Title
Snap Judgements: A Goal-Mediated Framework of The Transactive Memory System Between Self and Camera

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Publication Date
2020

UNIVERSITY OF CALIFORNIA
SANTA CRUZ

SNAP JUDGEMENTS: A GOAL-MEDIATED FRAMEWORK OF THE TRANSACTIVE MEMORY SYSTEM BETWEEN SELF AND CAMERA

A dissertation submitted in partial satisfaction
of the requirements for the degree of

DOCTOR OF PHILOSOPHY

in

PSYCHOLOGY

by

Julia S. Soares

June 2020

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Abstract

Snap Judgements: A Goal-Mediated Framework of The Transactive Memory System Between Self and Camera

Julia S. Soares

With the rise of smartphones with high-quality digital cameras, we are constantly deciding when and where to take photographs. All of this photo-taking is likely to influence how we interact with and subsequently remember personal events. A photo-taking-impairment effect has been observed such that objects that are photographed can be remembered less well than objects that are not photographed on a subsequent memory test. This effect and other memory effects of interacting with digital technology have been widely cited as evidence that a transactive memory system exists in which users of digital devices can rely on the memory of those digital devices, and so engage in cognitive offloading of memory onto those devices. Several experiments are reported here that provide evidence against an explicit or strategic cognitive offloading account. Two experiments are presented that demonstrate a photo-taking impairment effect even when participants cannot rely on their camera to remember for them, because photos are never saved or are immediately deleted from the device. If participants only offloaded onto a camera when it was strategically advantageous, the photo-taking-impairment effect would at least be attenuated in these delete conditions. Nonetheless, participants still demonstrated the photo-taking-impairment effect. Three more experiments are presented in which participants consistently predicted that photographed objects would be better remembered than non-photographed objects on a subsequent memory test. If participants believed that they had strategically offloaded memory onto the camera, they would have predicted the opposite pattern—relative under-confidence in photographed objects relative to non-photographed objects. Together, these two sets of studies provide evidence against a strategic offloading account. A third set of two studies is presented in which participants were asked to review their own naturalistically taken photos, and report on their recollective experience prompted by reviewing those photos. Both studies provide evidence that photo-taking goals may be important in determining how photographed events are recollected. Informed by these findings, a theoretical framework that characterizes the transactive memory system that might be formed between photo-takers and their cameras is proposed. Photo-taking goals are central to this theoretical framework. Implications and future directions are discussed.

Acknowledgements

I have so many people to thank for their help throughout my graduate career. I would not have been able to accomplish any of my goals without the support of my community. This degree belongs as much to you as it does to me.

First, I want to thank my doctoral advisor Ben Storm for your mentorship. Thank you for consistently challenging me to grow as a scientist, and for giving me the space and the support to become the researcher I am. Thank you for seeing the best in me even when I couldn't see it myself. I have learned more about mentorship from you than you know.

I am also grateful for my committee members and other faculty for their encouragement and feedback. Nick—I could never repay your unrelenting kindness over the past 6 years, but I will do my best to support my students, friends, and colleagues following from your thoughtful, generous example. Jason—your unabashed positivity and enthusiasm for research have been truly motivating and inspiring. Thank you also to Linda Henkel, Doug Bonett, and Leila Takayama for your guidance. My work has invaluably improved from the feedback of faculty who have been generous with their time and support. Thank you to Ralph Miller and to Cody Polack, who fostered my love for research and whose support made my graduate career possible. I hope to follow your examples.

I have also benefitted greatly from the support and camaraderie of many informal mentors and peers. Thank you to my labmates and to the members of CogMAP for your feedback, friendship, and advice. My ability to think critically, consider questions, and grow from critique has been shaped by you. I am grateful for my cognitive cohort—Chris, Peter, Jennifer, and Alina—I am so lucky to have worked alongside you. I am deeply grateful for the mentorship of folks who started before me in the program and who supported me through difficult times, challenged me to explore new methods, and whose friendship has made me both a better researcher and a better person—especially Annie, Acacia, Pat, and Nick.

Thank you to my stellar research assistants without whom I could not have collected the data presented in this dissertation. Specific thanks to Talia Bernstein, Meghna Das, Payam Etemadzahdeh, Madison Holdredge, Heyang Liu, Jack (Yanchen) Liu, Danielle Mitgang, Sandra Ochoa, Kamaria Potier, Oscar Ramirez-Perez, Nicolas Santer, Wesley Whittlesey, Joanne Wong, and Corey Zhang for your help collecting and coding these data.

I am extremely grateful for the excellent community of graduate students at UCSC, both within and beyond the area of cognitive psychology. My love, gratitude, and eternal solidarity are with my COLA comrades fighting for accessible graduate education and a living wage. Chris Karzmark, Chris Kay, Kelsey James, and Allie Allen, I am truly proud of our shared misbehavior. Thank you also to my friends who have not already been mentioned elsewhere, especially Chris Bojemski, Christian and Katie Suba, Aaron, Will, Carmen, Matt, Kate, and Emily. Thank you also to Ben Laraway and Bobby Russo for keeping me humble.

I want to express deep gratitude for my partner and emotional support human, Bradley. Your love, care, humor, patience, and compassion have held me together through my hardest struggles. You make my life better just by being in it.

Thank you also to my family—it is hard to be so far from you, but you are always in my heart. I am grateful for Lauren, Katie, and Joey for helping out at home in ways I could not in my absence. To my mom—thank you for your unwavering encouragement and for teaching me that learning is never a waste of time. To my dad, for whom I dedicate this dissertation—thank you for the countless hours you worked to provide for my education and for your unconditional love and support. It is difficult to complete my degree without you here, but you never doubted that this day would come.

Author Note

The text of this dissertation includes reprint[s] of the following previously published material, as well as material under review:

Soares, J. S., & Storm, B. C. (2018). Forget in a flash: A further investigation of the photo-taking-impairment effect. *Journal of Applied Research in Memory and Cognition*, *7*(1), 154-160.

Soares, J. S., & Storm, B. C. (under review). Volitional photography has a limited effect on memory but a large effect on metacognitive judgments of memory.

Soares, J. S., & Storm, B. C. (under review). Exploring functions of and recollections with photos in the age of smartphone cameras.

The co-author listed in these publications directed and supervised the research which forms the basis for the dissertation.

CHAPTER I: Introduction & Literature Review

Smartphone digital cameras have become so commonplace that many of our most important life events are experienced through the lens of a camera. Over one trillion photos are expected to be taken this year, the vast majority of which will be taken on smartphones (Cakebread, 2017). Our continued use of, and sometimes dependence on, digital technology may lead us to form transactive memory systems with our digital devices, a proposal that is often discussed in the literature on interactions between memory and digital technology (e.g., Sparrow, Liu, & Wegner, 2011; for review, see Marsh & Rajaram, 2019; Storm & Soares, in press). Transactive memory systems with a digital partner are often characterized by cognitive offloading; in this case, the choice to strategically not remember some information because the computer, smartphone, or internet can remember on the user's behalf. Studies that seek to explore the interaction between digital technology and memory have overwhelmingly focused on semantic, or fact-based information (e.g., Ferguson, McLean, & Risko, 2015; Storm & Stone, 2015; Storm, Stone, & Benjamin, 2017; Sparrow et al., 2011). Photo-taking, however, is typically intended to capture episodic, often autobiographical memories contextualized by a place, time, and observer.

In this dissertation, I will present data that suggests the memory interaction between photo-takers and cameras cannot exclusively be characterized by cognitive offloading. I will also present data that suggests the importance of a photo-taker's goals in photo-taking and informs how photographed events associated with different goals are remembered. I will then propose a theoretical framework of the transactive memory system formed between users and their digital cameras, which will imply several specific and empirically testable predictions. These claims will be substantiated by some of the existing literature. Finally, I will discuss some future work to test this theoretical framework. But first, to inform this discussion, I will review the relevant literature on autobiographical memory and transactive memory.

Background

Autobiographical Memory

When you ask someone to recount their first memory, their response will most likely constitute an episodic autobiographical memory (AM). Tulving (1972) discussed episodic memories as a foil to semantic—or fact-based, decontextualized—memories. Episodic memories, Tulving argues, are self-referencing, or autobiographical, and indicative of an experience rooted in a particular time and place. These memories include information about the what, when, and where of the past, but can also include aspects of recollecting or re-experiencing an event (Tulving, 2002). Fivush (2011) adds that while memory of what happened, and where and when events occurred is sufficient to constitute episodic memory, AM requires later-developing and uniquely human abstract understanding of time, the self, and one's own consciousness.

Structure. As such, theoretical models of AM must contain an element of the self. The Self-Memory System is a widely-used theoretical framework, and describes AM as being constructed through coordination between an autobiographical knowledge base and a working self. The autobiographical knowledge base is thought to contain information about the chronology and event structure of the past, along with event-specific knowledge, which can include details or imagery that makes a memory believable. The working self is a collection of an individual's self-images and active goals, and guides retrieval of information from the knowledge base to help achieve these goals (Conway & Pleydell-Pierce, 2000). In turn, the working self is constrained by the autobiographical knowledge base which provides information about what the self has been and can conceivably become. This model of AM focuses closely on how AM is used to accomplish goals, which is thought to require a long-term concept of the self (Conway, 2005).

The importance of narrative in structuring AM has also been emphasized in the literature. Bluck and Habermas (2000) propose that AM is organized by a *life-story schema.* Life stories are thought to be somewhat chronological, determined by cultural norms, include themes, metaphors, or morals and include an understanding of cause and effect. The schema is thought to provide scaffolding to a person's mental representation of their life story. Nelson and Fivush (2004) also emphasize the importance of storytelling and adult talk (which, they note, is rooted in cultural norms) about autobiographical events in the development of AM. Basic systems theory argues that information in the autobiographical knowledge base can be split further into component systems which have their own types of representations. The theory proposes separate systems for perception and imagery in each sense modality, along with systems for emotions, motor actions, explicit memory, and working memory. Memories are thought to be constructed, using narratives as a guide, by interactions between these systems (Rubin, 2006). The addition of narrative structure does not necessarily contradict the Self-Memory System but could be seen as a proposed organization for the autobiographical knowledge base.

Functions of Autobiographical Memory. AM is thought to serve several social and cognitive functions and thus play an important role in maintaining mental health. These functions can be split into directive, self, and social functions (Bluck, 2003; Bluck & Alea, 2002; Bluck, Alea, Habermas, & Rubin, 2005).

***Directive*.** AM is thought to be directive because we can use memories to help solve problems. AM helps us check the status of, update, and achieve goals (Conway, 2005; Conway & Pleydell-Pierce, 2000). Salient life events can provide guidelines for how to respond to new situations, and setbacks from goals can provide motivation to try harder. Participants report using lessons learned from their autobiographical past to guide their present or future decision-making and behaviors (Bluck & Glück, 2004; McCabe, Capron, & Peterson, 1991; Pratt, Norris, Arnold, & Filyer, 1999). That people use AM to simulate and plan for the future has been a major area of focus in the recent cognitive neuroscience literature on AM. Schacter and Addis (2007) even claim that our ability to construct episodic memories at all is a byproduct of a memory system developed to allow us to simulate possible futures. This hypothesis is supported by findings that AM and episodic simulation rely on activation of similar brain structures, called the core network (Schacter, Addis, & Buckner, 2008).

Research on clinical populations reinforces the importance of healthy simulation of and planning for the future. Pre-experiencing or simulating future events is thought to aid in planning for and coping with possible futures (Taylor &

Schneider, 1989). The ability to easily simulate coherent, realistic, and positive future outcomes has been found to correlate with decreased worry about the future, and increased predictions of positive outcomes of an imminent stressful event (e.g., giving birth) (Brown, MacLeod, Tata, & Goddard, 2002). Participants assigned to simulate possible futures also report using more coping strategies like seeking social support than those not assigned to pre-experience possibilities (Taylor, Pham, Rivkin, & Armor, 1998). Conversely, individuals with depression have been found to have less specific memories and future simulations of events relative to those without depression (Dickson & Bates, 2005; Kremers, Spinhoven, Van Der Does, & van Dyck, 2006; MacLeod, Tata, Kantish, Carroll, & Hunter, 1993; Williams et al., 1996). Individuals with anxiety also report less concrete futures than healthy controls and are found to report increasingly tangible concerns with therapy (Stöber & Borkovec, 2002). As such, directive functions of AM appear to be critical not just for future planning but for maintaining psychological health.

Self. Directive functions such as these also work in tandem with the self-functions of AM, which help to maintain, update, and assess threats to identity. AM has been theorized to help maintain continuity of the self: the sense of being the same person with some coherent life story throughout development and other life changes (Barclay, 1996; Bluck & Levine, 1998; Conway, 1990; Habermas & Bluck, 2000; Neisser, 1988). Self-related uses of AM are also important for psychological health and maintaining self-image. Participants report viewing their past selves less favorably than their current selves, and distancing their current selves from their former selves depending on how critically they view those past selves (Ross &

Wilson, 2000, 2002; Wilson & Ross, 2000, 2001). This distancing is thought to enhance the current self relative to the past and promote self-esteem (Ross & Wilson, 2002; Wilson & Ross, 2003).

Social. AM also serves a social function by providing material for conversation, promoting intimacy in new relationships and maintaining bonds in existing relationships (Bluck et al., 2005). Neisser (1988) has even argued that the social adaptivity of AM may have contributed to its evolutionary rise. Talking about one's autobiographical past can help people develop relationships by sharing information with others who did not co-experience an event, but also promote intimacy with existing friends, family, or partners through storytelling of shared experiences (Fivush, Haden, & Reese, 1996). Sharing past experiences can also elicit or provide empathy, as well as aid in illustrating a point or teaching others (Alea & Bluck, 2003). Social functions also appear to help maintain psychological health. Talking about past events can aid in emotion regulation (Pasupathi, 2003), as can writing about emotional past experiences (Pennebaker, 1997).

Operationalizing AM. Remembering an event in the past can include remembering facts about the what, when, and where of the event, but also feelings of reliving the experience itself (Tulving, 1985; 2002). This re-experiencing has also been referred to as *mental time travel*, which is thought to require awareness of time, of remembering, and of the self (Tulving, 2002). Tulving (1985) also emphasizes the feeling of knowing one is remembering an event from the past—instead of dreaming, daydreaming, or imagining—which he calls *autonoetic consciousness*. Details of re-experiencing and multimodal imagery are thought to aid in this distinction between autobiographical recollection and imagination (Conway & Pleydell-Pierce, 2000). Because of the elements of re-experiencing that typify AMs, they can also be studied in terms of emotionality, the perspective by which an event is re-experienced, and the vividness of the imagery generated (Rubin, Schrauf, & Greenberg, 2003).

Perspective of re-experience is important because distancing from memories occurs naturally and is linked to clinical outcomes (Nigro & Neisser, 1983). Typically, shifting to a third-person perspective when writing about emotional events is associated with improvements in mental health (Campbell & Pennebaker, 2003) and mindfulness therapy used to treat depressed individuals encourages acknowledging and distancing negative thoughts and experiences (e.g., Segal, Williams, & Teasdale, 2002). Conversely, depressed individuals use more first-person pronouns than healthy controls (Niederhoffer & Pennebaker 2002; Rude, Gortner, & Pennebaker, 2004) and those who do not show distancing are more likely to suffer from mental health problems (Francis & Pennebaker, 1992; Nolen-Hoeksema, Wisco, & Lyubomirsky, 2008). However, instances of extreme distancing or major distortions in perspective shifts can also be maladaptive. Conway (2005), describes the case of a 9/11 eyewitness who experienced vivid flashbacks of watching the event from high above, accompanied by feelings of persistent, devastating guilt. The patient needed Cognitive-Behavioral Therapy to shift her perspective back to a first-person view to allow her to process her feelings of fear, dread, and anger in response to what she had witnessed.

Because AMs can include such a rich breadth of information, it is insufficient to measure them binarily based on whether they were accessible or accurate alone.

Features of recollection including emotionality, vividness, and perspective view should also be included. There are already some measures of AM that include aspects of recollection when measuring memory. Tulving (1985) introduced the remember/know paradigm in which participants are asked to report whether they specifically remember having seen an item or if they more generally know that the item was presented. This test aims to assess autonoetic (remember) versus noetic (know) states of consciousness underlying retrieval.

Rubin and colleagues (2003) argue that the remember/know paradigm correlates more with accuracy of memories than autobiographical re-experiencing. As such, Rubin et al. developed an Autobiographical Memory Questionnaire (AMQ) that asks participants to self-report aspects of their recollective experience such as multimodal imagery and emotional intensity along with questions about the details, timing, and location of the event. In order to capture the breadth of the experience of autobiographical recollection, we can test for accuracy and accessibility of remembered events, as well as ask participants to self-report on yet-unobservable aspects like visual imagery, perspective view, and emotionality, which characterize the experience of recollection.

Transactive Memory

Much of the research on the interactions between digital technology and memory has been informed by seminal work on transactive memory (Wegner, Giuliano, & Hertel, 1985). Transactive memory theory developed, in part, as a return to the idea of the "group mind" (e.g., Hegel, 1807; Rousseau, 1767), which had been largely abandoned during the cognitive revolution. While many think of the group mind as the development of uniformity across members of the group, Wegner (1987) proposed transactive memory systems as an alternative to this simplistic view. Transactive memory systems, he argued, include knowledge that is shared between members of the memory system (integration), as well as information that is held in some minds, but not others (differentiation). Most of the resultant research has focused largely on differentiated transactive memory. Romantic couples, for example, can share the labor of remembering based on factors like expertise and situational responsibility—like who saw the information first. Each person in the couple can rely strategically on the other to remember certain information, with the division of labor determined by explicit or implicit strategies based on knowledge about one's transactive memory partner (Wegner et al., 1985, Wegner, Erber, & Raymond, 1991).

This focus on differentiation has carried through to more recent research that has focused on transactive memory systems that can form between humans and digital technologies. Indeed, our smartphones seem like ideal transactive memory partners. The internet is near-omnipresent, contains more information than any single person could know, is highly indexed and searchable, and can last longer than a relationship or even a lifespan (Ward, 2013). Indeed, objects like handwritten notes (Eskritt & Ma, 2014), folders saved on a computer (Sparrow et al., 2011), and the Internet (Ferguson et al., 2015) have been identified as potential transactive memory partners. In these systems, a user can become reliant on external prosthetic memory.

