

Comparing functions of and recollection with recently taken and recently deleted smartphone camera photos

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Abstract

The current study examined why people take and delete photos with smartphone cameras, and participants' recollective experiences with saved and deleted photos. Two mixed-methods surveys asked undergraduates (Study 1) and an international online sample (Study 2) to review both recently taken and recently deleted photos from their smartphones' photo album or trash bin. Participants recollected the photographed events for both types of photos and rated the quality of their recollections. Events recollected with saved photos were remembered more vividly, positively, and emotionally intensely compared to recollection with deleted photos. Participants also gave short responses about why they originally took both types of photos, as well as why they had deleted the recently deleted photos. Consistent with prior work, different photo-taking goals were associated with different recollective experiences, especially for photos taken as mementos compared to photos taken to offload information.

KEYWORDS

autobiographical memory, delete, digital artifacts, extended memory, photographic review

1 | INTRODUCTION

Cameras and photos are not new technology, but the rise of digital smartphones with high quality cameras and huge cloud-based digital photo albums has likely changed how cameras and photos are used (Gómez Cruz & Meyer, 2012; Hand, 2012; Sandbye & Larsen, 2013; van Dijck, 2004, 2007). Taking many digital photos comes with little cost compared to film, so it is easy and cheap to take digital photos in increasingly casual and personal situations ranging from eating a meal (Atwal et al., 2018) to attending a funeral (Gibbs et al., 2015). Digital photos are also exceptionally easy to share through social media, messages, or in person (Sarvas & Frohlich, 2011), leading some to argue that photo taking has generally become more social and self-representational in the digital age (van Dijck, 2008). Smartphones are also carried around regularly, able to access hundreds or even thousands of personal photos at any time (Sarvas & Frohlich, 2011). This kind of reliable access facilitates the use of photos as reminders or even sites of memory themselves (Clark & Chalmers, 1998). Photos often document events that will become autobiographical memories,

so it is important to examine the interface between photos and memory.

Memory-related uses have consistently emerged in studies of people's motivations for taking photos, both before and after the rise of smartphone cameras (for review, see Soares & Storm, 2022a). Even in early work, which focused on the social functions of family photos for telling stories, family photo albums were also described as records for future generations—externalized memory stores that could outlive the photo-taker (Langford, 2001; Spence & Holland, 1991). Memory-related functions also emerged from interviews with hobbyist photographers, along with social and artistic themes (Van House et al., 2004). These same themes emerged again some years later in interviews with users of a photography social media platform, joined by the theme of self-representation (Van House, 2011).

More recent work has examined people's goals for taking photos with digital smartphone cameras, with particular interest paid to memory-related goals. As part of a larger 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-- Finley et al. (2018) asked participants to report their main reasons for taking photos. Over half of the reported reasons (52%) were coded as related to memory. These memory-related reasons were further coded, with 31% of reasons coded as likely to be about episodic memories, and 6% of reasons coded as likely to be about semantic memories.

Soares and Storm (2022a) conducted two mixed-methods surveys to specifically investigate memory-related goals for taking photos with smartphone cameras. In these studies, participants were instructed to review the last six photos they had taken and report why they had taken each one. For each photo, participants also remembered the event during which the photo was taken and completed several scales to indicate qualities of their recollection. Photo-taking goals were coded consistently with the themes discussed from the literature: *social* goals that focused on photo-taking to share or communicate, *esthetic* goals associated with artistic expression or capturing interesting images, *self-related* goals concerned with self-representation or tracking personal progress, and *memory* goals which were divided into two sub-goals.

Goals associated with creating memory cues for later recollection were coded as *mementos*, while goals associated with saving information for later reference were coded as attempts to engage in *offloading*. Offloading refers the use of resources outside of the head to improve performance or make cognitively demanding tasks feel easier (Kirsh & Maglio, 1994; for review, see Risko & Gilbert, 2016). It is impossible to know whether participants were successful, but the code was assigned to goals described as attempts to offload the task of remembering onto a photo (Soares & Storm, 2022a). Though subtle, the distinction between *offload* and *memento* goals was substantial when it came to participants' recollective experiences. Participants reported significantly more vivid, positive, and emotionally intense recollections associated with photos taken as *mementos* compared to photos taken to *offload*. Consistent with how the codes were operationalized, participants reported sharing more information between their own organic memory and the external memory of the photo for photos taken with *memento* goals compared to *offload* goals. Likewise, participants reported that significantly more information was stored exclusively in photos associated with *offload* goals (Soares & Storm, 2022a).

That photo-taking seems to be consistently intertwined with memory raises interesting questions about how photo albums are curated—if people often take photos with the intention to remember, do they also delete photos with the intention to forget? Research in personal information management suggests that people do delete photos and other digital objects to help them forget or move on from the past. One study, which interviewed people who had recently experienced a romantic breakup, found that photos were the most prevalent form of digital artifacts of a relationship, and that most participants (16 of 24) deleted at least some of these artifacts (Sas & Whittaker, 2013). A larger, more recent survey also found that a majority of participants reported deleting digital artifacts after a breakup, some of them going out of their way to purge social media pages (McDaniel et al., 2021). Some therapists even have clients

ritually dispose of photos or other objects as a means of moving on from grief after bereavement or separation (Sas et al., 2016). Wolters et al. (2014) examined more casual deletion practices by having participants take many photos of a street festival and later pare down the photos they had taken. Participants' reasons for deleting photos included that the photo evoked negative emotions, aligning with the work on separation, but also more mundane reasons like poor esthetics or not capturing the intended subject, having duplicate photos, and losing interest.

