital divide: myths and realities. *Advocacy, activism and the Internet*, 199-211.

Stone, S. M., & Storm, B. C. (2019). Search fluency as a misleading measure of memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition*.

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.

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.

Strömbäck, J. (2008). Four phases of mediatization: An analysis of the mediatization of politics. *The International Journal of Press/Politics*, *13*(3), 228-246.

Sundar, S. S., Narayan, S., Obregon, R., & Uppal, C. (1998). Does web advertising work?

Memory for print vs. online media. *Journalism & Mass Communication Quarterly*, *75*(4), 822-835.

Thiede, K. W. (1999). The importance of monitoring and self-regulation during multitrial learning. *Psychonomic Bulletin & Review*, *6*(4), 662-667.

Turner, J. S. (2011). Termites as models of swarm cognition. *Swarm Intelligence*, *5*(1), 19-43.

VanVoorhis, C. W., & Morgan, B. L. (2007). Understanding power and rules of thumb for determining sample sizes. *Tutorials in quantitative methods for psychology*, *3*(2), 43-50.

Vanian, J. (2018, June 25). *Unmasking A.I.'s Bias Problem.* Retrieved from http://fortune.com

Walther, J. B. (2011). Theories of computer-mediated communication and interpersonal relations. *The handbook of interpersonal communication*, *4,* 443-479.

Ward, A. F. (2013). One with the cloud: Why people mistake the Internet's knowledge for their own. Harvard University.

Watanabe, T. (2001). Effects of constrained choice on memory: The extension of the multiple-cue hypothesis to the self-choice effect. *Japanese Psychological Research, 43*(2), 98-103.

Wegner, D. M. (1987). Transactive memory: A contemporary analysis of the group mind. In *Theories of group behavior* (pp. 185-208). Springer New York.

Wegner, D. M., Giuliano, T., & Hertel, P. T. (1985). Cognitive interdependence in close relationships. In W. J. Ickes (Ed.), *Compatible and incompatible relationships* (pp. 253-276). New York: Springer-Verlag.

van Deursen, A. J. A. M., & Van Diepen, S. (2013). Information and strategic Internet skills of secondary students: A performance test. *Computers & Education*, *63*, 218-226.

Deursen, A. V., & van Dijk, J. A. (2010). Measuring internet skills. *International journal of human-computer interaction*, *26*(10), 891-916.

Van Deursen, A. J., van Dijk, J. A., & Peter, M. (2015). Increasing inequalities in what we do online: A longitudinal cross-sectional analysis of Internet activities among the Dutch population (2010 to 2013) over gender, age, education, and income. *Telematics and informatics*, *32*(2), 259-272.

van Zoonen, W., & Rice, R. E. (2017). Paradoxical implications of personal social media use for work. *New Technology, Work and Employment*, *32*(3), 228-246.

Yang, M., & Roskos-Ewoldsen, D. R. (2007). The effectiveness of brand placements in the movies: Levels of placements, explicit and implicit memory, and brand-choice behavior. *Journal of communication*, *57*(3), 469-489.

Appendix A: Strategic Skill Scenarios

Scenario #1. Consider the case of a journalist completing a news report to be published online. Their short-term goal is to write a report so that all of the facts are correct. Assume in this scenario that the journalist's reliability in verifying the veracity of factual information is 90.00% (they catch 9 of 10 errors). The reliability of the information that this journalist uses to write the report is 70.00% (7 of 10 facts are correct). Therefore, the overall reliability of this article will likely be 97.00%. A fact-checking software is installed on the journalist's computer with a reliability of 80%. The assumption is that it will catch 8 out of 10 errors that the journalist fails to catch. So, the reliability of the article should now be 99.40%.

How does this influence (short-term) performance on the task? Ideally, this would lead to a profitable trade off. If the journalist has the goal of producing reports with near perfect accuracy, then adding this software would allow the journalist to optimize their goal of writing a factual report. Instead, the reliability of the article dropped to 94.00%. Why? This is because the journalist decided to offload responsibility for fact checking to what they considered to be a reasonably reliable software. From this scenario, we see that one benefit of offloading responsibility is that it allows the opportunity for humans to increase access to useful information (e.g., relatively correct facts) while decreasing the cost of doing so (e.g., time spent fact-checking). Yet, if we consider the adaptiveness of the human-technology extended organism, we see that the ecological strengths and weaknesses of the two constituents threaten efficient memory in this scenario. The individual has inferred that it is not necessary for them to fact-check, and the machine does not have the inferencing abilities to surmount the human's role.

There are also several downstream consequences in this scenario. First, we see that choosing to rely on the fact checker comes at the expense of the journalist's fact-checking skill.

As mentioned previously, humans have a unique ability to solve complex problems and effortlessly draw inferences from data. Offloading the responsibility for this skill to a device not only compromises the quality of content, but it restricts future learning of this task. Fact-checking is an essential skill of journalism. Optimally, the journalist would have appropriate knowledge of what the machines was good at (e.g., comparing content from a vast number of online sources) and then use fact-checking strategies that were outside the scope of the machine's abilities (e.g., considering the subtext of the article).