This reliance is manifested in cognitive offloading of shared memories. When an individual comes to rely on an external source to remember information on one's behalf, the individual will often demonstrate poorer memory for that shared information in the absence of their transactive memory partner than they would otherwise (e.g., Sparrow et al., 2011). More generally, cognitive offloading is observed whenever people distribute cognitive processes onto the body or into the environment to improve cognitive performance (Kirsh & Maglio, 1994; for review, see Risko & Gilbert, 2016). This form of offloading is likely useful because it allows people to focus on other tasks, improve performance, or overcome limits in cognitive capacities (Carlson, Avraamides, Cary, & Strasberg, 2007, Chu & Kita, 2011; Gilbert, 2015; Goldin-Meadow, Nusbaum, Kelly, & Wagner, 2001; Risko, Medimorec, Chisholm, & Kingstone, 2014). In the context of memory, offloading information by saving on a computer or handwritten notes, for example, can enhance memory for subsequently learned information (Eskritt & Ma, 2014; Storm & Stone, 2015). As such, offloading is as helpful as an external agent used to share cognition is reliable.

Offloading can occur for differentiated information in a transactive memory system. Integration occurs when members of a transactive memory system have overlap in the information stored within each mind (Wegner, 1987). The balance of integrated information can be critical for couples as too much integration can result in couples running out of stories to tell one another, and too little integration can cause couples to feel that they lack intimacy. Integration can also include processes by which members of a transactive memory system come together to create new knowledge or understanding (Wegner et al., 1985). Within the context of romantic couples, integration might occur as a couple debriefs at the end of a night out at a party. If, say, Alex and Jaime both talked to their mutual friend Chris, Alex might report that Chris mentioned starting a new job. Jaime might add that Chris told a story about being in a car accident and showing up late to work some weeks before. The couple might come to the new conclusion that Chris was fired for being late. Integration, therefore, is the process by which a transactive memory system becomes more than the sum of its parts. That is, integration allows members of a transactive memory system to generate more information than the sum of what each individual would separately be able to generate.

Integration can also be considered in the context of "cross-cuing" at recall. Cross-cuing can occur when couples attempt to retrieve the same event information and cue one another to retrieve more or different information than they would have independently. Below is an example from a study in which a heterosexual married couple is asked to collectively recall an autobiographical event, in this case, their honeymoon, and the wife cues to husband to provide some information that neither independently recalled (Harris, Keil, Sutton, Barnier, and McIlwain, 2011):

> "F: And we went to two shows, can you remember what they were called?
>
> M: We did. One was a musical, or were they both? I don't… no … one…
>
> F: John Hanson was in it.
>
> M: *Desert Song*.
>
> F: *Desert Song*, that's it, I couldn't remember what it was called, but yes, I knew John Hanson was in it.
>
> M: Yes." (p. 292).

Although transactive memory systems were originally discussed as a delicate balance between integration and differentiation (Wegner et al., 1985), very little literature followed up on processes of integration. In a notable exception, Hollingshead (2001) showed that task parameters and incentive structures can cause dyads to favor more or less integrative structures, depending on their goals. When learning a list together, dyads favored an integrative approach when words counted toward their scores only if both partners recalled those words, whereas a differentiated structure was favored when recalling a word counted toward the group's score regardless of who recalled the word. Integrated transactive memory may also be more useful in situations in which groups must collaborate to solve a problem, whereas differentiated structures can be useful for quickly recalling a lot of information (Gupta & Hollingshead, 2010).

Likewise, much of the literature on memory and technology has discussed these interactions in the context of differentiation, more specifically, cognitive offloading. Interactions with digital cameras are no exception. The following two chapters describe projects that intended to test whether cognitive offloading explains the memory effects of interaction with a camera. These two projects provide evidence against a strategic cognitive offloading account. In Chapter IV, data are presented which study naturalistic photo-taking and episodic recollection of photographed events. More specifically, Chapter IV explores participants reported taking their photos, and how events were recollected after photo-taking with different goals. Informed by this, Chapter V presents a theoretical framework that uses these goals to predict the effects of taking photos, both in the context of the photo-taking-impairment effect paradigm, and in the broader context of episodic recollection.

CHAPTER II: Forget in a Flash: A Further Investigation of the Photo-Taking-Impairment Effect

"I used to carry a camera when I traveled, but almost never took pictures with it, and apologized when I returned home, until I realized that my reluctance to point and click was really a reluctance to line up and edit and frame whatever I was seeing or hearing or smelling. The fall of the morning sunlight against the glittering sea. The crinkled face of an old woman selling spices in the market. It was, I believe, an instinctive reluctance to remove myself from my experience, an experience that could only occur far from home and habit, where the rules as much as the landscape were unfamiliar. To photograph it was somehow to reduce and domesticate my experience and ultimately to kill it."

Russel Banks, 2015

The widespread use of camera phones has made it easier than ever to capture, store, and share photographs, yet little is known about how photographing an experience influences memory of that experience. Photographs can serve as powerful cues for facilitating retrieval (Berry et al., 2007; Deocampo & Hudson, 2003; Hodges, Berry, & Wood, 2011; Loveday & Conway, 2011; St. Jacques & Schacter, 2013), but what about the act of taking a photo itself? Does taking a photo make someone more or less likely to remember the experience being photographed?

People often report taking photos as a strategy for remembering information and life events (Chalfen, 1998; Harrison, 2002), and indeed there are many reasons to expect taking a photo to improve memory for the objects and experiences being photographed. Photo-taking can isolate an item from other items (von Restorff, 1933; Wallace, 1965), for example, or lead to a deeper, more elaborate, or more variable encoding opportunity (Craik & Lockhart, 1972; Estes, 1950; Glenberg, 1979; Nist & Hogrebe, 1987). As demonstrated by Henkel (2014), however, taking a photo can have the opposite effect, rendering photographed objects less well-remembered than observed objects.

Henkel's (2014) study involved participants going on a guided museum tour while they took photos of certain objects (art pieces) and observed others. Participants were later tested, without access to the camera, on what they saw. Henkel found that photographed objects were less well-remembered than observed objects, a phenomenon referred to as the photo-taking-impairment effect. Henkel speculated that the effect could be the result of offloading, with participants not needing to remember the photographed objects because they could safely assume that the camera was doing the remembering for them (Risko & Gilbert, 2016).

The offloading hypothesis of the photo-taking-impairment effect draws heavily from transactive memory theory (Wegner, 1987; Wegner, Guiliano, & Hertel, 1985). Couples tend to split the labor of remembering based on their relative ease of recall, for example, with each person strategically relying on the other to remember certain information (Wegner, Erber, & Raymond, 1991). Their shared memory system is called transactive memory. Transactive memories are not just shared among groups of people, but also between people and objects that can "remember" (Ward, 2013). Taking notes, (Eskritt & Ma, 2014), saving on a computer (Sparrow, Liu, & Wegner, 2011), or accessing the Internet (Ferguson, McLean, & Risko, 2015), for example, can create a transactive memory system reliant on the prosthetic memory of a notepad, computer, or Internet. This form of offloading is likely to have many benefits in that it allows individuals to focus on other tasks (Storm & Stone, 2015), but it can also make offloaded information less recallable in the future than it would have been otherwise when the transactive memory partner is not available (Sparrow et al., 2011). Henkel's (2014) photo-taking-impairment effect could be explained by participants offloading their memory onto the camera. Specifically, participants may have failed to remember the photographed objects because they relied on the camera's prosthetic memory instead of their own organic memories.

An alternative possibility is what we refer to as the attentional-disengagement hypothesis—the idea that when people take photos they disengage from the moment to handle the task of capturing the object or experience, thus leading them to encode it less deeply or elaborately than they would have otherwise. Recent work by Niforatos, Cinel, Mack, Langheinrich, and Ward (2017), for example, replicated the photo-taking impairment effect, but only when participants manually took photos. Specifically, the effect was not observed when photos were taken automatically by a wearable camera. In other work, participants have also reported being somewhat aware of the experience that taking photos can cause them to become disengaged. Mols, Broekhuijsen, van den Hoven, Markopoulos, and Eggen (2015), for example, found that when asked to use various methods to document a trip, participants reported feeling more disengaged from the experience when taking photos relative to other recording strategies. Such disengagement could prompt participants to perform shallower encoding processes and make them more likely to miss or fail to encode visual details into memory—not only during the photo-taking experience itself, but also, perhaps, when participants continue to process and consolidate the experience into memory after photo-taking is complete. A critical assumption of the attentional-disengagement hypothesis is that encoding suffers automatically as a consequence of taking photos, and therefore that the photo-taking-impairment effect should not depend on whether the photographer considers the camera a reliable transactive memory partner.

The current study sought to extend the work of Henkel (2014) while more directly testing the offloading hypothesis. To do this, we employed a laboratory version of Henkel's paradigm (taking pictures of paintings on a computer screen) that included the two conditions employed by Henkel (camera vs. observe) as well as a third condition in which participants took photos but could not rely on the camera to "remember" for them. In this new condition, the camera did not function as an effective transactive memory partner and participants should therefore not have considered taking photos to serve as a form of offloading. According to the offloading hypothesis, if participants do not expect the camera to save the photos, then the photo-taking-impairment effect should be eliminated or greatly reduced. According to the attentional-disengagement hypothesis, however, taking photos should impair memory regardless of whether participants expect the photos to be saved.

Experiment 1

To construct a condition in which participants would be able to take photos but not consider it a form of offloading, we took advantage of the smartphone application Snapchat. Snapchat is a photo-messenger application that takes photos and sends them to contacts without saving the photos. Once the sender has shared a photo, it is no longer available on their phone. Likewise, once viewed on the recipient's phone, the photo disappears. We used a camera phone rather than a standalone camera because Snapchat is only available on smartphones and for purposes of ecological validity (far more photos are taken today with smartphones than with standalone cameras; Heyman, 2015).

Because Snapchat takes photos without saving them, it allows participants to capture photos without expecting the camera to save the information being photographed. According to the offloading hypothesis, the photo-taking-impairment effect should be reduced in this condition. That is, Snapchatted information should be remembered like observed information because participants cannot rely on the phone to remember for them. At the very least, the offloading hypothesis would seem to predict that participants should remember the photographed objects better in the Snapchat condition than in the camera condition, whereas the disengagement hypothesis predicts impairment automatically regardless of whether photos are saved.

Method

Participants. Forty-two undergraduates from the University of California, Santa Cruz (UCSC) participated for partial course credit.

Design. The experiment was run within-subjects and included three levels of a single independent variable (condition): Observe, Camera, and Snapchat. In the Observe condition, participants simply observed the images presented on a computer screen. In the Camera and Snapchat conditions, participants used the Camera or Snapchat application to photograph images presented on a computer screen. The dependent variable was performance on a multiple-choice visual detail test that tested memory for the objects in a way similar to the visual detail test used by Henkel (2014).

Materials. For full materials, see https://osf.io/ah29s/. Participants were equipped with an Apple iPhone 5. The iPhone had three applications available for participants to use: Snapchat, Camera, and Photo Album. Fifteen images of paintings were selected. The paintings were available for non-commercial use online and could be resized without degrading image quality. The paintings were chosen because they provided enough visual detail to ask participants multiple questions at test. Abstract paintings were avoided.

A slide was created for each painting to be shown during the experiment, with the image sized to a height of 4.95" and a width of 9.00". The title and artist for each painting appeared above the image in black 44-point text. The 15 paintings were organized into three blocks of five, separated by instructions that determined the condition assignment of each block. Paintings always appeared in the same order, but instructions were counterbalanced using a Latin Square across the three blocks of paintings, simultaneously counterbalancing both painting assignment to condition and condition order across participants.

The test consisted of 30 multiple-choice questions, two for each of the 15 paintings that were presented during the study phase. Pairs of questions about the same painting appeared in succession. The questions asked about various visual details in the paintings and referenced the paintings by title and artist; for example, "What was the instructor cutting with scissors in *The Anatomy Lesson* by Rembrandt?" The correct answer (in this case, *the cadaver's arm*), along with three lures were presented below each question. Participants were required to provide a response on every test question.

Procedure. Participants were run individually in a laboratory. The experiment consisted of three main phases: Demonstration, Study, and Test.

Demonstration. Participants were seated at a desk with a desktop computer and an iPhone 5. They were informed that they would be loaned the phone for the duration of the study and that they would be able to use the phone to access the photos they took when completing a later test. Participants were shown how to use the basic iPhone camera application and how to access the phone's photo album to review the images they captured. They were also shown how to use Snapchat to take and send photos to an account set up by the experimenter. It was stressed in the instructions that unlike photos taken with the camera, photos taken with Snapchat would not be saved on the phone (or anywhere else) for participants to access later. An experimenter then demonstrated how to take photos with each application and access photos taken with Camera on a sample painting. Finally, before proceeding to the study phase, participants were shown a sample multiple-choice question to ensure they knew they would be tested and the type of test they would be given (i.e., visual detail).

Study. Participants were given instructions about what to do when paintings were displayed in each of the three blocks. Each painting was displayed on screen for 15 s with each slide advancing automatically. During the block of Observe trials, participants were instructed to "look at the painting and title for the entire time" and to "place the experiment phone face down on the desk" while viewing the paintings. During the block of Camera trials, participants were instructed to "take a photo of [the painting and title] with the application Camera, which will save it to the Photo

Album" and to continue to look at the painting for what remained of the 15 s. During the block of Snapchat trials, participants were instructed, once a painting appeared, to "Snapchat and send it to the contact 'Snap Here'" within the application. They were also told to continue to look at the painting for what remained of the 15 s. For both the Camera and Snapchat conditions, participants were told to "make sure to include the entire painting in the frame, including the name." An experimenter remained close to the participant to verify that they complied with the instructions, which they reliably did.

Test. After the Study phase was complete, the experimenter took the phone back from the participant. After a 10-min delay, during which participants played Tetris on the same computer, participants were given a maximum of 10 min to complete the multiple-choice test. They were informed that they would not have access to the camera right before beginning the test. Following the test, participants were given a survey that asked demographic questions as well as about their use of Snapchat. After completing the survey, participants were debriefed and thanked for their participation.

Results

Responses from the visual detail test were scored by an experimenter blind to condition using a coding scheme determined prior to data collection. A repeated-measures ANOVA was run to investigate differences in test performance between the three conditions (Observe vs. Camera vs. Snapchat). The ANOVA revealed a significant main effect, $F(2, 82) = 15.35$, $p < .001$, $\eta_p^2 = .27$. We then investigated differences between the conditions using planned comparisons. Importantly, as can be observed in the left panel of Figure 1, Henkel's (2014) photo-taking impairment effect replicated. Specifically, participants correctly answered fewer questions about the details of the paintings in the Camera condition than in the Observe condition, $t(41) = 3.12$, $p = .003$, $d = 0.70$, $CI_{95\%}$ of $d = [0.24, 1.16]$. In contrast to the predictions of the offloading hypothesis, however, a photo-taking-impairment effect was also observed in the Snapchat condition, $t(41) = 5.78$, $p < .001$, $d = 1.21$, $CI_{95\%}$ of $d = [0.74, 1.68]$. In fact, participants performed less well in the Snapchat condition than in the Camera condition $t(41) = 2.23$, $p = .031$, $d = .48$, $CI_{95\%}$ of $d = [0.03, 0.92]$, a finding that would seem particularly difficult to explain from the perspective of the offloading hypothesis.

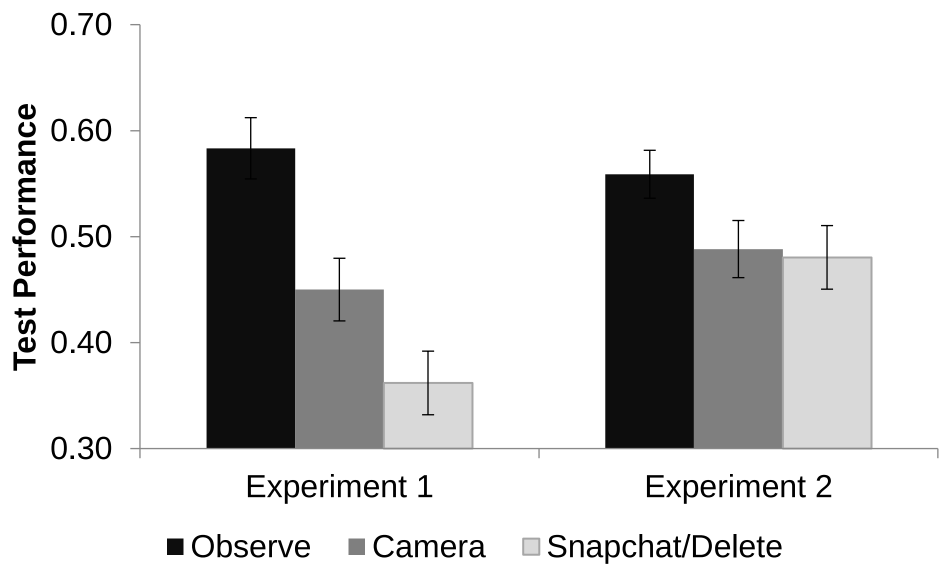

Figure 1. Mean proportion of visual detail multiple-choice questions answered correctly as a function of condition in Experiments 1 and 2. The Observe condition consisted of questions about paintings participants only observed. The Camera condition consisted of questions about paintings participants took pictures of with the Camera application. The Snapchat condition was used only in Experiment 1 and consisted of questions about paintings participants photographed using the Snapchat application. The Delete condition appeared only in Experiment 2 and consisted of questions about paintings participants photographed using the Camera application and immediately deleted. Note that because each multiple-choice question included four

options, chance performance was 0.25. Error bars indicate standard error of the mean.

Several results deserve emphasis. First, the photo-taking-impairment effect replicated using a somewhat artificial laboratory task (relative to that used by Henkel, 2014) in which participants observed and took pictures of paintings as they appeared on a computer screen, a task which would seem to be much easier for researchers to adapt in the future. Second, the use of Snapchat failed to reduce the photo-taking-impairment effect. In fact, the impairment effect was larger in the Snapchat condition than in the Camera condition. Although intriguing, this difference should be interpreted with caution. Most notably, time was controlled in such a way that participants had 15 s to view the paintings in all three conditions, including the conditions in which participants had to use part of their time to take photos. There are advantages to this sort of control as in natural settings the use of cameras can impede the amount of exposure one has to an object, but there are also disadvantages when it comes to interpreting the theoretical mechanisms involved in causing the photo-taking-impairment effect. Namely, participants may not have been able to spend as much time encoding the objects in the Snapchat condition as in the Camera condition. Henkel (2014) controlled for this difference and still showed a photo-taking-impairment effect, but relative to the Camera condition, taking pictures via Snapchat may have been even more time-consuming. Indeed, based on our subjective/anecdotal observations, participants did take longer interacting with the phone in the Snapchat condition than in the Camera condition. Another potential issue is that despite our instructions, participants may not have been fully convinced that the photos taken with Snapchat would be unavailable to them. If participants did not believe the Snapchat manipulation then the condition would not have provided a fair test of the offloading hypothesis.