There is evidence to suggest that deleting photos might indeed be an effective strategy for forgetting autobiographical memories. In one survey, participants who deleted digital artifacts like photos following a breakup showed lower levels of distress compared to participants who maintained those digital artifacts (McDaniel et al., 2021). Conversely, repeatedly visiting the social media page of an ex-partner is also associated higher negative affect (Marshall, 2012). Facebook's Year in Review and Memories features, which show users old posts, sparked controversy by accidentally providing painful reminders of deceased loved ones or ex-partners, fostering interest in algorithms that can strategically "forget" painful memories (Jacobsen, 2021).

Since photos are so related to memory, deleting photos could also physically represent engaging in intentional or directed forgetting. Directed forgetting occurs when information flagged with a cue to forget is less likely to be remembered than information flagged with a cue to remember (Bjork, 1970; for review, see Anderson & Hanslmayr, 2014). Directed forgetting has been observed for autobiographical memories (Joslyn & Oakes, 2005), as has intentional forgetting using the think/no think paradigm (Noreen & MacLeod, 2013). There is some evidence to show that engaging in physical actions that represent mental processes can have effects similar to engaging in those mental processes. Briñol et al. (2013) had participants write down their thoughts on paper and either keep them in a safe place or throw them away. Relative to a control group that turned their papers into the experimenter, participants who kept their papers safe formed judgments (about their own bodies in Experiment 1, and about the Mediterranean diet in Experiment 2) more consistent with those thoughts, while participants who threw away their papers formed judgments less consistent with their thoughts. Some have suggested that people interact with photographs as they would physically materialized memories (van den Hoven et al., 2021). As such, deleting a photo could represent and encourage intentional forgetting that could degrade the vividness and emotional salience of recollective experiences associated with deleted photos.

2 | STUDY 1

Study 1 sought to examine differences in recollective experiences of autobiographical memories evoked by saved and deleted photos as well as participants' self-reported reasons for deleting certain photos. Borrowing from the methodology of Soares and Storm (2022a), a mixed-methods survey was constructed that asked participants to

review their own naturalistically taken smartphone camera photos and answer questions about the characteristics of their recollection of each photographed event. Participants reviewed both saved photos from their photo album, as well as deleted photos in their trash bin or recently deleted folder. In addition to qualitatively reporting their reasons for taking each photo, participants additionally reported why they deleted each photo that had been deleted.

Using this design, I examined whether participants naturalistically described deleting some photographs to forget and could determine the prevalence of this behavior. In addition, I examined whether qualities of recollection varied with saved compared to deleted photos. If participants reported that recollection with deleted photos was less vivid and less emotionally evocative than recollection with deleted photos, this finding would be consistent with the hypothesis that deleting photos acts as a cue for or embodiment of intentional forgetting. Finally, this design afforded exploratory examination of the reasons that photos are deleted and the opportunity to replicate Soares and Storm's (2022a) findings that recollective experience varies depending on photo-taking goal, specifically with respect to the two memory-related sub-goals.

2.1 | Method

2.1.1 | Participants

A total of 213 participants were recruited from the psychology participant pool at Mississippi State University and were compensated with partial course credit. Data from eight participants were removed because they reported being unable to access their deleted photos or having no recently deleted photos. Of the remaining 205 participants, 155 were women, 48 were men, one was non-binary/third gender, and one left the option blank. Participants had a mean age of 20.3 years ($SD = 13.9$; $Mdn = 18$).

2.1.2 | Materials and design

Full materials are available online: <https://osf.io/h8zqn/>. An online survey was constructed with two conditions examined within-subjects: Saved and Deleted photos. Participants reviewed their three most recently taken photos and their three most recently deleted photos. Recent photos were selected for this study because participants should be more likely to accurately recall their photo-taking goals for recent photos, and because most mobile operating systems empty the recently deleted photos folder after 30 or 60 days.

For the Saved condition, participants were instructed to review the last three photos they had taken that were saved in their photo album. While reviewing each photograph, participants were first asked "Why did you take this photo? (please make sure that you do not describe the photo, just your motivation for taking it)". For the Deleted condition, participants accessed their three most recently deleted photos. They were asked the same initial question, and then

asked to report their reason for deleting each photo. For both types of photo, participants answered "Where is the information needed to accomplish your goal stored?" using a sliding scale that ranged from "entirely in the photo" to "entirely in my organic memory" (Soares & Storm, 2022a). Saved and Deleted photos were accessed in blocks, and the order in which participants accessed their Saved or Deleted photos was counterbalanced across participants.

Participants were also asked questions about their recollection of each photographed event. Participants reported their perspective view with options *first-person (from your own eyes)*, *third-person (as an observer or spectator)*, *both (it switches back and forth)*, and *unsure* (Rice & Rubin, 2009). Questions about the vividness of multimodal imagery associated with participants' recollections were selected from the Autobiographical Memory Questionnaire (Rubin et al., 2003). These questions probed the extent to which participants re-experienced the sights, sounds, and setting associated with their recollection using a 1–7 Likert scale ranging from *not at all* to *as clearly if it were happening right now*. Participants reported the valence and intensity of the emotions associated with their memory using the Self-Assessment Manikin, which uses a 9-point Likert scale from negative to positive valence and from low to high intensity with corresponding images (Bradley & Lang, 1994).