Another downstream consequence is related to the content that is published. When the journalist chooses to offload responsibility to the fact-checker, they are publishing content online that contributes to a crisis of misinformation. Although the internet contains a record of known facts, queries, objects, and writings; it is also a collection of misgivings, biases, secrets, and attempts to distort. The proliferation of misleading, oversimplified, or incomplete information leaves the extended organism vulnerable to new and unprecedented dangers that threaten the successful use of memory. This illuminates another risk of the tradeoff—digital memory does not (inherently) hold the types of self-reflective mechanisms that are characteristic of human memory for evaluating and reevaluating their progress and for changing their on-going processes (Nelson & Narens). In other words, the internet does not seek to establish coherence across its body of knowledge and the fact-checking software does not have the ability to reflect upon whether it is serving an adaptive role to its human partner. This journalist will likely continue to offload this responsibility until a problem arises (e.g., users online point out the poor quality of content) that prompts active reflection.

Scenario #2. Consider the case of a graduate researcher learning to code by analyzing a dataset. Their short-term goal is to analyze a dataset using a commonly used programming language for statistical computing. The researcher begins by watching basic tutorials, but does not understand how to put together arguments. Therefore, the researcher chooses to search online for code that will allow them to easily change variable names and run the necessary analyses on their dataset.

How does this influence (short-term) performance on the task? The researcher is able to accomplish their goal of analyzing a dataset. But, there are also some contextual factors relevant to the completion of the task. For example, in this scenario the researcher tried learning by watching tutorials and when they realized that they still did not know how to analyze their data, they chose to search online. This highlights two profitable tradeoffs that are characteristic of this extended cognitive system. The first is that an extended cognitive system gives the individual access to a vast body of knowledge that can be used to accomplish their cognitive goals. Second, this aspect of the extended cognitive system affords users the flexibility to make strategic decisions about when and how to accomplish their goals. In this scenario, the researcher made an adaptive decision to search the internet by realizing that there is no benefit to trying to learn something that they are not going to get at all. Under the time pressure to produce the analysis, this may have been a smart decision.

To understand the downstream consequences of these offloading decisions, we should consider the unique context of the researcher. First, we should consider that this is the researcher’s first time using this programming language, but also this is a skill they will need to develop for future use. Although choosing to find code online may have reflected an adaptive decision given their short-term goals, it may have been at the expense of future learning. Information that is self-produced is better remembered than information that is presented and passively read (Slamecka & Graf, 1978). A more effective decision may have been to integrate internal and external memory processes that focused on ways to access new information (e.g., different packages and scripts) while drawing connections between this information and the concepts already understood.

Yet, if we consider downstream consequences from an extended organism perspective, we will notice that the reasonable adaptive decision previously mentioned does not strategically consider characteristics of their constituents. For example, say that this research is learning the R computing environment. A major strength of R is that it has open source capabilities so that users can continue to develop and share programs that will accommodate new and complex statistical problems in the future (R Core Team, 2018). Another strength of R is its strong community of active users who help beginner programmers or academics find a particular package or learn how to solve statistical problems. A truly effective researcher would make strategic decisions about encoding with consideration of the unique characteristics of their counterpart. Understanding how to access this community of active users and how to quickly find useful tools and packages are important to consider in the broader context of memory use.

Appendix B: Strategic Encoding General Information Questions and Answers (60 items)

Question	Answer
How many seconds are in a minute?	60
In what state is the Empire State Building located?	New York
What season comes after Fall?	Winter
Who is credited with writing Romeo and Juliet?	Shakespeare
What color do you get when you mix red and yellow?	Orange
What does the "F" stand for in the law enforcement acronym FBI?	Federal
From what city is the "Red Sox" baseball team?	Boston
What car company produces the Mustang?	Ford
What is the name of the currency used in Japan?	Yen
What is the largest mammal in the world?	Blue Whale
Who was the first man on the moon?	Neil Armstrong
In what time zone is the state of Maine?	Eastern
Who painted the Mona Lisa?	Leonardo da Vinci
What is the name of the longest river in the world?	Amazon
In which US city is Hollywood located?	Los Angeles
In what country did the Olympic Games originate?	Greece
Who directed the movie Titanic?	James Cameron
How many days are there in April?	30
What is the name of the highest mountain in the world?	Everest
What currency is used in Germany?	Euro
What is a baby kangaroo called?	Joey
Who painted the Sistine Chapel?	Michelangelo
What is the capital of Alaska?	Juneau
What is the smallest state in the USA (in terms of land area)?	Rhode Island
Who wrote the horror book The Shining?	Stephen King
What is the capital of Australia?	Canberra
In what US city were the 2002 winter Olympics held?	Salt Lake City
What is the most spoken language on Earth?	Chinese
What is the capital of California?	Sacramento
During games, how many basketball players from one team are on the court?	5
What is the fastest land animal in the world?	Cheetah
What male athlete has won the most Olympic medals?	Michael Phelps
Who wrote the children's book The Chronicles of Narnia?	C.S. Lewis
What is the capital of Peru?	Lima
What animal represents the astrological sign of Cancer?	Crab
Which US state is called the volunteer state?	Tennessee