Experiment 2

In Experiment 2 we aimed to replicate the photo-taking-impairment effect while controlling for potential differences in time available to visually encode the paintings and ensuring that participants fully understood that the photos would be saved in one condition and not in the other. First, we replaced the Snapchat condition with a Delete condition in which participants were instructed to delete each photo immediately after taking it. The Delete condition has the benefit of allowing us to be confident participants fully understood that the photos would be unavailable for subsequent review. Second, steps were taken to ensure that observation time was equal or even greater in the Camera conditions than in the Observe condition. Specifically, the timer for participants to view paintings started only after they finished taking a photo. Thus, participants had 15 s of unimpeded view time regardless of whether they took a photo of the object prior to that viewing. It is important to note that this methodological decision differed from that of Henkel (2014). Specifically, in the experiment used to control for exposure duration, Henkel had participants view the museum objects for a specified amount of time before taking a photo. Reversing the order allowed us to test the hypothesis that photo-taking disrupts encoding not only during the act of taking a photo, but in the seconds following as well—that participants would still have impaired memory for a photographed painting even when given the same amount of time to view the painting after deleting the photo (and therefore knowing that they would not have access to it).

Method

Participants. Fifty-one UCSC undergraduates participated for partial course credit. Sample size was determined based on the results of a power analysis using data from Experiment 1. Specifically, the analysis suggested that a sample size of at least 49 would be necessary to give us 90% power to observe a significant photo-taking-impairment effect (assuming an alpha of .05), which we rounded up to 51 to have equal numbers of participants randomly assigned to each of the counterbalancing conditions.

Design. The experiment was within-subjects and included three levels of the independent variable (condition): Observe, Camera, and Delete. The Observe and Camera conditions were the same as those employed in Experiment 1. In the Delete condition, participants took photos of the paintings and then immediately deleted them.

Materials. The Snapchat application was removed from the main screen of the iPhone. Thus, participants only had the Camera and Photo Album applications available on the main screen. Other than that, the materials were the same as those used in Experiment 1.

Procedure. Participants were run individually in a laboratory. The same protocol was used as in Experiment 1 except as noted below.

Demonstration. Participants were not shown how to use Snapchat. Instead, participants were shown how to delete photos after taking them using the Camera application.

Study. Participants were given a set of instructions before each block of five trials. The instructions for the Observe trials were identical to those of Experiment 1. Specifically, participants were given 15 s to view each of the paintings. For the Camera trials, participants were told to photograph each painting before pressing the spacebar to view the painting for an additional 15 s. For the Delete trials, participants were told to photograph and immediately delete the photo of the painting before pressing the spacebar to view the painting for an additional 15 s. As in Experiment 1, participants were told that they would be given a test on the visual details of the paintings and led to believe that they would have access to the photos they took when taking that test (or more specifically the photos they took but did not delete).

Test. The filled delay, final test, and post-experiment survey were the same as in Experiment 1. Unfortunately, due to experimenter error, only 31 of the 51 participants were administered the demographic and survey questions at the conclusion of the study. In addition to the demographic questions asked in Experiment 1, participants were also asked the open-ended question: “What effect do you think taking a photo of an event has on your memory for it?”

Results

A repeated-measures ANOVA was run on the visual-detail multiple-choice test data (Observe vs. Camera vs. Delete), revealing a significant main effect of condition, $F(2, 100) = 4.26$, $p = .017$, $\eta_p^2 = .08$. As shown in the right panel of Figure 1, participants correctly answered fewer questions about the details of the paintings in the Camera condition than in the Observe condition, $t(50) = 2.30$, $p = .026$, $d = 0.58$, $CI_{95\%}$ of $d = [0.23, 0.93]$, once again replicating the photo-taking-impairment effect.

Similar to Experiment 1, however, and contrary to the offloading hypothesis, the photo-taking-impairment effect remained significant even when participants deleted photos immediately after taking them, $t(50) = 2.92$, $p = .005$, $d = 0.61$, $CI_{95\%}$ of d = [0.30, 0.92]. Performance in the Camera and Delete conditions did not significantly differ, $t(50) = .25$, $p = .80$.

Responses to the debriefing question about the effects of photo-taking on photographed material were marked by an experimenter blind to participant performance as belonging to one of four categories: benefit, no effect, not sure, and impairment. All responses aligned with one of these categories. Surprisingly, despite just experiencing a photo-taking-impairment effect (at least when combined across participants), most participants (52%) reported that taking photos helps them remember. Of the remaining participants, 3% had no guess, 26% predicted no effect, and only 19% of participants correctly responded that taking photos impairs memory. Interestingly, the majority (62.5%) of the participants who reported believing that photo-taking improves memory nevertheless remembered less about the paintings they photographed than those they simply observed.

General Discussion

A photo-taking-impairment effect was observed in every condition in which photos were taken, even in the Snapchat and Delete conditions in which participants did not save the photos they took. These results are inconsistent with the offloading hypothesis. If taking photos causes people to forget because they think of the camera as a prosthetic memory device onto which they can offload memory, then making the camera less reliable (or entirely unreliable in the case of the Snapchat and Delete conditions) should have eliminated or significantly reduced the extent to which memory was impaired. Instead, memory was impaired by photo-taking regardless of whether participants thought the photos would be saved, a finding that suggests that some other mechanism might be at play. Indeed, the results are more consistent with the idea that taking photos causes participants to limit or disengage their attention when encoding an experience, an effect that is assumed to take place regardless of whether participants believe the photos are being saved.

Importantly, the photo-taking impairment effect was observed in Experiment 2 even though total viewing time was controlled. Participants were given 15 additional s to view the paintings after taking the picture, giving them effectively more time to look at the paintings in the Camera and Delete conditions than in the Observe condition. This finding suggests that the photo-taking-impairment effect cannot be explained by participants simply being distracted or disengaged while using the camera, but that photo-taking prospectively impairs how an experience is encoded even after the camera is put down. Reasonably, participants could have re-engaged with the paintings during the time after taking a photo, especially when they knew the photo was deleted or rendered inaccessible, leading to a level of encoding at least as good (if not better) in the camera conditions than in the observe condition. Our results instead suggest that after taking a photo, participants continued to encode the paintings less effectively than they would have otherwise.

Although speculative, one possible interpretation of this finding is that participants suffered from a sort of metacognitive illusion. Specifically, photo-taking may have given participants a subjective sense of encoding fluency, leading them to think they had already encoded the objects—not only via the camera, but via their own organic memory—thus rendering them less likely to put additional effort toward encoding the objects in the time that followed. Said differently, photo-taking may have led participants to think that they had already encoded the paintings, making them less likely to employ the type of encoding strategies that would have been useful for improving memory (Bjork, Dunlosky, & Kornell, 2013; Hertzog, Dunlosky, Robinson, & Didder, 2003; Koriat, 1993). A related possibility is that encoding was disrupted by a sort of automatic offloading. Although the present results are inconsistent with an "explicit" form of offloading, they cannot rule out the possibility that through learned experience, people develop a sort of implicit transactive memory system with cameras such that they automatically process information in a way that assumes photographed information is going to be offloaded and available later (even if they consciously know this to be untrue). Indeed, if this sort of automatic offloading does occur then it could be a mechanism by which photo-taking causes attentional disengagement.

Clearly, the mechanisms and boundary conditions of the photo-taking impairment effect remain to be elucidated. It is possible, for example, that any secondary task can cause attentional disengagement. Future research should explore whether there is something unique about taking photos that causes people to become less likely to encode an experience. Furthermore, it is unclear whether the effect is limited to the type of photo-taking situation used here and by Henkel (2014) in which individuals are instructed to take pictures of some objects but not of others (a control feature which is necessary for current purposes but which may not reflect situations outside of the laboratory where participants decide on their own whether to take a photo). Recent work has shown that when participants can decide for themselves what items to photograph (i.e., "volitional photography") photo-taking can enhance both engagement in an experience (Diehl, Zauberman, & Barasch, 2016) and memory for that experience (Barasch, Diehl, Silberman, & Zauberman, 2017). Thus, it is possible that taking pictures impairs memory by disrupting attentional engagement, but only when participants are not actively in control of deciding what to photograph. At this point we still know very little about exactly when and why photo-taking impairs memory.

So where do our findings leave snap-happy photographers and social media addicts documenting their daily lives? Although it remains to be seen whether the present results generalize to other types of conditions, they do suggest that taking photos can impair a person's ability to remember the details of the experiences being photographed, an effect that appears to linger even after the camera has been put down. Of course, one of the benefits of taking photos is that the photo-taker can look back at the photos later, thus arguably providing a much more powerful opportunity to transactively remember the details of an experience than would be possible through observation alone. This benefit requires that participants actually take the time to successfully locate and view their photos, however; something which may be done far less frequently than one would imagine (Whittaker, Bergman, & Clough, 2010). It is also worth noting that photos can only capture a portion of an experience and that photographic review may therefore not always help participants recover the uncaptured portions of an experience. In this way Russell Banks (2015) may not have been exaggerating when he wrote that to photograph an experience was "somehow to reduce and domesticate (it) and ultimately to kill it." To the extent that taking a photo does affect memory for an experience, whatever aspect of that experience that is impaired could remain impaired indefinitely. For a truly memorable experience, therefore, it might sometimes be best to put the camera away.

CHAPTER III: Volitional Photography has a Limited Effect on Memory but a Large Effect on Metacognitive Judgments of Memory

In the bourgeoning era of digital camera phones, photo-taking is everywhere. People take selfies at bus stops, snap photos in lectures, and document meals in restaurants. Even bathroom-mirror photos have become a thing to post on social media. Given this ubiquity, it is unsurprising that the number of photos taken each year has passed into the trillions (Heyman, 2015). In the context of the more general effort to understand how cognition is changing in the digital age (e.g., Finley, Naaz, & Goh, 2018; Marsh & Rajaram, 2019; Storm & Soares, in press), elucidating how all this photography is influencing memory is critical. Although photos can serve as detailed cues for facilitating memory retrieval (Berry et al., 2007; Deocampo & Hudson, 2003; Hodges, Berry, & Wood, 2011; Loveday & Conway, 2011; St. Jacques & Schacter, 2013), excessive photo-taking can make it challenging to find and review photos (Whittaker, Bergman, & Clough, 2010). Moreover, there is evidence that the very act of taking a photo can cause a photographed experience to be remembered less well than non-photographed experiences, a phenomenon known as the photo-taking-impairment effect.

The photo-taking-impairment effect was first demonstrated by Henkel (2014). Participants were taken on a guided museum tour and instructed to photograph some objects while merely observing others. A photo-taking-impairment effect was observed such that memory for the photographed objects was impaired relative to non-photographed objects. This effect held across a variety of assessments, including recall, recognition, and multiple-choice visual detail tests. It has also been replicated numerous times, both inside and outside of the laboratory (Soares & Storm, 2018; Niforatos, Cinel, Mack, Langheinrich, & Ward, 2017).

Initially, Henkel (2014) speculated that the photo-taking-impairment effect could be the result of cognitive offloading (e.g., Kirsh & Maglio, 1994; for a review, see Risko & Gilbert, 2016). The cognitive offloading account assumes that people form a transactive memory system with the camera (e.g., Wegner, 1987; Wegner, Guiliano, & Hertel, 1985), and that they rely on the camera to "remember" photographed items on their behalf. By treating the camera as a transactive memory partner, participants may offload the need to encode and remember the item onto the camera, thus leading to the memory impairment observed when they are tested in the absence of the camera. Similar dynamics have been argued to take place in other contexts, such as when people take notes (Eskritt & Ma, 2014), or save files on a computer (Sparrow, Liu, & Wegner, 2011; Storm & Stone, 2015). According to the cognitive offloading account, memory impairment occurs because participants strategically forget or fail to encode information internally, because it will be saved or has already been saved externally.

Soares and Storm (2018) tested the cognitive offloading account of the photo-taking-impairment effect by having participants take photos in a way that would not result in the photos being saved. In one condition of Experiment 2, for example, participants took photos and immediately deleted them, creating no opportunity for strategic offloading. Still, participants showed a photo-taking-impairment effect. These findings are problematic for at least the most straightforward version of the cognitive offloading account because the memory impairment does not seem to depend on the extent to which participants can rely on the camera to serve as their transactive memory partner.

Soares and Storm (2018) proposed that an alternative account of the photo-taking-impairment effect might be that of attentional disengagement. Specifically, people may be less likely to remember the details of an event they photograph because they disengage from the experience while using a camera. This disengagement is thought to go beyond the simple costs of multitasking or task-switching that might take place when someone is using a camera. Instead, it is argued to reflect a more qualitative type of experiential disengagement, one that leads photo-takers to encode an experience in a less elaborate or meaningful way than they would have otherwise. Consistent with this idea, the photo-taking-impairment effect persists even when participants are given additional time to compensate for the time spent taking photos (Henkel, 2014; Soares & Storm, 2018). The cognitive offloading account predicts memory impairment whenever photos are saved; the attentional disengagement account predicts memory impairment whenever photos are taken. Observations that the photo-taking-impairment effect persists even when participants delete their photos (Soares & Storm, 2018), but is attenuated when photos are captured automatically by a wearable camera (Nifaratos et al., 2017), are more consistent with the attentional disengagement account than the cognitive offloading account.

Finally, another factor complicating the photo-taking and memory literature is the potential role of volition. Barasch, Diehl, Silverman, and Zauberman (2017) showed that at least under certain circumstances, photo-taking is capable of improving a person's overall memory for an experienced event. Their participants took a real (Study 1) or virtual (Studies 2-4) museum tour either with or without a camera, and participants who used a camera outperformed those who did not on a visual recognition test for all of the art they encountered. Recognition rates of photographed objects were also reliably higher than recognition rates of non-photographed objects in the camera condition in three of the four studies they report. Barasch et al. speculated that the discrepancy between their findings and the photo-taking-impairment effect observed by others might be explained by volition. Unlike in studies reporting a photo-taking-impairment effect, in which specific objects were assigned to be photographed (Henkel, 2014; Niforatos et al., 2017; Soares & Storm, 2018), Barasch et al. gave participants the freedom to choose which objects to photograph. They argued that the difference between volitional and nonvolitional photography is critical; specifically, that volitional photography directs attention while experiencing a visual scene, whereas nonvolitional photography comes at an attentional cost. To date, however, no published research has directly examined the effect of volition on the photo-taking-impairment effect. It thus remains to be seen whether taking a photo fails to cause forgetting simply because the participant chooses to take that photo.

In the current study, we investigated the memory and metamemory consequences of volitional and non-volitional photography to further clarify the theoretical mechanisms and boundary conditions of the photo-taking-impairment effect. As in the study by Soares and Storm (2018), participants were shown a series of paintings. In this study, however, some participants were given the freedom to choose which paintings to photograph (Volitional Condition), whereas others were not (Non-Volitional Condition). Based on the results reported by Barasch et al. (2017), we expected participants in the Volitional Condition to exhibit a reversal of the typical photo-taking-impairment effect, remembering the photographed paintings better than the non-photographed paintings.

In attempt to control for possible item effects (i.e., that participants in the Volitional Condition get to choose which paintings to photograph and which paintings to observe, and that the two sets of items are therefore likely to differ in ways other than whether they were or were not photographed), participants in the Non-Volitional Condition were yoked to participants in the Volitional Condition, thus ensuring that across participants in the two conditions, the same items served in the photographed and non-photographed conditions. That said, even with this yoking procedure, it would be impossible to control for item effects completely, as participants in the Volitional Condition may choose which items to photograph based on idiosyncratic factors that are not relevant to participants in the Non-Volitional Condition. Thus, we will hesitate to make too much of any difference or lack of difference in the photo-taking-impairment effect between the volitional and non-volitional conditions.

There are many reasons to expect a reversal of the photo-taking-impairment effect for volitionally photographed items. For one, selection effects will likely favor items participants choose to photograph since participants will most likely prefer or otherwise favor chosen items over unchosen items (e.g., Mather, Shafir, & Johnson, 2000). Choosing to photograph an item could also distinguish it from other items in memory (von Restorff, 1933; Wallace, 1965) or cause the item to benefit from additional visual attention in the course of deciding whether or not to take a photo. In fact, Diehl, Zauberman, and Barasch (2016, Study 6) used eye-tracking to show that visual aspects of volitionally photographed objects were fixated on longer and more often than other elements of a scene. From a practical standpoint, however, if a photo-taking-impairment effect is observed in the Volitional Condition, then such a finding would provide new insight into the robustness and generality of the photo-taking-impairment phenomenon. In naturalistic settings, people are rarely instructed when and where to take photographs, thus making it essential to determine whether a photo-taking-impairment effect can also be observed under such conditions. Moreover, no study to date has examined the effects of volitional photography using the same method that has been used to study the photo-taking-impairment effect.

Another goal of the current study was to examine the metacognitive predictions participants make about how photo-taking affects memory. Soares and Storm (2018) asked participants to make judgments about how photo-taking affected their memory after taking the final test. However, in none of the prior studies have participants been asked to predict their performance for photographed and non-photographed objects before taking a final test. In the current study, after viewing all of the paintings, participants were asked to predict the proportion of paintings in each condition (photographed versus non-photographed) that they would be able to remember. According to the cognitive offloading account, participants should predict worse memory for photographed items than non-photographed items. That is, if participants are strategically not remembering what the camera is remembering for them, then they should judge the photographed items to be remembered less well than the non-photographed items since it was their strategic choice to offload the encoding and remembering of those items onto the camera. If participants do not expect to remember photographed items less well than non-photographed items, then such a finding would be inconsistent with at least a conscious or strategic form of cognitive offloading being responsible for the photo-taking-impairment effect.

More generally, it remains to be seen how metacognitive judgments of memory might be affected by photo-taking, and whether the effect might differ as a function of volition. It is possible, for example, that volitional photo-taking will give participants an unfounded or exaggerated sense of confidence in their ability to remember photographed information in a way that non-volitional photo-taking does not. If, as Barasch et al., (2017) argued, volitional photo-taking enhances engagement with photographed objects, but non-volitional photo-taking disrupts engagement with photographed objects, one would expect such a pattern of results. In support of this prediction, Barasch, Zauberman, and Diehl (2018) also found that participants reported higher engagement in an activity after taking photos for themselves relative to taking photos with the intention to share on social media. Though participants in the social-media focused condition were still allowed to take photos volitionally, it seems that having an external audience in mind—like an experimenter—can reduce engagement relative to photo-taking for oneself. These findings give us reason to expect that participants might feel more engaged overall when taking photos volitionally, and particularly in the items they choose to photograph, than when they take photos non-volitionally. Assuming subjective feelings of engagement (in the case of volitional photography) and disengagement (in the case of non-volitional photography) are reflected in metacognitive judgements of memory, participants should predict particularly high confidence for volitionally photographed information relative to non-volitionally photographed and non-photographed information.