2.1.3 | Procedure

Data collection was conducted in November 2021. Participants completed the survey remotely through Qualtrics. First, they saw a digital consent form and were allowed to continue if they agreed to participate. Then, participants completed the Saved condition (counterbalanced for order), reviewing photos they had taken on their camera phone that were saved in their photo album. They were instructed to exclude photos that someone else took, that they accidentally took, and screenshots. Participants were told to choose only one of a set of photos in the same series when they had multiple attempts at the same photo subject or burst shots. Participants were also reminded that their qualitative responses would not be linked to their identities, but would be made available online, so they should refrain from including any private or identifying information. For the first photo, participants were asked to describe their goal for taking the photo and saw a text box in which to answer. They also used a slider to report the location of the information ranging from entirely in the photo to entirely in their organic memory. Then, participants were asked to recall the photographed event and answer questions about their perspective view, vividness of multimodal imagery, and the qualities of emotions associated with their recollection. Participants were instructed to leave the answers to these questions blank if they could not recall the photographed event. Participants would then complete this for their second newest, and third newest saved photo.

Participants then moved to the Deleted condition (counterbalanced for order). In this condition, participants were given instructions on how to access their recently deleted photos folder for both Android and iOS devices. They were given the same instructions as in

the Saved condition about which photos to exclude. Then, they answered the same questions about deleted photos as were asked about saved photos with one exception: in the Deleted condition, participants were also asked to report why they had deleted each photo after reporting why they had originally taken the photo.

After reviewing six total photos, three Saved and three Deleted, participants answered demographic questions as well as questions about their camera phone use and photo album size. Finally, they were debriefed and granted credit for their participation. The median time for participants to complete the study was 14:09.

2.2 | Results

2.2.1 | Qualitative coding

Full codebooks with examples are available in Table 1 and the full dataset is available through the Open Science Framework. A total of 1843 qualitative responses were coded (two were left blank), 1229 were participants' responses about their initial goals for taking their photos, and 614 were participants' reasons for deleting a photo. Nine cases were excluded because participants reported that someone else

took the photo on their behalf and another 36 cases were excluded because participants reported responses about screenshots. If a person reported that the photo was a screenshot for a deleted photo, their response for why it was taken and why it was deleted were both excluded.

Goal responses were coded using top-down qualitative codes developed by Soares and Storm (2022a) by two raters with the quantitative data masked. The two raters showed substantial agreement (Cohen's $\kappa = 0.70$). For any disagreements, a third rater determined which of the codes assigned was more accurate. Coders could assign more than one code to each response, but in these cases only the agreed-upon codes were retained. Two codes were applied in only 15 cases, so the third rater determined which of the two codes fit the response best. The codes for why participants took photos included *social*, *self-related*, *esthetic*, and *memory* related goals. The *memory* goals were assigned two sub-goals: *offloading* and *memento*. *No reason articulated* was also available to code for responses too vague or irrelevant to code.

The deleted codes were developed to parallel the initial goal codes and were assigned using the same process. These themes included *completed-offloading* and *completed-social* goals, for cases where offloading or social goals had been completed, as well as

TABLE 1 Qualitative codes and examples.

Code	Description	Examples
Social	To share with someone, post online (including to social media), or to document or celebrate a social bond	To show my dad Because I was dating the person in the picture
Self	To track progress, make note of esthetic changes or choices (e.g., hair, makeup), for self-confidence or to otherwise represent oneself	I took a photo to compare to an older photo of myself I was very happy about how I looked
Esthetic	Artistic reasons, something looked nice, interesting, or funny	My food looked good It was funny
Offloading	To hold onto information externally	So I could go back and look at the information For HW
Memento	To help with remembering or planning to remember in the future	Because I wanted to capture a moment with my friends To capture a memory
Social-Completed*	Completed a social goal; shared the photo with intended audience	Because I showed my dad Sent to person and no longer needed the photo
Self-Inverse*	Photo evoked negative body image or an image of the photo-taker they no longer wanted	Because it was not the most flattering photo Because I look ugly in the photo
Esthetic-Inverse*	The photo had poor esthetic quality	The picture turned out blurry Eyes are closed
Offloading-Completed*	The information captured in the photo was stored elsewhere in external memory, stored in internal memory, or the task the information was saved for was completed	I do not need it anymore because I know how to make the recipe by memory now The test passed
Memento-Inverse*	Participant reports no longer wanting to remember the event, that it evokes negative feelings, including broken social connections	The memories were no longer good. We broke up

Note: Codes that appear without an asterisk correspond to codes assigned to qualitative responses about why participants took their (Saved or Deleted) photos. Codes that appear with an asterisk correspond to codes assigned to qualitative responses about why participants deleted their (Deleted) photos.

inverses of the other codes: *negative self-image (inverse-self)*, *poor esthetics (inverse-esthetic)*, and *wanting to forget (inverse-memento)*. More information about these novel codes for deleted photos, including examples from the data for each code, is included in Table 1. Practical constraints, like running out of storage, having duplicate photos, or having concerns about privacy, were coded consistent with the *no reason articulated* code, along with vague or irrelevant responses. When participants gave qualitative responses about deleted photos, they were first asked why they initially took the photo, and then why they deleted it. For this reason, participants' responses for why they deleted a photo sometimes referred to the initial goal. In cases in which the coder could not discern enough information about why a participant deleted a photo to assign a code (e.g., a participant responding that a photo was no longer needed without additional context), they could read the initial goal response to help inform their coding. That said, deleted codes were not assigned based on goal codes. That is, deleted codes were not always completed or inverted versions of the corresponding initial goal codes. The two initial raters were in substantial agreement (Cohen's $\kappa = 0.78$) when assigning deletion codes. Two codes were assigned to only three of these responses, so a third coder picked the code that best applied.