Who directed the film Psycho?	Alfred Hitchcock
Which fast food restaurant chain was established by Ray Kroc?	McDonald's
What animal's diet is made up almost entirely of eucalyptus leaves?	Koala
What number does the roman numeral "C" represent?	100
In what Colorado town was there a shooting at the opening of The Dark Knight Rises?	Aurora
What is the most abundant element in the universe?	Hydrogen
In what language does "obrigado" mean "thank you"?	Portuguese
In which month does the Kentucky Derby take place?	May
What country gave the state of Florida to the US in 1819?	Spain
In US government, what body must pass federal bills before they are sent to the president?	Congress
Who is the Greek god of the sea?	Poseidon
In what country is Mt. Vesuvius located?	Italy
In what US state was pop star Madonna born?	Michigan
"Lutz" and "Axel" are terms associated with what sport?	Figure skating
What is the capital of Austria?	Vienna
What is the name of the smallest ocean in the world?	Arctic Ocean
What is the profession of Annie Leibovitz?	Photographer
Which game was the computer program "Deep Blue" was programmed to play?	Chess
Who has been nominated for the most Oscars?	Meryl Streep
If you were born on May 22nd, what is your Zodiac symbol?	Gemini
What is a baby shark called?	Pup
What is the most populous city in the country of India?	New Delhi
Worldwide, what is the most popular religion?	Christianity
Which US President served the shortest term in office?	William Henry Harrison

Appendix C: Metacognition General Information Questions and Answers (60 items)

Question	Answer
In which year were the Olympics first held in the United Kingdom?	1908
In which year did WWI begin?	1914
In which year did the United States abolish slavery?	1865
In which year was the Treaty of Versailles signed?	1919
In which year was the Eiffel Tower built?	1887
In which year was Mahatma Gandhi's salt march?	1930
In which year did the first person land on the moon?	1969
In which year was Coca Cola founded?	1892
In which year did the Berlin Wall go up?	1961
In which year was the first telephone call made?	1876
In which year was the USSR dissolved?	1991
In which year did Bill Gates and Paul Allen found the Microsoft corporation?	1975
In which year did China's population reach 1 billion?	1980
In which year was Gangnam Style by PSY released?	2012
In which year did Princess Diana of Wales die?	1997
In which year was Facebook created?	2004
In which year was Machu Picchu discovered?	1911
In which year was Yellow Fever discovered?	1900
In which year did the partition of India take place?	1947
In which year was the first dog launched into space?	1957
In which year was Pepsi founded?	1898
In which year did the Berlin wall come down?	1990
In which year was Morse Code invented?	1836
In which year was the John Hancock Center opened?	1969
In which year did the British leave Hong Kong?	1997
In which year did Steve Jobs and Stephen Wozniak found Apple Computers?	1976
In which year was Call Me Maybe by Carly Rae Jepsen released?	2012
In which year did Marilyn Monroe die?	1962
In which year was Google created?	1998
In which year was the United States affected by Hurricane Katarina?	2005
In which year did the Euro become the official currency of 12 European countries?	2002

In which year did the G-15 Summit end?	1999
In which year did Sir Winston Churchill die?	1965
In which year was the first artificial satellite launched by Russia?	1957
In which year was Alfred Hitchcock’s movie "Psycho" released?	1960
In which year was the debut of the television show "I Love Lucy"?	1951
In which year was the founding of IKEA?	1943
In which year was penicillin discovered?	1928
In which year was the first radio program broadcast?	1906
In which year was Twinkie invented?	1930
In which year was the completion of the Hoover Dam?	1936
In which year did Joseph Stalin become the leader of the Soviet Union?	1927
In which year was the Wizard of Oz released?	1939
In which year did World War II end?	1945
In which year was DNA discovered?	1953
In which year did the first McDonald's open?	1955
In which year was Pac-Man released?	1980
In which year did Michael Jackson release "Thriller"?	1982
In which year did Beethoven perform his Fifth Symphony?	1808
In which year did Jane Austen publish Pride and Prejudice?	1813
In which year did the British Parliament pass the Great Reform Act?	1832
In which year did the Battle of the Alamo end?	1836
In which year did Charles Dickens publish "Oliver Twist"?	1837
In which year was the Great Exhibition in London, the world's first World Fair?	1851
In which year was the construction of Big Ben completed?	1859
In which year did Thomas Edison test his first light bulb?	1878
In which year did the Moulin Rouge open in Paris?	1889
In which year did Vincent van Gogh finish painting "Starry Night"?	1889
In which year was the Chernobyl nuclear accident?	1986
In which year was the assassination of Abraham Lincoln?	1865