Experiment 1

Method

Participants. A total of 128 undergraduates at the University of California, Santa Cruz (UCSC), participated for partial credit in a psychology course. The sample size was selected to observe a photo-taking-impairment effect with 90% power in the non-volitional condition (based on pilot data indicating an effect size of d = 0.45). The power analysis suggested we would need at least 54 participants, so we added 10 to our target to account for any participants who could not be included in the within-subjects analysis because they photographed all or none of the paintings. As demonstrated by a post-experiment survey, participants came into the study well-experienced with the use of smartphone cameras, reporting to use their smartphone cameras on average 21 times per week (SD = 29). Only two participants reported not using their cameras at all in a typical week.

Design. The study employed a 2 x 2 mixed design with Volition Condition (Volitional vs. Non-Volitional) manipulated between-subjects and Item Type (Photographed vs. Non-Photographed) serving as a within-subject variable determined by the actions of participants in the Volitional Condition. Specifically, participants in the Volitional Condition were allowed to choose whether to photograph a given painting (Photographed) or simply to observe it (Non-Photographed). Each participant in the Non-Volitional Condition was then yoked to a participant in the Volitional Condition such that they were instructed to photograph the exact same selection of paintings. Yoking participants in this way controls for the particular items photographed across the Volitional and Non-Volitional Conditions but does not control for the idiosyncratic meaningfulness of the paintings in relation to the individual participants. Nevertheless, given the nature of volitional photography, it seemed like the most effective way to at least partially control for item effects.

Materials. Twenty representational paintings were selected for the slideshow, each of which was painted by a different artist. The paintings were displayed on separate slides with the title of the painting and artist's name displayed directly above. To test participants' memory, 40 multiple-choice questions were created based on the visual details of the paintings (2 for each of the 20 paintings). Each question referenced the title and author of the painting and gave participants four options. For *The Bathers* by Seurat, for example, participants were asked (1) "What kind of animal was in the foreground of *The Bathers* by Seurat?" (options: hummingbird, moth, dog, mouse), and (2) "What color hair did the man with his feet in the river have in *The Bathers* by Seurat?" (options: brown, red, blonde, black).

Procedure. Participants were run individually in a laboratory. Upon arrival, they were each equipped with an Apple iPhone 6 smartphone and given a brief tutorial on how to use its camera application. Only two applications were visible: Camera and Photo Album. Participants then watched the slideshow of paintings.

Participants in the Volitional condition were told to take photos of any of the paintings they saw and that it was up to them to decide which paintings to photograph. Participants in the Non-Volitional condition were told that the experimenter would inform them of which paintings they should photograph and which paintings they should simply observe. As discussed in the Design section, each participant in the Non-Volitional Condition was yoked to an individual participant in the Volitional Condition such that they were instructed to photograph the exact same subset of paintings. Each painting was displayed for 15 s, with participants in the Non-Volitional Condition instructed to either photograph or observe each painting as soon as it appeared.

Immediately after viewing all 20 paintings, each participant was asked to predict the percentage of the paintings (out of 100%) that they would remember. Participants were always asked to predict their performance for the paintings they photographed first, and then to predict their performance for the paintings they did not photograph second. A subset of the participants in the Volitional Condition chose to photograph every painting. These participants, as well as the matched set of yoked participants in the Non-Volitional Condition, were only asked to predict their performance for the paintings they photographed.

After a 5-min delay, during which they played Tetris, participants were given the 40-item multiple-choice test. The questions were presented individually in a random order for 20 s each with the only constraint that the two questions associated with a given painting were always presented sequentially. Participants were permitted to move on to the next question if they answered before time elapsed. After completing the final test, participants were given a short survey to collect demographic information as well as information about their photo-taking habits. Once the survey was complete, participants were debriefed, thanked for their participation, and dismissed from the study.

Results

Photo-Taking Behavior. On average, participants in the Volitional Condition chose to photograph 57% (*SD* = 24%) of the paintings. No participant photographed less than 4 paintings, and ten of the participants photographed all 20 paintings. As such, ten of the participants in the Non-Volitional Condition were also instructed to photograph all 20 paintings, resulting in a total of 20 participants across the experiment who did not have any items in the Non-Photographed Condition. The remaining 108 participants chose to photograph 49% (*SD* = 16%) of the paintings.

Memory Performance. Performance was analyzed first by collapsing across all questions regardless of whether they were associated with paintings that were photographed. On average, participants in the Volitional Condition answered 43.2% (*SE* = 1.4%) of the questions correctly, whereas participants in the Non-Volitional Condition answered 41.4% (*SE* = 1.4%) of the questions correctly, a difference that was not statistically significant, $t(126) = .91$, $p = .37$, $d = .16$, 95% CI_d = [-0.19, 0.51].

Next we ran a 2 (Item Type: Photographed vs. Non-Photographed) x 2 (Volition Condition: Volitional vs. Non-Volitional) mixed-design ANOVA including only the 108 participants who did not photograph every painting, which allowed us to compare the recall of photographed and non-photographed paintings. Replicating the results of previous research, a significant photo-taking-impairment effect was observed. Specifically, as can be seen in the left side of Figure 2, a main effect of Item Type was found such that participants performed significantly worse on test questions for photographed paintings (M = 40.9%, SE = 1.3%) than they did on test questions for non-photographed paintings (M = 44.7%, SE = 1.6%), $F(1, 106) = 4.77$, $MSE = .02$, $p = .03$, $\eta p^2 = .04$. Neither the main effect of Volition Condition, $F(1, 106) = 2.18$, $MSE = .03$, $p = .10$, $\eta p^2 = .03$, nor the interaction, $F(1, 106) = .18$, $MSE = .02$, $p = .68$, $\eta p^2 = .00$, were statistically significant.

Metacognitive Judgments. Metacognitive judgments were analyzed first by collapsing across all items regardless of whether they were associated with paintings that were or were not photographed. We did this by weighting the average judgment for each participant based on the proportion of paintings that were photographed. On average, participants in the Volitional Condition (M = 42.4%, SE = 2.8%) were not significantly more confident than participants in the Non-Volitional Condition (M = 40.3%, SE = 2.7%), $t(126) = .55$, $p = .58$, $d = .10$, 95% CI_d = [-.25, .45].

We next analyzed metacognitive judgments by running a 2 (Item Type: Photographed vs. Non-Photographed) x 2 (Volition Condition: Volitional vs. Non-Volitional) ANOVA on the participants who did not photograph all 20 paintings. A significant main effect of Item Type was observed such that participants were more confident in their ability to remember photographed paintings (M = 46.7%, SE = 2.3%) than non-photographed paintings (M = 38.9%, SE = 2.6%), $F(1, 102) = 13.11$, $MSE = .02$, $p < .001$, $\eta p^2 = .11$. This main effect was qualified, however, by a significant interaction, $F(1, 102) = 8.51$, $MSE = .02$, $p = .004$, $\eta p^2 = .08$. No main effect of Volition Condition was observed, $F(1, 102) = .39$, $MSE = .10$, $p = .54$, $\eta p^2 =$

.00. Participants in the Volitional Condition reported significantly higher confidence in their memory of photographed paintings (*M* = 51.2%, *SE* = 3.4%) than non-photographed paintings (*M* = 37.1%, *SE* = 3.9%), $t(51) = 4.33$, $p < .001$, $d = .54$, 95% CI_d = [0.29, 0.79]. Participants in the Non-Volitional condition, however, reported levels of confidence for photographed paintings (*M* = 42.2%, *SE* = 3.2%) and non-photographed paintings (*M* = 40.7%, *SE* = 3.3%) that did not significantly differ, $t(51) = .54$, $p = .59$, $d = .07$, 95% CI_d = [-0.17, 0.30].

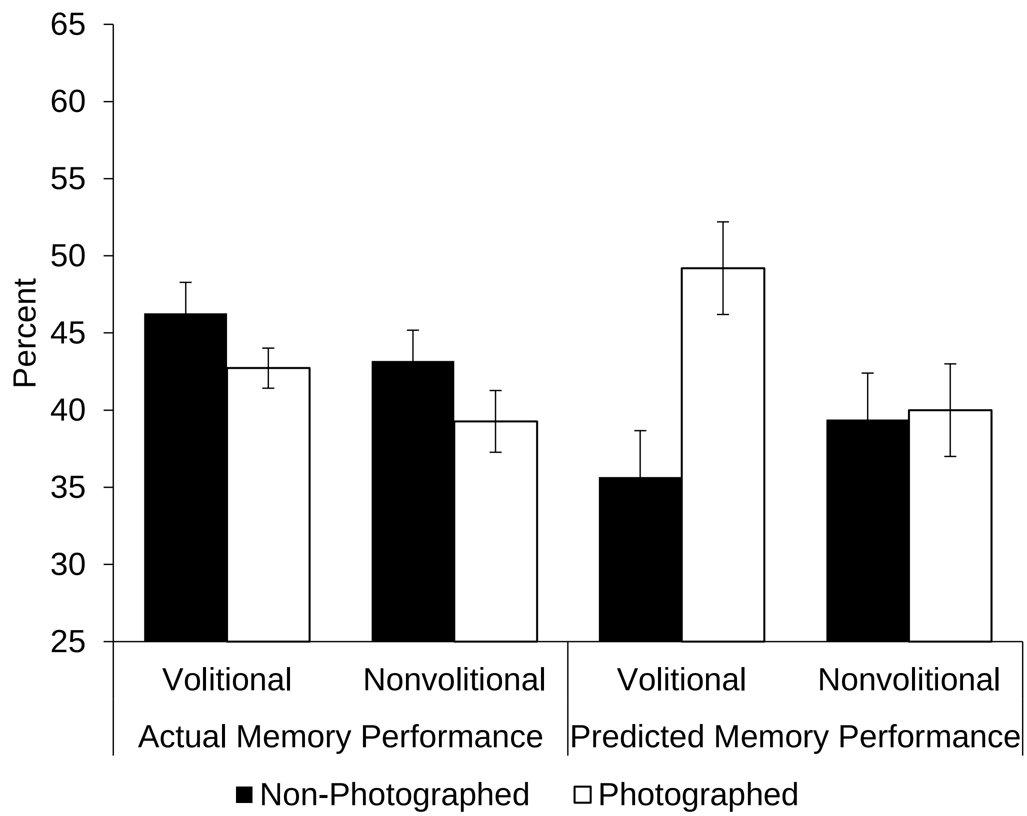

Figure 2. Mean percentage of predicted versus actual memory performance as a function of Volition Condition (Volitional vs. Non-Volitional) and Item Type (Photographed vs. Non-Photographed). Error bars indicate standard error of the mean.

Discussion

The results of Experiment 1 suggest that the photo-taking-impairment effect may persist, at least to some extent, even when participants are allowed to choose which paintings to photograph. Moreover, participants who took photos volitionally seemed to expect a substantial photo-taking benefit, whereas participants who took photos non-volitionally did not expect any reliable difference in memory for photographed versus non-photographed paintings. Contrary to the cognitive offloading account, participants did not predict a photo-taking-impairment effect, indicating that they were either not using an explicit strategy to offload memories onto the camera, or that if they were, they did not think it was effectively changing what they could and could not remember.

Experiment 2

At first glance, the results of Experiment 1 seem inconsistent with those of Barasch et al. (2017), who observed benefits to visual memory for photographed objects after volitional photo-taking. However, the methodologies employed in our Experiment 1 and by Barasch et al. varied in several aspects. In Experiment 1, participants took photos in a highly controlled environment; they sat in front of a computer screen and watched a slideshow of paintings one by one, photographing some but not others. Because participants in Experiment 1 saw candidates for photography one at a time, they might not have engaged in volitional photo-taking in the same way as they might when taking photos within a larger visual scene like that of an art exhibit.

Volitional photo-taking might only benefit memory for photographed information when a photo-taker can use the camera to direct their attention throughout a larger visual scene, taking photos to inspect and engage in their environment. Consistent with this idea, Diehl et al. (2016) found that their participants reported more engagement and enjoyment of events during which they had a camera than when they did not. It is important to understand the memory and metamemory effects of photo-taking while exploring a large visual scene, since such photo-taking characterizes most people's typical interactions with a camera. Thus, in Experiment 2, we constructed an in-laboratory "gallery" in which participants could engage in volitional photo-taking as they explored. This allowed us to investigate the photo-taking-impairment effect further, as well as participants' memory expectations for photographed and un-photographed items, following volitional photo-taking in a more naturalistic environment. If the photo-taking-impairment is still observed under these conditions, this would be a strong testament to the robustness of the effect. If, instead, the photo-taking-impairment effect is eliminated or reversed under these circumstances, it would provide additional evidence that volitional photography can be protected from the photo-taking-impairment effect.

It is also important to note that Barasch et al.'s (2017) main analysis focused on the between-subjects experimental manipulation between participants who either did or did not use a camera. In our Experiment 1, we did not have a control (no camera) condition with which to compare. Barasch et al. argued that having a camera with which to volitionally take photos enhanced participants' visual attention holistically, for both photographed and non-photographed items. In Experiment 2, we included a condition in which participants did not use a camera as they explored the gallery. This allowed us to examine the holistic effects of using a camera on both memory and metacognition. To create a better point of comparison (compared to the weighted averages analyzed in Experiment 1), all participants were asked to make an overall judgement of their expected memory performance. Participants who used cameras were then asked to make separate judgements of their expected performance for art they chose to photograph versus art they chose not to photograph. Based on the findings of Experiment 1, we expected to replicate the finding that participants expect to remember photographed objects better than non-photographed objects. Consistent with this finding, we also expected that participants who used a camera would report higher metacognitive judgments than participants who did not use a camera.

Method

Participants. A total of 153 participants from the UCSC participant pool were recruited. A power analysis was run based on the effect size (d = 0.54) of the memory benefit for participants who used a camera compared to participants who did not use a camera in the meta-analysis reported by Barasch et al. (2017). The power analysis suggested that at least 74 participants per group would be needed to observe the effect with 90% power, with alpha set to .05. A few additional participants were run in each condition because additional participants were scheduled to account for no-shows or technical errors. One participant's data were not analyzed because they failed to follow instructions and used their own phone during the experiment. This participant belonged to the experimental condition in which participants were given a camera, so this condition had 76 participants while the Control Condition had 77.

Design. Experiment 2 used a between-subjects design with 2 conditions—Camera and Control. Participants in the Camera Condition were provided with a camera phone with which to take photos freely at the beginning of the experiment. Participants in the Control Condition were not given a camera phone. Data for these participants could then be analyzed based on photographed and non-photographed objects. There were two dependent measures: memory performance, and metacognitive judgments.

Materials. An in-laboratory "art exhibit" was constructed with 20 framed representational art pieces (including photos, paintings, prints, and drawings) of various sizes hung on the walls of a medium-sized lab room. Small placards printed with the title and artist were displayed below each piece. To test participants' memory, 40 new multiple-choice questions were created based on the visual details of the pieces. As in Experiment 1, each question referenced the title and author of the painting and gave participants four options to choose from.

Procedure. Participants were run individually. Each participant signed a consent form in another room before being invited into "the gallery." Participants in both conditions were then welcomed into the gallery and told that they had 15 minutes to tour the gallery and to take their time while they look around. Participants in the Camera Condition were also given an Apple iPhone 6 and told to use it to take photos of whatever pieces they wanted, and to take as many or as few photos as they wanted. Participants in the Control Condition were given no further instructions.

After 15 minutes, participants were moved from the gallery to another room and the smartphone was collected from the participants in the Camera Condition. All participants were then asked, "*What percentage of the visual details of the art overall do you think you could remember if you were given a memory test?"*. Participants in the Camera Condition were then asked to make two additional predictions about their memory: one for the art that they photographed, and then one for the art that they did not photograph.

Finally, participants were given 20 minutes to complete the multiple-choice memory test administered through an online testing form. They were then debriefed and thanked for their participation.

Results

Photo-Taking Behavior. On average, participants in the Camera Condition chose to photograph 40% (SD = 27%) of the art pieces. Six participants in the Camera Condition chose not to photograph any art, and seven participants photographed all 20 pieces. The remaining 63 participants chose to photograph 37% (SD = 17%) of the paintings.

Memory Performance. Performance was analyzed first by comparing overall test scores between the Camera and Control Conditions. On average, participants in the Camera Condition answered 57.2% (SE = 1.4%) of the questions correctly, whereas participants in the Control Condition answered 57.6% (SE = 1.6%) of the questions correctly, a difference that was not statistically significant, $t(151) = .18$, $p = .56$, $d = .03$, 95% CI_d = [-0.35, 0.29].

Next, we compared memory performance on photographed vs. non-photographed pieces for the 63 participants who had at least one item that they photographed, and one item that they did not photograph. As shown in Figure 3, participants did not demonstrate a photo-taking-impairment effect. In fact, participants performed numerically better on the visual detail test for pieces they chose to photograph (*M* = 61.0%, *SE* = 2.0%) than they did for the pieces they did not photograph (*M* = 56.9%, *SE* = 1.9%), though this effect failed to reach statistical significance $t(62) = 1.51$, $p = .14$, $d = 0.24$, 95% CI_d = [-0.06, 0.54]. It should be noted that the same pattern of results was observed when we limited the analysis to participants who photographed at least 5 paintings, but no more than 15 paintings.

Metacognitive Judgments. Overall metacognitive judgments were compared first between the Camera and Control Conditions. On average, participants in both the Camera Condition (*M* = 50.2%, *SE* = 2.1%) and the Control Condition (*M* = 50.2%, *SE* = 2.1%) predicted that they would answer correctly about half of the test questions. No significant difference was observed, $t(151) = .02$, $p = .89$, $d = .004$, 95% CI_d = [-0.32, 0.32].

We then compared metacognitive judgments for photographed and non-photographed paintings for the 63 participants who made both judgements. Replicating Experiment 1, participants expected to remember substantially more visual details about the objects they chose to photograph (*M* = 61.2%, *SE* = 2.2%) than about the objects they did not (*M* = 42.0%, *SE* = 2.6%), $t(62) = 8.33$, $p < .001$, $d = 1.01$, 95% CI_d = [0.73, 1.28].