2.2.2 | Frequencies and demographics

Generally, participants used their cameras extensively, reporting taking several photos each day on average ($M = 9.0$; $SD = 14.6$; $Mdn = 4$, range: 0–80). Twenty-five participants reported taking fewer than one photo per day, only two of whom reported taking zero photos per day. Participants also reported having rather large photo albums often with thousands of photos ($M = 4539.6$; $SD = 5613.7$; $Mdn = 2752$, range: 27–35,000). As shown in Table 2, the most common photo-taking goals were social goals, followed closely by memory-related goals, then esthetic goals, and self-related goals. The

most common reasons for deletion were practical reasons like storage limitations, followed by completing offloading goals (*completed-offload*), completing social goals (*completed-social*), poor esthetics (*inverse-esthetic*), negative self-image (*inverse-self*), and wanting to forget (*inverse-memento*). Within the *inverse-memento* code, there were 22 cases of broken connections, like romantic break-ups and ended friendships.

2.2.3 | Saved vs. deleted photos

As shown in Figure 1, the prevalence of some goals varied substantially for Saved and Deleted photos, as confirmed by a chi-square test of independence, $\chi^2(4, N = 205) = 95.99, p < .001$. Interestingly, the pattern of goal frequency for the two *memory* codes reversed for Saved and Deleted photos. That is, photos taken with the *memento*

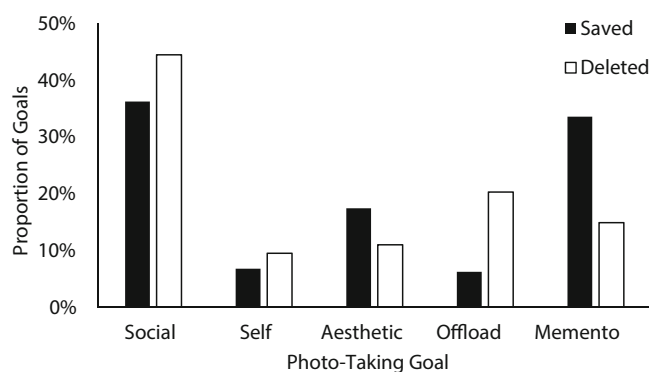


FIGURE 1 Proportions of goals reported for saved and deleted photos in Study 1. For deleted photos, codes were assigned to responses to a question about participants' original photo-taking goal. Proportions were calculated excluding qualitative responses that could not be assigned a goal code.

TABLE 2 Percentage of photos assigned to each goal code by study.

	Social (%)	Self (%)	Esthetic (%)	Offload (%)	Memento (%)	None (%)	Total
Taken							
Study 1	36.9	7.5	13.3	12.0	22.7	7.6	1184
Study 2	41.9	7.7	13.6	16.4	17.4	3.1	1187
Study 2*	43.6	9.5	14.7	16.8	15.4	N/A	1187
	Completed—social (%)	Inverse—self (%)	Inverse—esthetic (%)	Completed—offload (%)	Inverse—memento (%)	Practical reasons (%)	Total
Deleted							
Study 1	16.6	8.1	14.0	16.7	6.7	37.9	580
Study 2	17.7	9.8	29.7	17.0	2.4	23.4	593
Study 2*	21.1	13.2	32.7	13.3	9.6	10.1	593

Note: Percentage of photos assigned to each goal code by study. Taken codes were assigned to both saved and deleted photos based on the reported reason each photo was taken. Deleted codes were assigned only to deleted photos based on the reported reason for deletion. *Denotes percentages based on participant-assigned codes in Study 2.

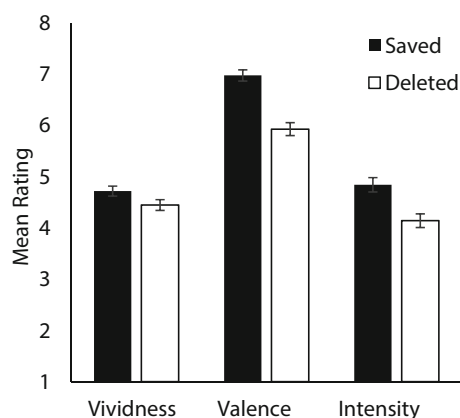


FIGURE 2 Mean ratings of qualities of recollection with saved and deleted photos in Study 1. Error bars indicate standard error of the mean. Vividness was rated using a 1–7 scale, with higher scores indicating more vivid recollection and re-experience. Emotional valence was rated using a 1–9 scale, with lower scores indicating negative valence, middle-range scores indicating neutral valence, and higher scores indicating positive valence. Emotional intensity was rated using a 1–9 scale with low scores indicating low intensity or arousal and higher scores indicating higher intensity.

goal were more frequent in the Saved condition compared to the Deleted condition, while photos taken with the *offload* goal were more frequent in the Deleted condition compared to the Saved condition.

As shown in Figure 2, paired *t*-tests revealed significant differences in qualities of recollection between Saved and Deleted photos. Interestingly, Saved photos were significantly older than Deleted photos, $t(204) = 8.15$, $p < .001$, $d = 0.57$, $CI_{95\%}$ of $d = [0.42, 0.72]$. Despite being older, Saved photos evoked significantly more vivid $t(204) = 1.69$, $p = .014$, $d = 0.17$, $CI_{95\%}$ of $d = [0.04, 0.31]$, positive $t(204) = 7.91$, $p < .001$, $d = 0.55$, $CI_{95\%}$ of $d = [0.41, 0.70]$, and emotionally intense $t(204) = 5.14$, $p < .001$, $d = 0.36$, $CI_{95\%}$ of $d = [0.22, 0.50]$ recollections compared to Deleted photos. Participants reported that slightly more information was shared with their organic memory for Saved than Deleted photos, but this difference failed to reach statistical significance $t(186) = 1.69$, $p = .093$, $d = 0.12$, $CI_{95\%}$ of $d = [-0.02, 0.27]$.

2.2.4 | Recollection by goal

Soares and Storm (2022a) found that participants' recollective experiences varied based on their photo-taking goals, with particular attention paid to the two *memory* sub-codes. To check whether these findings replicated, participants' ratings of vividness, emotional valence, emotional intensity, and self-reported goal location were analyzed using unstructured mixed linear models with Bonferroni-corrected pairwise comparisons. The models indicated significant differences in ratings of vividness $F(4, 906.2) = 8.89$, $p < .001$, emotional valence $F(4, 954.9) = 19.86$, $p < .001$, and emotional intensity, $F(4, 940.6)$

$= 13.22$, $p < .001$. Significant differences were also detected in participants' ratings of the extent to which information was stored in their organic memory compared to in the photo, $F(4, 865.0) = 8.31$, $p < .001$. Means and confidence intervals for ratings of recollective experience for each goal code can be found in Table 3.

Four additional unstructured mixed linear models were run to characterize the differences between the *memory* sub-codes. These models compared each measure for the *memento* and *offloading* sub-codes to a composite of the *social*, *self*, and *esthetic* codes. The model for vividness ratings was again significant, $F(2, 875.7) = 11.71$, $p < .001$. Participants reported recollecting events photographed with the *memento* goal more vividly than those photographed with the *offload* goal ($CI_{95\%}$ of the difference $[0.32, 0.96]$), and the composite of other goals ($CI_{95\%}$ of the difference $[0.01, 0.45]$). Events photographed to *offload* were also recollected less vividly than events photographed with non-memory-related goals ($CI_{95\%}$ of the difference $[0.14, 0.68]$).

Similar models were conducted for the measures of emotional valence and intensity, both of which indicated significant differences: valence, $F(2, 929.8) = 27.29$, $p < .001$; intensity: $F(2, 933.3) = 21.70$, $p < .001$. Events photographed with the *memento* goal were remembered more positively compared to those associated with both *offload* goals ($CI_{95\%}$ of the difference $[0.97, 1.94]$) and non-memory-related goals ($CI_{95\%}$ of the difference $[0.02, 0.70]$). *Offload* recollections were also less positive than the non-memory-related recollections ($CI_{95\%}$ of the difference $[0.68, 1.51]$). Events associated with *memento* goals were remembered more emotionally intensely than those associated with the *offload* goal ($CI_{95\%}$ of the difference $[0.90, 1.96]$) and other goals ($CI_{95\%}$ of the difference $[0.31, 1.05]$). Events associated with the *offload* goal were also remembered less emotionally intensely than the non-memory-related composite ($CI_{95\%}$ of the difference $[0.30, 1.04]$).

Finally, a similar set of analyses detected significant differences in participants' ratings of where information was stored, ranging from entirely in their organic memory to entirely in their photograph, $F(2, 878.5) = 14.67$, $p < .001$. Specifically, ratings associated with the *offload* goal indicated that more information was stored in those photos compared to photos taken with the *memento* goal ($CI_{95\%}$ of the difference $[8.74, 23.43]$), or the non-memory-related goals ($CI_{95\%}$ of the difference $[6.00, 18.60]$). Significant differences were not detected between the *memento* goal and the non-memory-related goals ($CI_{95\%}$ of the difference $[-1.44, 9.01]$).

3 | STUDY 2

Study 2 was designed to replicate Study 1 with a more heterogeneous sample than a university participant pool. Participants were also instructed to choose photos from six different events so they would review photos from a larger range of circumstances than participants in Study 1 might have. Participants in Study 2 were also asked to self-code their photo-taking goals by giving qualitative responses about why they took each photo and why they deleted the photos they had, and then choosing from multiple-choice options that described each

TABLE 3 Descriptive statistics for Study 1.

Goal	Vividness		Valence		Intensity		Location	
	M	CI _{95%} of M	M	CI _{95%} of M	M	CI _{95%} of M	M	CI _{95%} of M
Social	4.84	[4.66, 5.01]	6.65	[6.43, 6.88]	4.49	[4.22, 4.77]	56.68	[53.05, 60.30]
Self	4.34	[4.04, 4.64]	5.88	[5.45, 6.30]	4.01	[3.53, 4.49]	52.14	[45.62, 58.64]
Esthetic	4.97	[4.42, 4.89]	7.07	[6.75, 7.39]	4.78	[4.41, 5.16]	52.17	[47.11, 57.24]
Offloading	4.32	[4.08, 4.56]	5.54	[5.21, 5.88]	3.73	[3.34, 4.13]	43.02	[37.78, 48.27]
Memento	4.99	[4.42, 5.17]	6.91	[6.76, 7.30]	5.19	[4.87, 5.51]	58.82	[54.48, 63.18]

Note: Descriptive statistics for ratings of vividness, valence, and emotional intensity, divided by codes assigned to qualitative reports of photo-taking goals. Vividness was rated on a 1–7 scale, with higher scores indicating more vivid imagery. Emotional valence was rated on a scale of 1–9, with low scores representing negative valence and high scores representing positive valence. Emotional intensity was rated on a scale of 1–9, with higher scores indicating more intense emotions. Memory location information was rated on a scale of 0–100, with 0 indicating that information was stored entirely in the photo, and 100 indicating that information was stored exclusively in organic memory.

of the five major qualitative codes. Participants could therefore indicate which code matched each of their goals most closely for themselves.