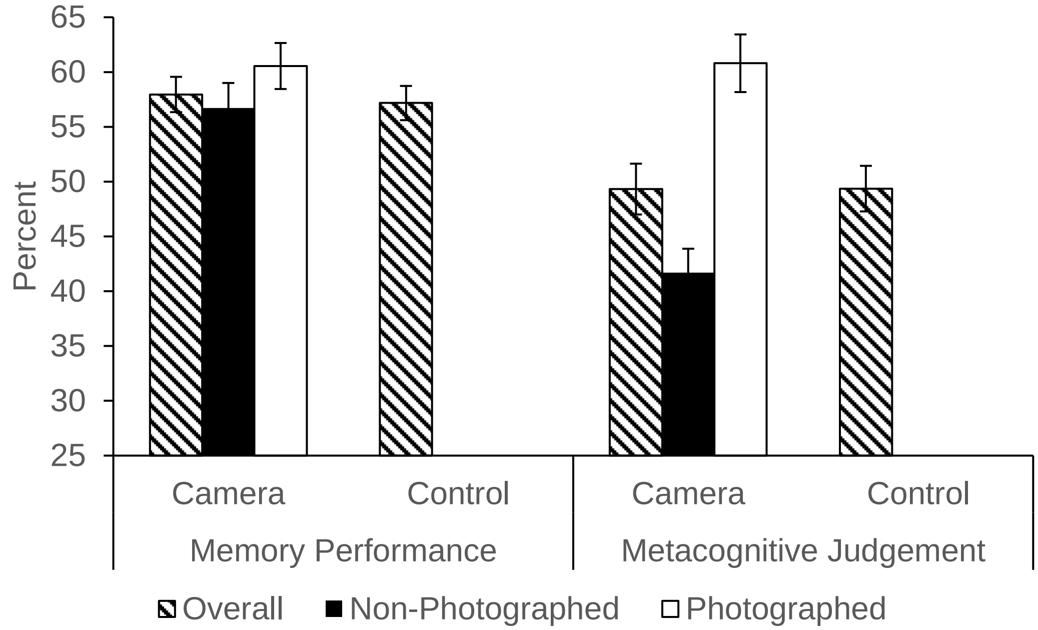

Figure 3. Mean percentage of memory performance and metacognitive judgements of memory performance for Experiment 2 as a function of Camera Condition (Camera vs. Control) and Item Type (Overall vs. Photographed vs. Non-Photographed). Error bars indicate standard error of the mean.

Discussion

Experiment 2 replicated the finding that participants believe that they will remember items they choose to photograph better than items they choose not to photograph. The effect appears to hold regardless of the actual memory effect (or lack thereof) of taking photos. Interestingly, volitional photo-taking within a larger scene appeared to protect against the photo-taking-impairment effect. Though the benefit in memory performance for photographed items compared to non-photographed items was not statistically significant, we can say with 95% confidence that the photo-taking-impairment effect that would be observed in the population under these conditions is, at most, quite small. Experiment 2 also failed to conceptually replicate Barasch et al.'s (2017) finding that exploring an art gallery with a camera improves overall visual memory relative to exploring an art gallery without a camera.

Experiment 3

In Experiment 3, participants were granted even more control over their time in the gallery to allow for a more naturalistic photo-taking experience. In Experiment 2, participants were instructed to explore the gallery for 15 minutes, and experimenters observed that almost every participant took multiple trips around the gallery to fill that time. It is possible that the time constraint forced participants to explore the gallery more thoroughly than they would have otherwise. Participants may have initially used the camera to direct their attention, but the effect of that attention could have been washed out once participants revisited paintings to fill the time. It is possible that the effects of having a camera and of taking photos might emerge if participants could decide how much time to allocate to the gallery themselves. Moreover, by measuring the amount of time participants in the Camera and Control conditions spent in the gallery, as opposed to controlling it, we should be able to learn more about how using a camera might affect the way in which people engage in a given experience.

Experiment 3 was designed to give participants control over how they explored the gallery environment by allowing them to decide how long they spent inside. Based on the research cited earlier by Barasch et al., we expected that participants who used a camera would spend more time exploring the gallery than participants without a camera, and that these participants would have relatively higher metacognitive judgments and actual memory performance than participants who did not have a camera. At the very least, we anticipated that participants in the camera condition would preferentially remember photographed items, since taking a photo of these items would force them to take an additional moment to pay attention to those items, and that this benefit would be especially pronounced for participants who spent little time in the gallery. If, as in Experiment 2, no benefits of photo taking are observed, then this would indicate that additional circumstances beyond unconstrained volitional photo-taking are required for the memory benefits of using a camera to be observed.

Method

Participants. A total of 152 undergraduate students were recruited from the UCSC participant pool. Participants were split evenly between the two between-subject conditions, with 76 in the Camera Condition and 76 in the Control Condition. This sample size was selected based on the power analysis run in Experiment 1.

Design. The design was the same as in Experiment 2, with one exception: since participants controlled the amount of time they spent in the gallery, time spent was recorded as a dependent measure.

Materials. All materials were the same as Experiment 2.

Procedure. Experiment 3 proceeded the same as Experiment 2, except that participants were allowed to control the amount of time they spent in the gallery. As such, the instructions were changed such that participants were told to let the experimenter know when they were ready to leave. Participants in the Camera Condition were also given the smartphone before they entered the gallery, such that being handed the camera would not influence how long they spent in the gallery.

Results

Photo-Taking Behavior. Participants in the Camera Condition chose to photograph an average of 41.3% (*SD* = 27.1%) of the art pieces. Six participants chose not to photograph any art, and six participants photographed all 20 pieces. The remaining 64 participants in the Camera Condition chose to photograph 39.7% (*SD* = 19.6%) of the paintings.

Time. Overall, participants chose to spend an average of 234.9 *s* (*SD* = 118.7 *s*) touring the gallery (or about 4 min), a duration substantially shorter than the 15 min spent by participants in Experiment 2. Participants in the Camera Condition spent an average of 250.8 *s* (*SD* = 139.7 *s*) in the gallery, whereas participants in the Control Condition spent an average of 219.0 *s* (*SD* = 91.3 *s*) in the gallery. This difference failed to reach statistical significance $t(150) = 1.66$, $p = .10$, $d = 0.27$, 95% CI_d = [-0.05, 0.59]. The longer participants spent in the gallery, the more likely they were to perform well on the memory test, $r(150) = .46$, $p < .001$, CI_r = [.32, .58], and the more confident they were in their expectations of their overall memory performance, $r(150) = .33$, $p < .001$, CI_r = [.18, .47].

Memory Performance. Performance was analyzed by comparing overall test scores between the Camera and Control Conditions. On average, participants in the Camera Condition answered 41.5% (*SE* = 1.4%) of the questions correctly, whereas participants in the Control Condition answered 42.5% (*SE* = 1.5%) of the questions correctly. As in Experiment 2, this difference was not statistically significant, $t(150) = 0.47$, $p = .64$, $d = .13$, 95% CI_d = [-0.18, 0.45] (see Figure 4).

We then compared memory performance on photographed vs. non-photographed pieces for the 64 participants who had at least one item that they photographed and at least one item that they did not photograph. As in Experiment 2, participants answered a similar number of questions correctly about the items they chose to photograph (M = 42.0%, SE = 2.1%) as they did for the items they chose not to photograph (M = 42.0%, SE = 1.8%), $t(63) = .01$, $p > .99$, $d = 0.09$, 95% CI_d = [-0.17, 0.35]. The same pattern of results was observed when we limited the analysis to participants who photographed at least 5 paintings, but no more than 15.

Metacognitive Judgments. Overall metacognitive judgments were first compared between the Camera and Control Conditions. As in Experiment 2, participants in the Camera Condition (M = 44.8%, SE = 2.2%) and Control Condition (M = 43.1%, SE = 2.2%) predicted similar performance on the memory test, $t(150) = .55$, $p = .58$, $d = 0.09$, 95% CI_d = [-0.23, 0.41].

We then compared judgments for photographed and non-photographed paintings for the 64 participants who could make both types of judgements. Replicating Experiments 1 and 2, participants again expected to correctly answer substantially more questions about the objects they chose to photograph (M = 58.7%, SE = 2.5%) than they did for the objects they chose not to photograph (M = 32.1%, SE = 2.4%), $t(63) = 10.43$, $p < .001$, $d = 1.22$, 95% CI_d = [0.93, 1.52]. It is interesting to note that the magnitude of the difference observed in this experiment was considerably larger than that observed in the previous experiments.

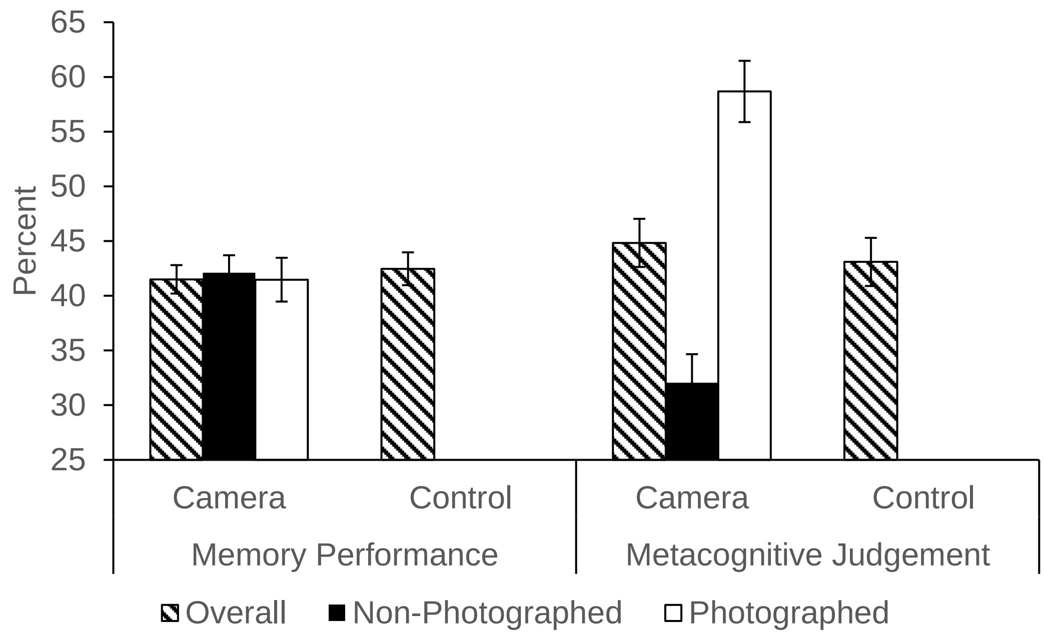

Figure 4. Mean percentage of memory performance and metacognitive judgements of memory performance for Experiment 3 as a function of Camera Condition (Camera vs. Control) and Item Type (Overall vs. Photographed vs. Non-Photographed). Error bars indicate standard error of the mean.

Correlations with Time in the Gallery. We also investigated how time was associated with participants' metacognitive judgements of the effects of taking photos by examining the correlation between time and the difference between participants' judgements for photographed and non-photographed items. We found no evidence that time in the gallery correlated with participants' judgements of the effect, $r(62) = -.12$, $p = .37$, $CI_r = [-.35, .13]$.

A similar analysis was done on memory performance data, examining the correlation between time and the photo-taking-memory effect (i.e., performance for photographed items minus performance for non-photographed items). No significant correlation was observed between time and any photo-taking-memory effect, $r(62) = -.01$, $p = .93$, $CI_r = [-.26, .24]$.

General Discussion

Across three experiments, participants consistently predicted that they would remember objects they chose to photograph better than objects they chose not to photograph, even though no such benefit was observed in actual memory performance. In Experiment 1, participants took photos of paintings they viewed on a computer screen either volitionally, or non-volitionally: having been yoked to the photo-taking choices of a volitional participant. A main effect of the photo-taking-impairment effect was observed such that participants answered fewer questions correctly about photographed paintings relative to non-photographed paintings; an effect that did not interact with volition condition. In Experiment 2, participants toured an in-laboratory art exhibit for 15-min and were either given a camera with which to volitionally take photos, or no camera. Participants did not reliably remember photographed objects differently from non-photographed objects, but again anticipated preferentially remembering photographed objects better than non-photographed objects. Participants who had cameras also performed similarly to participants who did not have cameras. Experiment 3 replicated the results of Experiment 2, even when participants could control how long they toured the art exhibit. Although participants spent substantially less time touring the gallery in Experiment 3 than they did in Experiment 2, no significant benefit of taking photos was observed. Participants still, however, anticipated a photo-taking benefit, and they still performed similarly regardless of whether they were assigned to use a camera. In both Experiments 2 and 3, participants who used a camera predicted similar overall memory performance to participants in the control condition, who did not use a camera, they just predicted that photographed pieces would be remembered better than non-photographed pieces.

Participants' metacognitive judgements seemed to align with the idea that when they choose to photograph an item, they think of that choice as akin to choosing to remember that item. Likewise, when participants choose not to photograph that item, they seem to expect to forget it. Of course, the test performance data indicate that memory is not actually directed this way, but participants seem to expect that they can direct memory toward photographed items and away from non-photographed items. This hypothesis is supported by the finding in Experiment 1 that participants reported the expectation that their memory for photographed objects would be better than their memory for non-photographed objects in the volitional condition, but this was not the case for the participants in the non-volitional condition. This type of curation seems to occur with more personal photos, as well. People frequently cite a desire to remember an event as a primary motivation for taking photos (Chapter IV), and many people report deleting photos when hoping to forget (Sas & Whittaker, 2013).

Our results can be compared to those reported by Barasch et al. (2017), which found that participants who used a camera outperformed participants who did not use a camera on a visual recognition test. Collapsing across both Experiments 2 and 3, we found no evidence that participants who used a camera (M = 49.4%, SE = 1.2) remembered the visual details within the art gallery any better than participants who did not use a camera (M = 50.1%, SE = 1.2), $t(303) = 0.42$, $p = .67$, $d = 0.05$, 95% CI_d = [-0.18, 0.27]. Although it can be challenging to interpret null results, a Bayesian odds analysis in this case indicates 7.28 odds in favor of the null (Rouder, Speckman, Sun, Morey, & Iverson, 2009).

Although we did not observe the same pattern of results as Barasch et al. (2017), our methodologies and parameters differed, and thus our results should not necessarily be interpreted as a failure to replicate. Their participants, for example, were tested using a visual recognition test, whereas our participants answered visual-detail multiple-choice questions. Participants may rely on a more holistic sense of familiarity when making judgements on a visual recognition test compared to a visual-detail test. It is therefore possible that exploring an environment with a camera benefits memory performance that is based on a general sense of familiarity, but not memory for visual details. Except for their Experiment 1, Barasch et al.'s (2017) participants were also run online and explored a virtual gallery using an on-screen viewfinder to approximate a camera. Our participants interacted with a physical smartphone. Interacting physically with a camera might be mechanistically important to how using a camera affects memory. For instance, the act of physically placing a camera between oneself and a visual scene could encourage some momentary or more prolonged attentional disengagement from that scene that counteracted the attentional focus afforded by exploring the scene with a camera. Future work should explore the effects of taking photos on different kinds of memory tests, as well as how the embodied aspects of handling a camera may interact with how using a camera impacts memory.

Consistent with Barasch et al.'s (2017) claim that volitional photo-taking attenuates or reverses the photo-taking-impairment effect, the results observed in the present study do appear to show that the impairment effect is at least attenuated when participants engage in volitional photo-taking. While the photo-taking-impairment effect was observed as a main effect collapsed across volition conditions in Experiment 1, when the analysis was constrained just to the participants who volitionally took photos, the photo-taking-impairment effect was no longer statistically significant, $t(53) = 1.35$, $p = 0.18$, $d = 0.21$, $CI_d = [-0.09, 0.52]$. In Experiments 2 and 3, participants also seemed to be protected from the photo-taking-impairment effect. These participants did not, however, reliably demonstrate preferential memory for photographed objects, even though they predicted this would be the case. We hesitate to make too much of these findings, given that item effects cannot be fully controlled when participants engage in volitional photo-taking. However, it is surprising considering the many reasons to expect volitionally photographed objects to be remembered better than non-photographed objects. It is possible that the effects of choosing items to photograph does indeed benefit memory for chosen items beyond unchosen items, but that this benefit was offset by the photo-taking-impairment effect. This sort of dual-mechanism offset hypothesis is somewhat unsatisfying though, and further research must be done to disentangle the effects of choosing items to photograph and the effects of taking photos (cf., Diehl et al., 2016, Study 5).

The results are also inconsistent with the prevailing cognitive offloading account of the photo-taking-impairment effect (Henkel, 2014). As discussed earlier, the cognitive offloading account predicts that, if anything, participants should be underconfident in their memory for photographed objects relative to non-photographed objects since they supposedly rely on the camera to remember the visual details of the objects for them. The overconfidence observed for photographed objects (or even the lack of there being under-confidence) makes it difficult to argue that participants intentionally forgot or failed to fully encode the paintings because they offloaded the job of remembering them onto the camera. Indeed, contrary to the predictions of the cognitive offloading account, taking photos had the effect of inflating participants' confidence in their own memory for photographed items relative to non-photographed items, at least in the context of volitional photo-taking.

Even though cognitive offloading is used to characterize many of our interactions with digital technology, there are other instances in which using digital technology causes people to be, as observed here, overconfident in their own memory. Using the Internet to access information, for example, has been shown to inflate estimates of one's own internal knowledge even though the information being accessed is held primarily online (Fisher, Goddu, & Keil, 2015). Such findings seem inconsistent with the idea that participants make metacognitive judgments based on a rational determination of what is and what is not stored in memory versus an external agent. Instead, they suggest that our use of digital transactive memory partners must be characterized as a more complex interaction than a decision to strategically "dump" memory into the internet or onto a digital device. Rather, our feelings and interactions with digital memory seem to characterize something of a "digital mind" with which we are deeply familiar and sometimes mistake for organic memory. Risko, Ferguson, and McClean (2016), for instance, found that participants reported distinct and accurate *feelings of findability* about information that could be found online. Likewise, Stone and Storm (2019) found that participants mistakenly attribute the time it takes to find information online as being predictive of how likely that information will later be recalled. Of course, this is not to say that there are no instances in which people take photos explicitly to offload memory of photographed information. However, we must move beyond exclusively characterizing our interactions with digital technology as strategic or explicit cognitive offloading, and instead develop more comprehensive theories of how memory and digital technology interact.

Concluding Comments

The ways we use digital technology are changing just as rapidly as the technology itself. Much of the research addressing memory in the digital age thus far has focused on how users strategically offload memory onto their devices (see Storm & Soares, in press). Indeed, people have been using external agents to offload the demands of memory for as long as they have been recording history (Nestojko, Roediger, & Finley, 2013). The current results suggest, however, that the cognitive and metacognitive effects of using digital technology and the mechanisms of those effects are likely to stretch well beyond the strategic use of cognitive offloading.

Moreover, these findings suggest that people's intuitions about the consequences of using and interacting with relatively new technologies, such as camera phones, can be surprisingly wrong. Indeed, it seems that photo-takers might intuit the act of taking a photo to be analogous to deciding to remember that information. Likewise, participants seemed to intuit the act of not photographing other information to be akin to forgetting that information. Perhaps everyday photographers might make their decisions to snap or not snap with a sense that they are intentionally curating their memories for later days. Curating organic memory, however, does not seem to be quite so straightforward as point-and-shoot. As digital devices become even more ingrained in our interactions with the world, we will likely continue to be challenged by the counter-intuitive effects of digitizing memory.

CHAPTER IV: Exploring Functions of and Recollections with Photos in the Age of Smartphone Cameras

Recent work has drawn attention to the consequences of photo-taking on memory (Barasch et al., 2018; Henkel, 2014; Niforatos et al., 2017; Soares and Storm, 2018). People report taking photos for reasons related to remembering personal events (Finley et al., 2018), but little is known about the effects of taking photos on autobiographical recollection. Because smartphone digital cameras and photo albums are so accessible, people are taking and viewing more photos than ever before (Heyman, 2015). Given the ubiquity of smartphone use and the rapidly decreasing cost of taking and storing photos, understanding the reasons that people take photos and how memory interacts with photo-taking has become increasingly important.