3.1 | Method

3.1.1 | Participants

A total of 201 participants were recruited through the Prolific online platform. Participants were compensated 3.00 USD for their participation, with a median compensation rate of \$10.80/hour. Participants were required to be fluent in English and to have access to a smartphone with a photo album containing photos they had taken themselves. Three participants were excluded, two for not having access to any deleted photos and one for a reported technical issue. The remaining participants had a mean age of 29.9 years ($SD = 10.0$; $Mdn = 27$), 82 were women, 113 were men, and three were non-binary/third gender. The sample included participants who reported nationalities from 23 different countries. The most frequently reported nationalities were United Kingdom ($N = 44$), Poland ($N = 34$), and Portugal ($N = 19$).

3.1.2 | Materials and design

The materials were identical to those used in Study 1 except for the following changes. The question written in Study 1 as “Where is the information needed to accomplish your goal stored?” was replaced with the following text and question throughout the survey for both the Saved and Deleted photos: “When saving information externally, sometimes the responsibility for holding onto information shifts between our own internal or organic memory and the external memory source (in this case, the photo). Between your own organic memory for the event and the information held in this photo, where is the information about this event stored?”. This change was made to better explain the question so that participants were more likely to

understand the terminology and context of the question. Two additional multiple-choice questions were also added asking participants to choose which option best aligned with their goal. Questions and answer options with corresponding codes assigned to each answer are provided in Table A1.

3.1.3 | Procedure

Data were collected in January 2023. The procedure was the same as in Study 1 except for one change. When selecting each photo, participants were instructed to only include a photo from a particular event once in the study. For each photo besides the first in each set of saved or deleted photos, participants saw the reminder “If this photo was taken during the same event as the first/second, move to the most recently taken photo of the next event in your album.” This ensured that participants would review a variety of photos from different kinds of events. The median completion time was 16:40.

3.2 | Results

The analyses reported are based on experimenter-assigned codes, but a similar pattern of results was observed using the participant-assigned codes. Full analyses and datasets using the participant-assigned codes are included in the supplemental materials posted to the Open Science Framework.

3.2.1 | Qualitative coding

A total of 1782 qualitative responses were coded, 1188 were participants' responses about their initial goals for taking their photos, and 594 were participants' reasons for deleting a photo. Two cases were excluded, one because a participant reported that someone else took the photo and one because a participant reported that someone else deleted their photo.

The same codebooks and procedures were used as in Study 1 to assign qualitative codes. Raters again showed substantial agreement for both codes assigned to reasons why photos were taken (Cohen's $\kappa = 0.83$) and deleted (Cohen's $\kappa = 0.79$). Twenty-eight responses were assigned two codes for reasons taken and three responses were assigned two codes for reasons deleted. As in Study 1, these instances were re-assigned one of the codes by a third rater. There was moderate agreement between the self-assigned codes participants selected and the codes assigned based on their qualitative responses (taken: Cohen's $\kappa = 0.52$, deleted: Cohen's $\kappa = 0.58$).

3.2.2 | Frequencies and demographics

Overall, participants reported taking multiple photos per day with their phones, but substantially fewer compared to the student sample in Study 1 ($M = 2.7$; $SD = 4.7$; $Mdn = 2$, range: 0.001–50). No participant reported taking zero photos per day, but 58 reported taking fewer than one per day. Participants reported albums with hundreds, often thousands, of photos ($M = 3323.5$; $SD = 5561.4$; $Mdn = 1543$, range: 5–51,754). As in Study 1, social goals were the most frequently reported, followed by memory goals, esthetic, and self-related goals. Eight cases of broken social connections were reported. Percentages of goal codes assigned to qualitative responses by raters and participant-selected codes are available in Table 2.

3.2.3 | Saved vs. deleted photos

As in Study 1, the prevalence of goal frequencies varied significantly for Saved and Deleted photos, as confirmed by a chi-square test of independence, $\chi^2(4, N = 198) = 26.54, p < .001$ (Figure 3). The

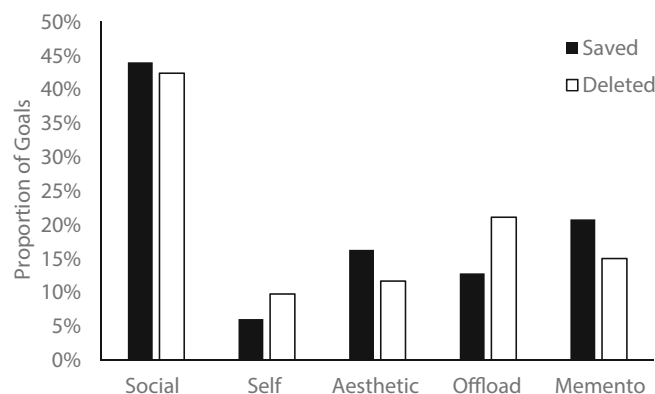


FIGURE 3 Proportions of goals reported for both saved and deleted photos in Study 2. The proportion of photos associated with social, self-related, esthetic, offloading, and memento goals for saved and deleted photos in Study 2. For deleted photos, these codes were assigned to responses to a question about participants' original photo-taking goal. Proportions reported correspond to experimenter-assigned qualitative codes, but a similar pattern was observed using participant-assigned codes.

apparent crossover interaction for the two memory sub-codes was also replicated, indicating that a higher proportion of deleted photos than saved were taken with the *offload* goal, while a higher proportion of saved than deleted photos were taken with the *memento* goal.