Some work in the existing literature can inform our understanding of why people take photos. Chalfen (1987) visited participants in their homes to review their family photo collections, and observed that photos seemed to be used to document events, support future remembering, and define a family's culture. Van House et al. (2004) interviewed casual photographers about why they took photos, and responses fell generally into three categories: memory, creating and maintaining social relationships, and artistic expression. Some years later, similar themes emerged from interviews with Flickr users, along with an additional category: self-representation (online and in other social settings)—the addition of which was perhaps due to the growth of social media networking (Van House, 2011). Some have attempted to organize motivations for photo-taking along two dimensions: social versus individual, and functional versus affective (Kindberg et al., 2005). These categories, however, often overlap or have fuzzy boundaries. Many participants report, for example, taking a photo for social reasons but then retain that photo to review individually (Lux et al, 2010).

More recently, Finley et al. (2018) asked participants to report the main reasons they take photos in a free response question as part of a large survey about participants' use of and beliefs about their own organic memory and *external memory*—devices and practices that allow people to store information out in the world. Over half of the reported reasons for photo-taking included ideas about taking photos to remember (52%), with 31% of reasons coded as likely to be about episodic memories, and 6% of reasons coded as likely to be about semantic memories. Finley et al.'s participants also reported taking photos for social and artistic reasons, as well as for reasons related to work or hobby-related activities. Taken together, several functions of photo-taking have emerged. People report using photos frequently to support memory. In addition, people use photos for social reasons, such as sharing experiences with others. Photos also seem to help people represent or otherwise express themselves by using photography as an artistic medium.

It stands to reason that taking photos with different goals would lead to different recollective experiences. Barasch et al. (2018), for example, found that when participants took photos of a given event with the intention to post to social media, they reported enjoying the event less than they did when they took photos to review later by themselves. The authors attributed this effect, in part, to participants in the social media condition being concerned about self-presentation. On the other hand, Diehl et al. (2016) found that taking photo enhanced participants' enjoyment of positive experiences relative to not taking photos. Diehl et al. also found that photo-taking caused participants to report being more engaged than when they did not take photos, and that this engagement mediated enjoyment of the photographed event. These findings suggest that, at least under certain circumstances, taking photos may enhance the enjoyment of and engagement in photographed events.

Little is known about how interactions with digital technology influence autobiographical recollection (but see Stone and Wang, 2019), yet photos are taken frequently to document autobiographical events. The bulk of the work that has explored the effects of photo-taking on memory has focused on how photo-taking influences the recall of semantic and or perceptual details related to an event (e.g., Henkel, 2014). Autobiographical recollection can also be characterized by aspects of episodic recollection, such as the multimodal imagery and emotional experience that accompany reliving an experience (e.g., Rubin et al., 2003). Much is still unclear, however, about how using digital technology influences such aspects of recollection. A notable exception is the work of Fawns (2019), which argued that photos belong to a kind of "blended memory system." This blended memory system characterizes remembering as a collaboration between internal memory systems and remembering practices, like taking and reviewing photos, over time. In an effort to advance upon Fawns' arguments, the current study sought to investigate participants' photo-taking behaviors in the context of their naturalistic photo-taking practices and real-life autobiographical experiences.

Camera phones have likely changed how people go about taking and reviewing photos as they are small, sleek, and easy to access. In the present studies, we were particularly interested in recruiting participants who owned smartphones with high-quality cameras. Though smartphone ownership has become quite common across all age groups, the 18-29 age group is the most likely to own a smartphone, with 96% reporting smartphone ownership (Pew Research Center, 2019). As such, a sample of college students were recruited, the vast majority of whom belonged to the 18-29 age demographic group.

The current study had two main goals: first, to investigate participants' reasons for taking photos; second, to examine whether a person's goals while taking photos are associated with how photographed experiences are subsequently recollected. The extant literature provides valuable information about the goals people have when engaged in photo-taking, but studies to date have relied heavily on participants' self-reported characterizations of their overall photo-taking behavior, an approach that could have led to certain general or thematic goals being over or under represented. Some motives could be more salient or accessible than others, for example, leading participants to think that they characterize a greater proportion of their photo-taking behavior than they actually do in reality. To circumvent this limitation, participants in the current study reviewed some of their own recently taken photos and reported their reasons for taking each photo individually. Participants were also allowed to respond freely with their goals so that they would not be led toward certain answers. Responses were then divided into categories using top-down deductive qualitative codes (e.g., Greene et al., 1989).

These qualitative codes were informed by the existing literature, and included broad themes divided into *social*, *self-related*, *aesthetic*, and *memory-related* goals. Here, photo-taking goals are defined as a participant's motivation for, or planned function of, a given photo. The present manuscript will focus largely on the memory-related goals, for which we included codes for goals associated with taking photos to later cue memory (memento), and goals associated with taking photos to hold onto information for future reference (offloading). These goals were designed to have some parallel to Finley et al.'s (2018) distinction between photos that likely contained episodic and semantic information, respectively. The memento and offloading goals were also constructed to provide a consistent coding scheme that would not require coders to speculate about the photographed content itself. These separate memory codes were of particular interest given that the two sub-codes describe distinct relationships between a participant's memory and the photographed information. In the case of the offloading goal, participants were expected to treat their photos as, at least to some extent, a replacement for their own internal memory. That is, the photo was expected to "remember" photographed information on the participant's behalf. For the memento goal, participants were expected to have a different, more collaborative relationship with their photos. When taking a photo with the memento goal, participants would have anticipated reviewing the photo at a later time and using it as a memory cue, rather than as a memory replacement.

For each photo, participants also reported features of their autobiographical recollection of the photographed event, including perceptual vividness, emotional valence, and emotional intensity. As such, we were able to explore differences in how participants recollected events during which photos were taken with different goals in mind. It is worth noting that the photographs participants reviewed in these studies were taken naturalistically, presumably of events in participants' everyday lives. Thus, the events during which photos were taken and the photos themselves likely differed as a function of participants' intentions while taking their photos, so causal inferences cannot be made about the impact of taking photos with a particular goal on how a given event is recollected. The aim of these studies is, rather, to explore naturally occurring associations between recollective experiences of photographed events and participants' motivations for taking photos in their everyday lives.

Several predictions can be made about memory-related photo-taking goals. First, we predicted that participants would report having taken photos for memory-related reasons for a substantial proportion of their photos, since memory is reported frequently as a reason for taking photos (e.g., Finley et al., 2018). We also planned to compare the patterns of recollection associated with the two different memory-related sub-goals. We predicted that participants would recall events associated with memento goals more vividly and more positively than events photographed without memento goals, and especially compared to events associated with offloading goals. This prediction was made because memento goals should be associated with participants' expectation to later recollect the photographed event in the presence of their photo. Presumably, participants would anticipate remembering these events more vividly and positively with the help of their photo, and we predicted that they would be at least somewhat successful in their goal. It also makes sense that people would choose to take photos of positive experiences with the goal of keeping those photos as mementos, whereas they would seem less likely to do so for negative experiences. In contrast, when participants take photos with the goal of offloading, the camera is responsible for "remembering" information about the photographed event. As such, we expected participants to remember events for which they engaged in offloading to be relatively less vivid and emotional than events for which they did not engage in offloading. More generally, if participants report both types of memory goals (i.e., memento and offloading) consistently, and if the events associated with such goals are recollected differently, then it would provide further support for a distinction between the two memory sub-goals, and further impetus for exploring the relationship between how people think about their photo-taking behavior and the recollective experiences that result from that photo-taking behavior.

Study 1

Method

Participants. A total of 103 participants (M_{age} = 20.6) were recruited through the University of California, Santa Cruz (UCSC) participant pool and compensated with partial course credit in a psychology course.

Materials. Participants completed an online survey instructing them to review the last six photos they had taken, either on their smartphone or using a digital camera (as expected, 95% of the participants reported using photos taken on a smartphone). Participants were asked to report their goal for taking each photo as a free response to the following question: "Why did you take this photograph? (no need to describe the photo, just your motivation for taking it)". If the photo was taken on a smartphone, they were also asked to indicate which camera mode they used (front-facing or back-facing).

Participants were asked several questions about their memory for each of the photographed events (for full materials, see https://osf.io/z2sk4/). First, perspective view was assessed using multiple-choice options that included *first-person, third-person, both,* and *unsure* answer options (Rice and Rubin, 2009). Memory for visual details was measured by asking participants select questions from the Autobiographical Memory Questionnaire (Rubin et al., 2003). These questions probed participants' vividness of re-experience of auditory, visual, and spatial imagery, along with their overall feelings of reliving the experience, including the extent of their emotional re-experience. A 1-7 Likert scale ranging from *not at all* to *as clearly as if it were happening right now* was used to assess vividness. Participants were then asked to rate the valence and intensity of the emotions associated with their memory using the Self-Assessment Manikin (Bradley and Lang, 1994), which used a 1-9 scale. For valence, a 1 rating indicated negative valence and a 9 indicated positive valence. For intensity, low ratings indicated weak emotional intensity, and high ratings indicated strong emotional intensity.

Procedure. The procedure was approved through UCSC's Institutional Review Board through an exempt protocol. Participants agreed to participate digitally in an online survey. They were told to use their smartphone or digital camera to report information about the last six photos they had taken. The photos themselves were never shared with the researchers. Participants were asked to include only photos that they took personally and intentionally, and to exclude photos that someone else took or that they might have taken by accident. Screenshots were requested not to be included, and if multiple attempts at taking the same photo were made, participants were instructed to consider only one photo from the series. Participants were asked to start with their most recent photo and move backwards, completing the questionnaire about their experience of recollection for each photo before moving onto the next, until six in total were completed. They were instructed to skip the remembering portion of the survey if they could not at all remember the event during which a photo was taken. At the end of the survey, participants reported how often they took photos, and whether they used a camera phone or another type of camera to take the photos. Finally, they were debriefed and thanked for their participation.

Results

Qualitative coding. A total of 618 cases were collected, only four of which involved participants reporting no associated recollection. Goal responses were coded using top-down qualitative codes, which split responses into *social*, *self-related*, *aesthetic,* and *memory-related* goals. Two memory sub-codes were assigned: *offloading* goals and *memento* goals. Raters could also assign a "no reason articulated" code in instances in which participants did not answer the goal question effectively or failed to provide enough detail for coding. Such photos were not included in any additional analyses.

Two independent raters blind to the quantitative data coded all of the qualitative goal data. If deemed appropriate, the raters were allowed to report more than one goal code, but only goals that overlapped between both raters were retained.

Across all codes, raters reached 83% agreement (Cohen's $\kappa = 0.78$), with 81% agreement in the memory-related subset, which will be the focus of additional analyses (Cohen's $\kappa = 0.65$). Disagreements were reviewed by a third blind rater to break ties between the first two raters. Only five cases were coded as belonging to two goals. Due to their infrequency, these cases were assigned one code by the third rater that seemed to best fit the response.

Frequencies and demographics. Participants reported taking an average of 3.9 photos per day ($SD = 5.4$), notably more than previous reports ranging between 1.8 (Hartman, 2013) to 2.8 (Hartman, 2017). Memory-related goals made up the largest proportion of goals (36.4%; $f = 225$) (for frequencies across both studies, see Figure 5). This proportion included 24.8% ($f = 153$) with memento goals, and 11.7% ($f = 72$) with offloading goals. Aesthetic goals were also frequently mentioned (30.1%; $f = 186$), as were social goals (21.4%; $f = 132$). Self-related goals appeared least frequently (5.2%; $f = 32$), making up an even smaller proportion of responses than those in which participants did not report a discernable goal (7.0%; $f = 43$).

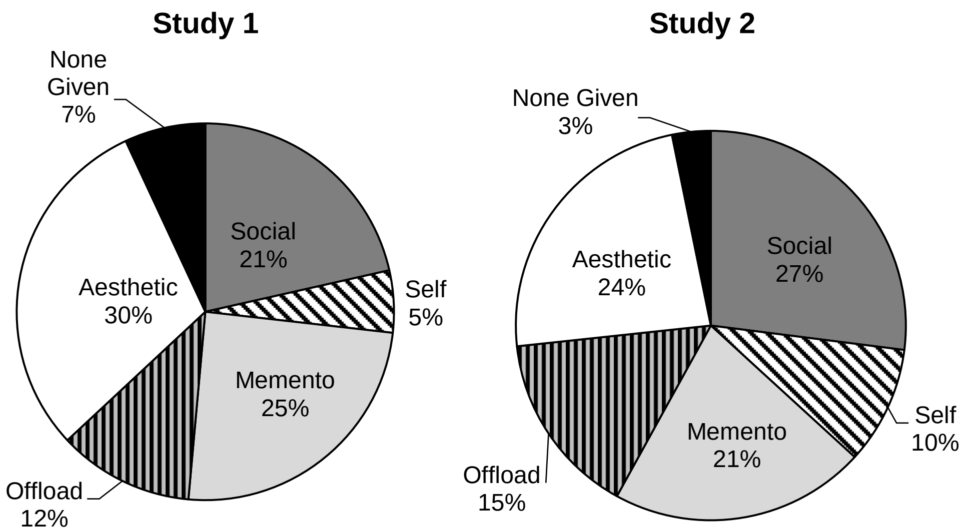

Figure 5. Proportion of photos reported across photo-taking goals in Study 1 and Study 2. Percentages indicate proportion of total goals assigned to each goal.

Memory Ratings. Each of the phenomenological ratings (vividness, valence, intensity) were compared across codes using an unstructured mixed linear model. All three models indicated significant differences between goal codes: vividness, $F(4, 345.3) = 13.58$, $p < .001$, valence, $F(4, 360.3) = 43.13$, $p < .001$, and intensity, $F(4, 366.2) = 21.68$, $p < .001$. The means and 95% confidence intervals can be seen in Table 1.

Table 1
Descriptive Statistics for Study 1

Goal	Vividness *M*	Vividness $CI_{95\%}$ of *M*	Valence *M*	Valence $CI_{95\%}$ of *M*	Intensity *M*	Intensity $CI_{95\%}$ of *M*
Social	4.81	[4.59, 5.04]	6.66	[6.39, 6.93]	4.68	[4.27, 5.09]
Self	4.78	[4.43, 5.13]	6.62	[6.08, 7.16]	4.19	[3.48, 4.90]
Aesthetic	5.12	[4.93, 5.30]	7.31	[7.10, 7.52]	5.14	[4.77, 5.52]
Offloading	4.67	[4.41, 4.93]	5.24	[4.89, 5.60]	3.91	[3.41, 4.40]
Memento	5.52	[5.32, 5.72]	7.90	[7.65, 8.14]	6.20	[5.81, 6.59]

Note. Descriptive statistics for measures of vividness, valence, and emotional intensity, split by qualitative codes associated with self-reported photo-taking functions. Vividness questions were rated on a scale of 1-7 with higher scores indicating more vividness of imagery. Emotional valence was rated on a scale of 1-9 with 1 representing negative valence and 9 representing positive valence. Emotional intensity was rated on a scale of 1-9 with higher scores indicating more emotional intensity.

Three additional unstructured mixed linear models were run to complete the planned analyses to investigate differences associated with the two memory sub-goals. These models compared the ratings as a function of the memento sub-code, the offloading sub-code, and the composite of the non-memory-related codes (social, self, and aesthetic). All three models were statistically significant: vividness, $F(2, 361.8) = 39.33$, $p < .001$; valence, $F(2, 391.4) = 74.37$, $p < .001$; and intensity, $F(2, 361.8) = 39.33$, $p < .001$.

Follow-up pairwise comparisons indicated significant differences between the memory-related sub-codes. Specifically, events associated with photos taken with the memento goal were recalled more vividly ($d = .74$, $CI_{95\%}$ of the difference [.60, 1.13]), more positively ($d = 1.68$, $CI_{95\%}$ of the difference [2.25, 3.12]), and more intensely (d = 1.11, $CI_{95\%}$ of the difference [1.76, 2.85]), than were events associated with photos taken with the goal of offloading.

Significant differences were also observed between each of the memory sub-codes and the non-memory-related composite. Specifically, events associated with photos taken with the memento goal were recalled more vividly (d = .51, $CI_{95\%}$ of the difference [.39, .76]), more positively (d = .56, $CI_{95\%}$ of the difference [.58, 1.16]), and more intensely (d = .60, $CI_{95\%}$ of the difference [.94, 1.71]), than were events associated with photos taken with a non-memory-related goal, whereas events associated with photos taken with the offloading goal were recalled less vividly (d = .24, $CI_{95\%}$ of the difference [.05, .53]), less positively (d = 1.10, $CI_{95\%}$ of the difference [1.42, 2.21]), and less intensely (d = .43, $CI_{95\%}$ of the difference [.49, 1.47]), than were events associated with photos taken with a non-memory-related goal.

Discussion

Overall, participants reported a variety of goals when taking photos, of which memory-related goals were well represented. Consistent with our predictions, both memory codes were reported frequently, and raters were able to differentiate consistently between the two codes. Participants reported markedly different recollective experiences after taking photos with each of the memory-related sub-goals. Consistent with our predictions, events associated with photos taken as mementos were recollected vividly, positively, and with strong emotional intensity, whereas events associated with photos taken to offload were recollected less vividly, more neutrally, and with less emotional intensity. Together, these findings indicate that people's recollective experiences do vary as a function of their goals when taking photos.

Study 2

One potential limitation of Study 1 is that all data were collected from participants across the same two weeks in late November, which included a university campus closure and a national holiday. It is possible, therefore, that the frequencies and goals of participants' photo-taking observed in Study 1 were not representative of their photo-taking behavior at other times of the year. For instance, many participants may have traveled to attend family gatherings at a time near data collection, leading to more photo-taking associated with memento goals. The holiday could also make recollection more vivid or emotional, since holidays are distinctive events. As such, Study 2 aimed to replicate the results of Study 1 with data collected several months later during a time period that did not include any national holidays.

Study 2 was also designed to further explore the metacognitive differences between the two memory-related sub-goals. The difference between the offloading and memento goals should be related to the subjective relationship between the participants' internal memory and their external memory. That is to say, when participants take photos to offload, the photo ostensibly becomes responsible for "remembering" the photographed information. The memento goal, however, implies a more collaborative or blended relationship in which the photo-taker expects to use the photo to supplement their memory. Another way to consider the distinction between the memento and offloading memory goals is in terms of participants' metacognitive experience of where goal-relevant information is stored—primarily in the photo itself, or shared between their internal memory and the photo. To explore this relationship more directly, participants in Study 2 were asked about the location of goal-relevant information, be it in the photo, or in their internal memory. Based on our conceptualization, we expected participants to report a larger proportion of information being stored in their photos (as opposed to their own internal memory) when they took a given photo to offload than when they took a given photo to serve as a memento.

Method

Participants. A total of 100 participants (M_{age} = 21.4) from the UCSC Participant Pool were recruited for partial course credit in a psychology class.

Materials and Procedure. The materials and procedure were largely the same as those of Study 1. Most importantly, a question was added asking participants to report the location of where goal-relevant information was stored—in their own internal memory, or in the photo's external memory. For each photo, participants were asked "Where is the information needed to accomplish your goal stored?" which they could answer using a Likert scale that ranged from 1 (*entirely in the photo*) to 7 (*entirely in my organic memory*).

Results

Qualitative coding. Results were analyzed using the same qualitative codes as in Study 1. A total of 600 cases were collected, with only two cases for which participants reported no recollective data, and three cases for which participants left their goal response blank. Across all codes, raters reached 87.2% agreement (Cohen's κ = .84), with 88.3% agreement (Cohen's κ = .77) on items for which at least one rater assigned a memory sub-code. Only one item was assigned two qualitative codes. As in Study 1, this item was assigned one code by the third rater.

Frequencies and demographics. As in Study 1, the vast majority of participants (96%) reported that their photos were taken using a camera phone. Overall, participants reported taking 3.4 photos daily (SD = 10.1), and memory-related goals once again made up the largest proportion of goals (36.5%; f = 219). This proportion included 21.2% (f = 127) photos with memento goals, and 15.3% (f = 92) with offloading goals. It is noteworthy that the relative proportion of memento to offloading goals decreased in Study 2 compared to Study 1 (from 68% to 58%), perhaps because of the difference in the time period under investigation (with Study 2 not taking place during a national holiday). Social goals were mentioned next most frequently (27.0%; f = 162), followed by aesthetic goals (23.5%; f = 141). Self-related goals appeared somewhat more frequently than in Study 1, but were still relatively infrequent (9.8%; f = 59). Participants did not report a clear or discernable goal for a small minority of photos (3.2%, f = 19).

Memory ratings. As in Study 1, each of the phenomenological ratings (vividness, valence, intensity), along with the location rating, were compared across codes using unstructured mixed linear models. The models indicated significant differences between goal codes with regard to all four ratings: vividness, $F(4, 453.5) = 20.06$, $p < .001$, valence, $F(4, 495.5) = 25.12$, $p < .001$, intensity, $F(4, 472.7) = 18.37$, $p < .001$, and the location of the goal-relevant information, $F(4, 490.1) = 12.27$, $p < .001$. The means and 95% confidence intervals can be seen in Table 2.

Table 2
Descriptive Statistics for Study 2

	Vividness		Valence		Intensity		Location	
Goal	*M*	$CI_{95\%}$ of *M*	*M*	$CI_{95\%}$ of *M*	*M*	$CI_{95\%}$ of *M*	*M*	$CI_{95\%}$ of *M*
Social	4.61	[4.40, 4.81]	6.55	[6.26, 6.84]	4.45	[4.07, 4.82]	3.30	[3.01, 3.60]
Self	4.35	[4.08, 4.62]	6.34	[5.89, 6.78]	4.67	[4.13, 5.20]	3.17	[2.75, 3.60]
Aesthetic	4.96	[4.75, 5.18]	7.31	[7.01, 7.61]	5.18	[4.79, 5.57]	3.68	[3.37, 3.99]
Offloading	4.02	[3.79, 4.26]	5.22	[4.85, 5.59]	3.24	[2.77, 3.71]	2.42	[2.03, 2.80]
Memento	4.94	[4.75, 5.18]	7.19	[6.86, 7.51]	5.41	[5.00, 5.83]	3.89	[3.56, 4.21]

Note. Descriptive statistics for measures of vividness, valence, and emotional intensity, split by qualitative codes associated with self-reported photo-taking goals. Vividness questions were rated on a scale of 1-7, with higher scores indicating more vividness of imagery. Emotional valence was rated on a scale of 1-9, with 1 representing negative valence and 9 representing positive valence. Emotional intensity was rated on a scale of 1-9, with higher scores indicating more emotional intensity. Location of goal-relevant information was rated on a scale of 1-7, with 1 representing information being stored exclusively in the photo, and 7 indicating information being stored exclusively in organic memory.

To analyze the ratings data further, and to explore the differences between the two memory sub-codes, four additional unstructured mixed linear models were run. As in Study 1, these models compared the ratings as a function of the memento sub-code, the offloading sub-code, and the composite of the three non-memory-related codes (social, self, and aesthetic). All four models were statistically significant: vividness, $F(2, 457.1) = 25.97$, $p < .001$; valence, $F(2, 508.9) = 37.08$, $p < .001$; intensity, $F(2, 477.34) = 30.28$, $p < .001$; and location, $F(2, 494.1) = 21.2$, $p < .001$.

Follow-up pairwise comparisons indicated significant differences between the memory-related sub-codes. Specifically, events associated with photos taken with the memento goal were recalled more vividly ($d = .74$, $CI_{95\%}$ of the difference [.66, 1.17]), more positively (*d* = 1.14, $CI_{95\%}$ of the difference [1.49, 2.44]), and more intensely (*d* = .99, $CI_{95\%}$ of the difference [1.62, 2.74]), than were events associated with photos taken with the goal of offloading.

Significant differences were also observed between each of the memory sub-codes and the non-memory-related composite. Specifically, events associated with photos taken with the memento goal were recalled more vividly (*d* = .22, $CI_{95\%}$ of the difference [.06, .43]), more positively (*d* = .22, $CI_{95\%}$ of the difference [.05, .75]), and more intensely (*d* = .30, $CI_{95\%}$ of the difference [.27, 1.08]), than were events associated with photos taken with a non-memory-related goal, whereas events associated with photos taken with the offloading goal were recalled less vividly (*d* = .54, $CI_{95\%}$ of the difference [.46, .88]), less positively (*d* = .86, $CI_{95\%}$ of the difference [1.16, 1.97]), and less intensely (*d* = .64, $CI_{95\%}$ of the difference [1.04, 1.97]), than were events associated with photos taken with a non-memory-related goal.

Finally, with regard to the location of the goal-relevant information, significant differences between each of the memory sub-codes and the non-memory-related goals were also observed. As expected, events associated with photos taken with the memento goal were judged to have more goal-relevant information stored in a way that was shared with the external photo than were events associated with photos taken with the offloading goal (*d* = .94, $CI_{95\%}$ of the difference [1.24, 1.93]). Moreover, events associated with photos taken with the memento goal were judged to have more information shared between organic memory and the photos than were events associated with photos taken with a non-memory-related goal (*d* = .26, $CI_{95\%}$ of the difference [.14, .78]), and events associated with photos taken with the offloading goal were judged to have more information stored internally than were events associated with photos taken with a non-memory-related goal ($d = .94$, $CI_{95\%}$ of the difference [.64, 1.39]).

An additional analysis was also conducted to explore the relationship between participants' reported location of goal-relevant information and their recollective experience of photographed events. Averages were taken of each participant's ratings of vividness, valence, intensity, and location ratings for memory-related codes. Significant positive correlations between higher ratings of shared goal-relevant information and vividness ($r(83) = .41$, $p < .001$, 95% CI of r [.21, .57]), valence ($r(83) = .37$, $p = .001$, 95% CI of r [.17, .54]), and intensity ($r(83) = .44$, $p < .001$, 95% CI of r [.25, .60]) were observed, such that when participants reported sharing more information between their photos and their internal memory, they were more likely to remember events vividly, positively, and with stronger emotional intensity.

General Discussion

Across two studies, participants reported taking photos with a variety of goals in mind, with no one goal emerging to represent the majority of photos taken (see Figure 5). Consistent with previous literature, and with our predictions, memory-related goals emerged to represent a large proportion of participants' photo-taking. Moreover, these memory-related goals could be divided into memento and offloading goals, with participants reporting notably different recollective experiences for events associated with each of the sub-goals. Participants reported recollecting events during which photos were taken to create a memento as being particularly vivid and positive, with this positivity being felt with more emotional intensity, than they did events during which photos were taken with other goals in mind, and particularly in comparison to events during which photos were taken with the goal of offloading.

The differentiation between offloading and memento goals, therefore, seems to be critical to understanding how memory and photo-taking interact. In Study 2, participants' reports of where goal-relevant information was stored provides more context to this distinction. When participants reported taking photos to offload, they reported that the photo itself was responsible for holding a large proportion of the information relevant to their photo-taking goal. Conversely, when participants reported taking photos in order to create a memento, they reported sharing more information between their organic memory and the camera's prosthetic memory. These findings suggest that the nature of a photo-taker's interaction with their camera depends on the relationship between their internal memory and the camera's external memory as it relates to their goal. Indeed, memory effects of taking photos could depend more generally on how a photo-taker conceptualizes the respective roles of their internal and external memory systems as they relate to the goal of their photo.

The focus of this investigation pertained specifically to the memory sub-goals. However, there were some patterns of note with respect to the non-memory codes (social, self, and aesthetic). Because self-related goals were reported so infrequently (S1: $f = 32$, S2: $f = 59$), it is difficult to make conclusions about how events associated with self-related photo-taking were recollected. However, it is noteworthy that events associated with the aesthetic goal were recollected relatively vividly, positively, and with high emotional intensity. This is perhaps unsurprising given that aesthetically motivated photos would be expected to be particularly interesting, engaging, or evocative. Perhaps more unexpectedly, events associated with social goals were recollected less vividly, less positively, and with less emotional intensity than most other goals. There are reasons to expect, for example, the retelling or rehearsal of an event to lead to the creation of a more vivid recollection of that event (Brown and Kulik, 1977; Tinti et al., 2014), and yet events associated with social goals, which by definition would seem to be likely retold and shared with others, tended to be recollected with limited vividness. Investigating the planned audience for whom photos are being taken might provide more context for this finding. For instance, people have been shown to recollect events photographed for acquaintances as less enjoyable than events photographed for close friends (Barasch et al., 2018). Future work should explore non-memory-related photo-taking further, with careful consideration paid to the intended audience in the case of social photo-taking.

Of course, because this work is correlational, little can be said (without further investigation) about the causal relationship between photo-taking and the experiential characteristics of mnemonic recollection. It is possible, for example, that the act of taking a photo with a particular goal causes a person to engage or disengage attention in such a way that photo-taking itself could cause a person to remember a photographed event in a particular way. It is just as likely, however, that certain photo-taking goals arise during different types of experiences. It is possible, for example, that certain photo-taking goals are more likely to occur during certain types of events than others. Future work should test this distinction experimentally, perhaps by manipulating participants' photo-taking strategies or plans for photographic review.

The present data can, however, speak more definitively to our understanding of why people take photos in the digital age. Camera phones afford photo-takers the opportunity to photograph events without planning ahead of time, and with little cost. Digital photo-taking has become so common an occurrence in so many spaces that some have argued that digital cameras have blurred the line between public and private life (Lasén and Gómez-Cruz, 2009). It seems likely that people's motivations for taking photos have changed as camera phones have become so widely available and relatively affordable. The practice of taking photos with an offloading goal, for example, may have become more frequent precisely because camera phones are likely to always be available for future reference. In this way, the present data provide a snapshot of photo-taking goals given the present ubiquity of smartphones.

As mentioned previously, the focus on recruiting smartphone users contributed to our recruitment of college students as participants. The vast majority of our participants were young adults (aged 18-29), who presumably grew up using digital technology. Patterns of camera phone use may differ qualitatively between older and younger adults. Older adults report different beliefs about their memory as well as different patterns of use for external memory aids relative to younger adults (Finley et al., 2018). Older adults are also less likely to engage in addictive and habitual smartphone behaviors than young adults (van Deursen et al., 2015). Future work should therefore explore potential differences in photo-taking goals and recollection across different age groups.

The present work aimed to build a foundation to improve our understanding of how photos are taken and how a photo-taker's goals while taking a photo may interact with the way in which they later remember a photographed event. Based on the current results, the goals people have with regard to the interactions between photo-taking and their internal memory are perhaps more diverse than previously appreciated. No single type of goal constituted the majority of photos taken, and the fact that we sampled the last six photos taken by each participant presumably ensured that the photos were more or less representative of the types of photos taken overall. Of course, the participants themselves consisted of only undergraduate students at a large university in the United States, and it remains to be seen whether the patterns of photo-taking motivations and associated mnemonic experiences would extend to other populations (Henrich et al., 2010). It also deserves emphasis that the effects of using any digital technology on memory and cognition are likely to be manifold and situational (Storm and Soares, in press; Wilmer et al., 2017). Future work should continue to investigate the complex interactions between cognition and digital technology with special consideration put toward investigating the naturalistic use of digital devices. Such work will be critical given that an individual's goals, expectations, and understandings of a digital device are likely to have a profound effect on how those devices interact with cognition.

CHAPTER V: A Goal-Mediated Self/Camera Framework

The data presented in Chapters II and III provide strong evidence that interactions between photo-taking and memory are not solely characterized by strategic cognitive offloading. The studies in Chapter IV extend this research line to include aspects of autobiographical recollection and indicate that photo-taking goals may be an important factor to consider when studying the effects of taking photos.

As such, I propose a theoretical framework that characterizes the structure of the transactive memory system formed between photo-takers and cameras. As previously discussed, the effects of photo-taking have been almost exclusively discussed in the context of differentiation—more specifically, cognitive offloading. Within this framework, I will also discuss the ways in which the camera could act as an integrated transactive memory partner, and when integration or differentiation might be more likely to occur. I will use this theoretical context to predict the effects of photo-taking on the various characteristics of autobiographical recollection, including accessibility, multimodal imagery, emotionality, and perspective view.

Central to this argument is the claim that taking a photo is to create cues for, or even "cross-cue" with, the future self. Said another way, I decide what, when, and where to photograph based on my predicted goals for remembering in the future. In this way, the proposed transactive memory system has parallels to the interaction between the working self and the autobiographical knowledge base described in the Self-Memory System (Conway, 2005; Conway & Pleydell-Pearce, 2000). The photographer must consider the goals of their current self as well as their potential future selves as they take photos that will meet those goals. Rather than selecting from information already in the autobiographical knowledge base, the act of taking a photo involves choosing what information will be included in an external autobiographical knowledge base—the camera's store of photos.

As such, the extent to which a photographer will differentiate or integrate with the camera will depend on the perceived memory goals of the photographer's future self. If the photo alone is sufficient to meet those goals, then differentiation will occur, and photographed information will effectively be offloaded onto the camera. That is, if my goal in photo-taking is to use the photo to store information or even tell a story in my absence, the photograph alone holds all of the necessary information to accomplish these goals and it would be inefficient for me to remember that information myself. If the photo alone is *insufficient* to meet the goals of the future self, then integration will occur such that information about the photographed event will be remembered better than non-photographed events. For a summary of the predicted effects of taking photos on AM based on type of photo-taking goal, see Table 3.

Differentiation

Photographic goals that will result in differentiation include instances in which the goal can be accomplished by the photo even in the absence of the photo-taker. If, for example, I take a photo of my parking spot number so that I can locate my car after a concert, my memory of the photographed information is not necessary to achieve my goal. In fact, if I sent the photo to a friend in response to their asking where in the lot I parked my car, they should be able to find my car without any further input from me. Differentiated goals in the context of social photo-taking and photo-sharing might involve taking a photo of something remarkable to show a friend or post on social media or taking a selfie while making a funny face. Insofar as the photo alone accomplishes the photo-taker's goal, their memory with the photo is differentiated.

Because the photo is to become responsible for the memory goals of the future self, the experience while taking a photo is likely to become *photo-focused*. The act of taking the photo as well as the content of the photo itself becomes the focus of the photo-taker until the camera is put down, or perhaps even for some time after the camera is put down. If this is the case, recollection—defined as the combination of accessibility, subjective vividness, emotionality, and perspective view—will have properties reflective of photo-focused experience.

Accessibility

As discussed earlier, differentiated transactive memory generally causes impairment in accessibility of shared information for individuals in the system (e.g., Sparrow et al., 2011). Based on these findings, memory for objects photographed with the intention to offload visual information or details onto the camera will be impaired relative to non-photographed information. Consistent with this prediction, memory impairment for photographed information relative to information that was just observed has been observed in several studies (Henkel, 2014; Niforatos et al., 2017; Soares & Storm, 2018). In each of these studies, participants expected to be tested on their memory, and Soares and Storm (2018) explicitly told participants they would be tested with the help of the camera. Using social media, including to take photos, also seems to impair memory regardless of whether participants are instructed to take photos to externalize for themselves or for others (Tamir, Templeton, Ward, & Zaki, 2018).

The mechanism by which cognitive offloading effects could occur is somewhat ambiguous. Cognitive offloading is often discussed as a strategic decision to maximize performance (Gray, Sims, Fu, & Schoelles, 2006; Kirsh, 1995; Maglio, Wenger, & Copeland, 2008; Risko, Medimorec, Chisholm, & Kingstone, 2014; Walsh & Anderson, 2009) or at least try to maximize perceived performance, though our metacognitive judgements might not be accurate (Dunn & Risko, 2015; Risko & Dunn, 2015). Memory impairment associated with cognitive offloading is thought to be caused by some disruption of encoding (e.g., Sparrow et al., 2011) or by intentional forgetting (Eskritt & Ma, 2014), intended to free up cognitive resources for remembering non-offloaded information (Storm & Stone, 2015). At least in the context of this theoretical framework, I argue that the mechanism for impairments to accessibility caused by differentiative photo-taking is attentional. Attentional disengagement with a photographed environment occurs because attention is directed toward the photo itself and toward the act of taking a photo during differentiative photo-taking.

Consistent with the attentional mechanism, Soares and Storm (2018) observed a photo-taking impairment effect even when participants explicitly could not rely on their camera as a transactive memory partner. In addition, Niforatos et al., (2017) found no evidence of the impairment when participants wore wearable cameras but did not interact with the camera itself. Likewise, this attentional mechanism is not inconsistent with the metacognitive findings discussed in Chapter III—that participants reported higher metacognitive judgements for photographed objects relative to non-photographed objects—in the way that a strategic offloading mechanism is inconsistent.

Vividness

Differentiative photo-taking will most likely result in less vivid feelings of re-experiencing the event while recollecting photographed events relative to non-photographed events. That is, multimodal imagery associated with remembering the events during which the photo was taken will be experienced less vividly than imagery associated with events during which no photos were taken. Because of the focus on the content of the photo itself, photographers will disengage from the concurrent event to focus on taking the photo.