As shown in Figure 4, paired *t*-tests again indicated significant differences in how participants recollected with Saved and Deleted photos. Unlike in Study 1, saved photos were not significantly older than deleted photos, although the numerical pattern was in that direction, $t(196) = 1.51, p = .132, d = 0.11, CI_{95\%} \text{ of } d = [-0.03, 0.25]$. The same patterns of recollective experience were observed as in Study 1. Saved photos were associated with significantly more vivid $t(197) = 6.31, p < .001, d = 0.45, CI_{95\%} \text{ of } d = [0.30, 0.60]$, positive $t(197) = 7.95, p < .001, d = 0.57, CI_{95\%} \text{ of } d = [0.41, 0.71]$, and emotionally intense $t(197) = 4.90, p < .001, d = 0.35, CI_{95\%} \text{ of } d = [0.20, 0.49]$ recollections compared to Deleted photos. Consistent with the non-significant pattern in Study 1, participants reported that relatively more information was shared with their organic memory for Saved than Deleted photos, $t(197) = 2.79, p = .006, d = 0.20, CI_{95\%} \text{ of } d = [0.06, 0.34]$. This finding may have been more reliable because Study 2 participants were given additional information explaining the context of the question.

3.2.4 | Recollection by goal

As in Study 1, unstructured mixed linear models indicated significant differences in ratings of vividness $F(4, 915.7) = 48.84, p < .001$, emotional valence $F(4, 1009.0) = 50.98, p < .001$, and emotional intensity, $F(4, 948.9) = 44.06, p < .001$. Participants' ratings of the extent to which their memory of an event was stored in their organic memory

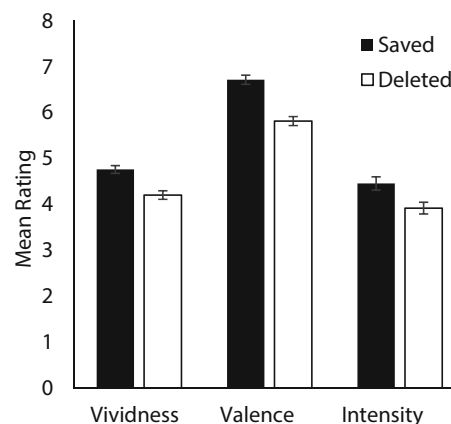


FIGURE 4 Mean ratings of qualities of recollection with saved and deleted photos in Study 2. Error bars indicate standard error of the mean. Vividness was rated using a 1–7 scale, with higher scores indicating more vivid recollection and re-experience. Emotional valence was rated using a 1–9 scale, with lower scores indicating negative valence, middle-range scores indicating neutral valence, and higher scores indicating positive valence. Emotional intensity was rated using a 1–9 scale with low scores indicating low intensity or arousal and higher scores indicating higher intensity.

TABLE 4 Descriptive Statistics for Study 2.

Goal	Vividness		Valence		Intensity		Location	
	M	CI _{95%} of M	M	CI _{95%} of M	M	CI _{95%} of M	M	CI _{95%} of M
Social	4.64	[4.49, 4.81]	6.63	[6.44, 6.82]	4.20	[3.93, 4.47]	47.20	[43.75, 50.65]
Self	4.18	[3.92, 4.44]	5.52	[5.15, 5.90]	4.01	[3.58, 4.44]	42.59	[36.35, 48.82]
Esthetic	4.80	[4.59, 5.01]	6.43	[6.15, 6.72]	4.31	[3.96, 4.67]	52.69	[47.78, 57.60]
Offloading	3.65	[3.45, 3.86]	4.96	[4.69, 5.22]	2.89	[2.56, 3.22]	27.33	[22.76, 31.91]
Memento	5.10	[4.90, 5.30]	7.14	[6.88, 7.40]	5.29	[4.96, 5.56]	60.10	[55.59, 64.62]

Note: Descriptive statistics for ratings of vividness, valence, and emotional intensity, divided by codes assigned to qualitative reports of photo-taking goals. Vividness was rated on a 1–7 scale, with higher scores indicating more vivid imagery. Emotional valence was rated on a scale of 1–9, with low scores representing negative valence and high scores representing positive valence. Emotional intensity was rated on a scale of 1–9, with higher scores indicating more intense emotions. Memory location information was rated on a scale of 0–100, with 0 indicating that information was stored entirely in the photo, and 100 indicating that information was stored exclusively in organic memory.

compared to in the photo also significantly varied based on their goal, $F(4, 1002.4) = 38.29, p < .001$. Means and confidence intervals for each measure by goal code can be found in Table 4.

Additional unstructured mixed linear models were run focusing on the *memory* sub-codes (*offloading* and *memento*) compared to a composite of the *social*, *self*, and *esthetic* codes. All comparisons were made using Bonferroni-adjusted confidence intervals. Vividness ratings were significantly different, $F(2, 929.0) = 86.76, p < .001$, as were all pairwise comparisons. Participants reported recollecting events photographed with the *memento* goal particularly vividly compared to events photographed with the *offload* goal (CI_{95%} of the difference [1.18, 1.73]) and events photographed for other reasons (CI_{95%} of the difference [0.27, 0.70]). Events photographed with the *offload* goal were also recollected less vividly than those photographed for non-memory reasons (CI_{95%} of the difference [0.75, 1.18]).