As shown in Chapter IV, when participants reported taking photos for reasons categorized as more differentiative, they recalled associated events less vividly than events during which they took photos with other goals in mind. There are also published data consistent with the claim that photo-taking can cause disengagement under certain circumstances. Soares and Storm (2018) demonstrated a photo-taking-impairment effect even when participants could not rely on the camera to save their photos, an effect which we attributed to attentional disengagement. Mols, Broekhuijsen, van den Hoven, Markopoulos, and Eggen (2015), have also found that participants reported feeling more subjective disengagement while taking photos during a city trip than participants who used other methods to document the trip. Disengagement during an event does not seem to lend itself well to vivid re-experience since the event itself is not experienced particularly vividly.

Emotionality

The photo-focused nature of differentiative photo-taking could also dampen the photographer's emotional connection to the photographed events, likely through similar mechanisms of disengagement. As the photographer literally places the camera between themself and the events or information they choose to document, they could experience such disengagement or feelings of emotional distancing. As such, events experienced during differentiative photo-taking are expected to be experienced with a more neutral valence and weaker intensity than non-photographed events or events photographed with other goals in mind.

In Chapter IV, I report findings consistent with this prediction. Participants reported that, when they took photos described as being more differentiative, they remembered events more neutrally and with less emotional intensity relative to events associated with other photo-taking goals.

Perspective view

Because of the photo-focused nature of encoding while taking photos for differentiation, memory for aspects of the photographed events may come to resemble the photo itself. Memories of such events are expected to, therefore, be more likely recollected from a first-person perspective, although the opposite effect is expected when selfies are taken. Generally, more recent events are more likely to be recalled from a first-person perspective than later events (Nigro & Neisser, 1983; Talarico, LaBar, & Rubin, 2004). Photo-focused attention could cause memories to get "stuck" in the first-person perspective relative to other memories.

This prediction is somewhat surprising considering that memories recalled from a first-person perspective are generally experienced more intensely emotionally and vividly than experiences retrieved from a third-person perspective (Marcotti & St. Jacques, 2018; Sutin & Robins, 2010; Talarico et al., 2004; Vella & Moulds, 2014). Photo-focused attention, however, could disrupt emotionality and vividness even for events recalled with a first-person perspective, as the camera and the viewer have the same perspective. Participants might even have the sense that they are viewing the event through the camera's "eyes" or on the camera's display to a larger extent than they sense viewing the event through their own eyes.

Additional effects

Photo-focused attention or priorities could cause several additional consequences of differentiative photo-taking. Recollection of events taken under these circumstances seem likely to develop characteristics of the photos themselves. Events should, therefore, be recalled as particularly static, prone to missing context not captured from the photo, and may be prone to influence by characteristics specific to the camera (e.g., bad lighting, details out of focus, depth of field). In addition, recognition memory for the photograph itself might be particularly accurate, since the photo itself is meant to "stand in" for organic memory.

Photographic review

Photographs can serve as extremely effective retrieval cues (Berry et al., 2007; Deocampo & Hudson, 2003; Finley, Brewer, & Benjamin, 2011; Hodges, Berry, & Wood, 2011; Loveday & Conway, 2011; St. Jacques & Schacter, 2013), and therefore any photographic review might cause participants to report more accessible recollection than they would otherwise. However, with the exception of accessibility and perhaps visual vividness, photographic review is expected not to fully compensate for the differences in recollective experience caused by differentiative photo-taking relative to when no photos are taken. Because differentiative photos are taken with the goal of holding information, photographic review should robustly benefit accessibility of photographed information, which should more than compensate for photo-takers' impaired access to information on their own.

Integration

Photographic goals that will result in integration include instances in which the photographer must collaborate with the photo to accomplish the goal of the future self. If, in an analogy to my previous example, my goal is to remember the experience of being in a particular parking spot because that is where I shared my first kiss with my current partner, the photo alone cannot achieve my goal. My own memory will have to contribute a lot of information about our conversation, the smell of rained-on concrete, and my nervous-excited emotional state. In the context of social photo-taking, integrative photos are taken with the intention to help the photo-taker tell the story to a listener or audience, rather than to have the photo speak for itself. In order to accomplish the goals of the photo, the photographer must provide some additional information, context, or narrative. It is worth noting that AMs in their totality cannot be captured by a camera. Some of the visual imagery will be preserved, but the emotions, sounds, and events as they happened will not. As such, integration is expected to occur whenever the goal of photo-taking is future autobiographical remembering.

The photo-taking that occurs with integrative goals is not photo-focused, but instead *event-focused*. Rather than stealing away attentional resources or putting the photo-taker in a new context, event-focused photo-taking instead enhances focus on the autobiographical experience of an event as photo-takers prepare for later autobiographical recollection. The photographer must consider their future self as they construct a photograph cue, and design that cue to achieve their memory goals. I argue that ideal autographical remembering with the help of a photo cue is easy, vivid, and emotionally positive.

Accessibility

Self-generated memory cues are particularly effective for cuing memory in many tasks (Bellezza & Poplawsky, 1974; Finley & Benjamin, 2012; Jamieson & Schimpf, 1980; Kuo & Hooper, 2004; Saber & Johnson, 2008, for review, see Tullis & Finley, 2018), and across long delays (Bloom & Lamkin, 2006; Mäntylä, 1986, Mäntylä & Nilsson, 1988). Though the task of generating a cue for future remembering involves complex cognitive processes like metacognition, prospection, and an understanding of one's own future goals and cognitive states, participants seem to rise to the task. For example, Tullis and Benjamin (2015) found that participants given the instruction to create memory cues recalled more target words than participants asked to simply describe the target when tested with their generated cues. As such, it seems that recollection during photographic review of integrative photos would be particularly successful, with success defined by the goals of the future self.

The act of self-generating unique memory cues seems to aid in later recall even in the absence of the cues themselves (Hunt & Smith, 1996). As such, photo-taking with the intention to create a cue should result in increased accessibility of photographed events relative to non-photographed events. Taking a photo could even make the experience more unique or more elaborate, which could also enhance memory for photographed details (Nist & Hogrebe, 1987; Von Restorff, 1933; Wallace, 1965).

Consistent with this prediction, Barasch, Diehl, Silverman, and Zauberman (2017) found that participants remembered more visual details from an art gallery when allowed to take photos than when not allowed. Barasch, Diehl, and colleagues randomly assigned participants to use a camera or to use no camera during a real (Study 1) or virtual (Studies 2-4) museum tour. Memory on a visual recognition test was better in the Camera condition than the No Camera condition, and photographed aspects were remembered better than non-photographed aspects within the Camera condition. The discrepancy between these studies and others that have shown a photo-taking-impairment effect (Henkel, 2014), was explained by volition. Choosing what to photograph, Barasch, Diehl, and colleagues (2017) argued, focuses visual attention, whereas nonvolitional photo-taking (in purely experimental designs) does not, because the choice is made by the experimenter.

However, as shown in Chapter III, it appears that volitional photo-taking does not always necessarily cause a reversal of the photo-taking-impairment effect. Tamir and colleagues (2018) demonstrated memory impairments following volitional photo-taking during tours of a church. As such, volition alone cannot explain the discrepancy between Barasch, Diehl, and colleagues' (2017) findings and demonstrations of the photo-taking-impairment effect.

Rather, the photo-taking goals associated with typical volitional or non-volitional paradigms could help explain the discrepancy in these findings. Each of the published demonstrations of the photo-taking-impairment effect used somewhat different methods, but participants were made aware that their memory would be tested, either by explicitly telling the participants so (Henkel, 2014; Soares & Storm, 2018), or by framing the experiment as a memory task (Niforatos et al., 2017). Barasch, Diehl, and colleagues' (2017) studies included no such instructions. Test expectancy frames the task of photo-taking as particularly differentiative, implying that capturing the visual details to be studied during a later test is the goal of photo-taking. While Tamir and colleagues (2018) allowed for volitional photo-taking and did not appear to inform participants that they would be tested for their memory later, participants were not allowed to use their own devices to take photos. Instead, participants were supplied with an iPod Touch by the experimenter. This design choice allowed for more experimental control than letting participants use their own devices but may have also disrupted integrative photo-taking goals since participants knew they would not be able to review their photos after the experiment was over. That is, participants had no incentive to create memory cues for their future selves since they knew they would not have access to those cues for much longer than the immediate future. The same is true for the data presented in Chapter III. Barasch, Diehl, and colleagues' (2017, Study 1) participants who toured a museum used their own smartphones.

Rather than reflecting different effects of volitional or non-volitional photo-taking, the literature as it stands may instead demonstrate discordant effects of photo-taking based on the goals implied by experimental designs with more (differentiation) or less (integration) experimental control. Of course, this claim is only a hypothesis since no published study, at least to my knowledge, has reported exploring an interaction between participant goals and the effects of taking photos on memory accessibility or accuracy.

Vividness

Because of the event-focused nature of integrative photo-taking, photographed events should be recalled with more vivid multimodal imagery than events photographed under other circumstances or non-photographed events. Integrative photo-taking goals should help to focus attention, particularly on the visual aspects of an event, but this focus could spill over to non-visual aspects, as well. If this is the case, participants should also report feeling particularly engaged in an experience while taking photos with integrative goals.

Consistent with this prediction, Diehl, Zauberman, and Barasch (2016) found that taking photos enhanced participants' enjoyment of positive experiences both in the field and in the lab. They argue that participants enjoyed events where they could freely take photos more than events where photo-taking was not allowed because photo-taking enhanced engagement, a hypothesis which was supported by their finding that engagement mediated enjoyment. Likewise, Barasch, Zauberman, and Diehl (2017) found that participants reported a similar moderation effect of engagement on enjoyment, and that participants were particularly engaged when they took photos after being instructed to take photos with the goal of "preserving the experience for [themselves]" (p. 1227). The hypothesis that integrative photo-taking produces more vivid recollection than differentiative photo-taking or no photo-taking at all has not yet been directly tested. However, if more engagement translates to more vivid re-experience of an event, the pattern of results in the literature bodes well for this hypothesis.

Emotionality

In the case of autobiographical remembering, "successful" remembering is likely to be positively valanced. Though remembering past mistakes or even traumatic events can be useful for personal growth and future safety (Herman, 1992; Pillemer, 2003), it seems that only a small minority of photos of particularly negative events would be taken and stored. In fact, many people report deleting mementos that come to elicit painful memories, such as emails from an ex-partner after a breakup (Sas & Whittaker, 2013). AMs reflect this bias, as recollections of the past are usually positively biased (Walker, Skowronski, & Thompson, 2003). Participants consistently report remembering more positive events in the past than negative or neutral (Berntsten, 1996; Chwalisz, Diener, & Gallagher, 1988; Suedfeld & Eich, 1995; Waldfogel, 1948). Likewise, participants tend to generate more positive than negative anticipated personal events in the future (MacLeod & Byrne, 1996; Shrikanth, Szpunar, & Szpunar, 2018). This bias may result from prioritization of information consistent with one's conception of the self, or the working-self (Conway, 2005). Psychologically healthy people tend to believe that they live generally happy lives (Chwalisz et al., 1988), and so this belief may cause them to remember their lives as generally happy.

Given this bias toward positivity about one's own life, photo-takers most likely take integrative photos with the intention of having a positive recollective experience. This is not to say that photo-takers will intentionally bias their photographic records toward the positive aspects of an event in pursuit of this goal. The event could be remembered fondly even given negative aspects that might have been captured by the camera. Taking a photo of a dropped cake at a birthday party might seem upsetting in the moment but reviewing said photo might elicit a chuckle later on, and with it fond memories of going out for ice cream instead. Taking a photo with the intention to positively remember later could cause the photographer to remember the photographed event itself more positively, even without photographic review.

This prediction is consistent with findings that photo-taking can enhance enjoyment of an event, particularly photo-taking with the intention of creating a record for oneself (Barasch, Zauberman, et al., 2017; Diehl et al., 2016). If an event is experienced particularly positively, it follows that it should be remembered more positively than others, since positive affect fades more slowly than negative affect over time (Cason, 1932; Holmes, 1970; Matlin & Stang, 1978; Robinson, 1980; Thompson et al., 1996).

Perspective view

Because integrative photo-taking is event-focused, photographed events should not "get stuck" in a first-person perspective in the way that photos taken with differentiative goals might. Rather, memories for events photographed with integrative goals should be recalled from a first-person perspective at a similar rate as any other AMs (Nigro & Neisser, 1983). This prediction has not yet been tested in the literature; the effects of photo-taking on perspective view are largely unknown.

Additional effects

Because integrative photo-taking is characterized by goals beyond the photograph itself, memories associated with such photos should not come to resemble the photographs themselves in the way that events during which differentiative photos are taken might. As such, memories associated with integrative photo-taking are not expected to be particularly static or missing context. Likewise, memories of events photographed with integrative goals should be relatively resilient to the influence of photo-specific distortions like poor lighting or focus. Recognition memory for one's own photo is not expected to be enhanced to the extent that it will be for photos taken with differentiative goals. Rather, similar photos taken by someone else of the same event might elicit many of the same feelings of rich recollection as viewing one's own photo.

Photographic review

Photographic review is expected to enhance the predicted effects of integrative photo-taking. If photos are taken with the goal of easy, positive, vivid recollection, participants should be at least somewhat successful in achieving these goals. Photographic review may not enhance accuracy, however, to the extent that it is expected to enhance other features of recollective experience. This pattern is expected because integrative photos are taken with more recollection-focused goals than accuracy-focused goals.

Further Implications

Differentiation and Integration are not Binary

Photo-takers can have multiple complex goals for photo-taking, of which they may not even be explicitly aware. I have discussed these goals to the extent that they might favor differentiation or integration with the transactive memory system between the photo-taker and the camera. It is worth noting, though, that differentiation and integration of different features of an experience can occur simultaneously. Some goals for the future self might require that certain information is differentiated between the photo-taker and camera while other information is integrated. For instance, I may take a photo of my brother's graduation with the intention of posting it to social media along with a story about how emotional I felt as I saw him walk across the stage. Both the photo and I are responsible for remembering some of the same information, but our responsibilities are different. The photo is responsible for documenting that my brother completed his degree at SUNY Buffalo and that he has grown into a man, but only I can account for my feelings of pride during the event. As such, depending on the division of labor between myself and the photo, I may show some memory effects consistent with photo-focused (e.g., my memory coming to resemble the photo itself) as well as event-focused (e.g., memory for the event being remembered as particularly positive) attention.

The Role of Metacognition

Another prediction that follows from the claim that the effects of photo-taking depend on the photographer's intended memory goals for the future self is that current and predicted future metacognition will influence the decision to take photos, as well as how photos will be taken. Individual differences in subjective beliefs about the efficacy of one's own internal memory, for example, could influence photo-taking behavior. Indeed, Finley, Naaz, and Goh (2018b) found that participants who reported having less effective internal memory reported more reliance on external memory. As such, participants beliefs about their own internal memory should influence their photo-taking behavior.

The decision to take a photo may also influence how participants expect to remember photographed events in the future. If participants have particularly differentiative goals while taking photos, they might be aware of the attentional disengagement or explicit offloading strategy taken while photographing to-be-offloaded information. As such, they might expect their own internal memory of photographed information, at least in the absence of the camera, to suffer relative to non-photographed information. Likewise, integrative photo-taking, and the engagement and event-focus associated with it, could cause participants to expect that they will recall photographed information better than non-photographed information. It should be noted, however, that metacognition does not always track actual memory performance, since participants can be misled by the subjective ease with which items are retrieved (Benjamin, Bjork, & Schwartz, 1998), perceived (Rhodes & Castel, 2008), and encoded (Begg, Duft, Lalonde, Melnick, & Sanvito, 1989). It is also possible, for example, that photo-taking in general could cause a metacognitive illusion of fluent encoding as participants save information to the camera (Soares & Storm, 2018), or have difficulty differentiating between their internal memory and the camera's external memory (e.g., Fisher, Goddu, & Kiel, 2015).

Measure of Memory	**Effect of Photo-Taking Relative to No Photo-Taking**	
	Integrative	*Differentiative*
Accessibility	More accessible	Less accessible
Vividness	More vivid	Less vivid
Emotional valence	More positive	More neutral
Emotional intensity	Stronger	Weaker
Perspective view	No effect	More similar to photo's perspective

Table 3. Principal predictions of the Goal-Mediated Self/Camera Framework.

CHAPTER VI: Future Directions & Conclusions

Future Directions

I have several plans to test the various predictions of the Goal-Oriented Self/Camera Framework. First and foremost, I hope to directly manipulate participants' photo-taking goals both within the lab and in the field in order to test the predictions of the framework directly. However, preliminary studies indicate that manipulating participants' photo-taking goals might not be so simple as providing different sets of instructions. Additional steps may be needed to convince participants to take on a photo-taking goal, such as manipulating task expectancy. I may have to ask participants to take photos for different purposes rather than just asking them to take photos with different goals in mind. Likewise, I will also need to include manipulation checks in order to determine whether participants actually remembered and adopted the photo-taking goals intended.

In addition, I plan to test the Goal-Oriented Self/Camera framework in the context of the photo-taking-impairment effect. As demonstrated by Chapter III, there is currently some confusion within the literature on when the photo-taking-impairment effect is observed versus when a reversal, or photo-taking benefit is observed. I believe that the framework could elucidate the conditions under which the photo-taking-impairment effect occurs. I plan to use a similar paradigm to that used in Chapter II (Soares & Storm, 2018), but use instructions and/or task expectancy to manipulate participants' photo-taking goals. There will be three between-subjects conditions, one with no additional instructions, one with instructions to encourage integrative photo-taking, and one with instructions to encourage differentiative photo-taking. I predict that participants who take photos with integrative goals will demonstrate at least an attenuated photo-taking-impairment effect, if not a reversal of the effect, relative to participants who receive no instructions or differentiative instructions. I also predict that participants who receive differentiative instructions will show a larger photo-taking impairment effect than the participants who receive no instructions or integrative instructions.

Conclusions

Very little is known about how transactive memory systems influence autobiographical remembering. The literature on the effects of photo-taking itself is also currently focused on the effects of photo-taking on memory for visual details. The proposed theoretical framework will benefit the study of digital transactive memory systems by researching them in the context of autobiographical memory, and by taking the photographer's relationship with their digital transactive memory system into account. Ultimately, the goal is to depict a nuanced relationship between camera and photo-taker which will be relevant for the literatures on transactive memory, embedded cognition, human-computer interaction, and applied memory.

It is also worth noting that the implications of the proposed framework are not limited to photo-taking. Photo-taking is a particularly common practice, but the framework is also relevant in any situation in which people create and curate cues for future remembering. As technology advances, new modes of record-keeping and documentation may emerge, but users' motivations for creating memory cues and their relationship with their external transactive memory partner should remain relevant.

Because of the theoretical functions AMs serve, advancing our understanding is also important in an applied sense. If frequent photo-taking generally disrupts AM formation, photo-junkies' social lives, sense of self, and ability to meet their goals could be unwittingly jeopardized. If, instead, the effects of photo-taking on AM depend on mindset when the photo is snapped, the solution to this feared problem could be as simple as thinking before you shoot.

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