Additional models indicated differences in emotional valence and intensity: valence, $F(2, 1013.5) = 85.68, p < .001$; intensity, $F(2, 973.8) = 87.44, p < .001$. Events with *memento* photographs were remembered particularly positively compared to both events photographed with the *offload* goal (CI_{95%} of the difference [1.78, 2.63]) and other goals (CI_{95%} of the difference [0.37, 1.02]). Events photographed to *offload* were also remembered less positively than the non-memory-related composite (CI_{95%} of the difference [1.18, 1.85]). Events photographed with *memento* goals were also remembered more emotionally intensely than those photographed to *offload* (CI_{95%} of the difference [1.97, 2.85]) and events photographed with other goals (CI_{95%} of the difference [0.75, 1.44]). Events associated with the *offload* goal were also remembered less emotionally intensely than those associated with non-memory-related goals (CI_{95%} of the difference [0.97, 1.67]).

Memory location ratings were also similarly analyzed, with significant differences emerging between goal codes, $F(2, 1004.7) = 71.65, p < .001$. Ratings associated with the *memento* goal indicated that more memory information was stored in organic memory compared to photos taken with the *offload* goal (CI_{95%} of the difference [26.18, 39.60]), or the other goals (CI_{95%} of the difference [7.07, 17.63]). Compared to the non-memory-related composite, participants also

reported relatively more information was stored in photos taken with *offload* goals (CI_{95%} of the difference [15.20, 25.87]).

4 | GENERAL DISCUSSION

Overall, participants reported significantly different patterns of recollection associated with deleted photos compared to saved photos. Recollection with deleted photos was less vivid, less positive (closer to the neutral middle point of the scale) and less emotionally intense compared to recollection with saved photos. Furthermore, qualitative results indicated that participants largely reported deleting photos because they had accomplished their initial goals for that photo, such as offloading information or sharing the photo socially, or due to poor esthetics. However, participants did report deleting some photos with the intention to forget, following negative events including romantic breakups, as well as deleting photos that evoked negative self-image. Finally, the results of the current study were largely consistent with the previous findings of Soares and Storm (2022a), which indicated that participants' recollective experiences with photos varied with their photo-taking goals, and that this variation was especially marked when comparing recollection with photos taken as mementos and photos taken to offload memory. Participants reported more vivid, positive, and emotionally intense recollections with photos taken as mementos compared to photos taken to offload memory.

Participants also reported consistently different proportions of saved and deleted photos taken with different goals, particularly the two memory sub-goals. Deleted photos were more likely to have been originally taken with the offloading goal than the memento goal, while saved photos were more likely to have been taken with the memento goal than the offloading goal. This pattern might occur because the offloading goal is often more short-term than the memento goal—people may take photos to hold onto a piece of information like an item they intend to buy, but then delete the photo once that goal is complete. Indeed, participants frequently reported deleting photos because their offloading goal had been completed. Meanwhile, photos taken as mementos may be taken with more long-term recollection in

mind, with people deleting photos taken as mementos primarily when those events are no longer remembered positively, or due to poor esthetics.

Because the current study examined participants' own photos, which they had already saved or deleted, it cannot be said that saving or deleting photos causally influenced qualities of recollection with those photos. The pattern observed, however, is consistent with what one would expect if deleting photos induced or embodied attempts to intentionally forget events that were photographed. It is also possible that photos that were deleted happened to contain different content to captured different kinds of events, which contributed to this relationship. Having participants review their own naturalistically taken photos and recall real autobiographical memories limited the kind of experimental control that would be needed to establish a causal relationship. Future work should examine this relationship experimentally to establish whether there is a causal relationship between deleting photos and reducing the vividness and emotionality of photographed events.

The current study also provided exploratory insight into the reasons why people delete photos. Though much of the research on deleting photos and other digital artifacts has focused on purging digital artifacts following painful events like bereavement and breakups (e.g., Sas et al., 2016; Sas & Whittaker, 2013), which were reflected in the present data as well, people deleted photos more frequently because they completed their (social or offloading) goals with those photos or because the photos were not esthetically pleasing. Still, participants did report deleting photos to forget negative events or because they evoked negative feelings about themselves frequently enough to warrant further investigation. Events like breakups are much less frequent than sending a photo to a friend and no longer needing it, but deleting photos for the former reason is likely much more emotionally salient than the latter.

The current study also replicated Soares and Storm's (2022a) findings that photos taken with two different memory-related goals, offloading memory onto photos, or using photos as memory cues for future recollection, were associated with substantially different patterns of recollection. This replication reinforces the importance of differentiating between these different photo-taking goals and how both uses may be reflected in how other types of digital technology are used in concert with memory more broadly. Finley and Naaz's (2022) *memory symbiosis framework* emphasizes the flexible nature with which people seem to use external and internal memory in concert with digital technologies. The framework focuses on how people favor internal or external memory depending on the purpose of the memory task at hand (i.e., semantic, episodic, prospective, and procedural). Offloading goals seem more likely to be associated with semantic memory, while memento goals seem to align with episodic recollection. Both goals can be served by different uses of external memory, but photo-takers' relationship with the external memory source (their photo) seems to vary between these uses. Participants reported that more information was shared between their memory and the photo when they reported taking photos as mementos, but that the photo was relatively more responsible for holding more information when

they took photos to offload. It may be that people do not just choose to rely on internal or external memory differently depending on the type of memory task they need to complete (Finley & Naaz, 2022), but may also interact with external memory in different ways depending on their goals.

Indeed, photo-taking goals could help elucidate the mixed literature examining photo-taking effects on memory. Some studies have indicated that photo-taking can impair memory for photographed information (Henkel, 2014; Lurie & Westerman, 2021; Soares & Storm, 2018, 2022b), while others have found the opposite effect: that photo taking benefits memory for photographed information (Barasch et al., 2017; Ditta et al., 2023). It is possible that taking photos with different goals in mind or in different situations could trigger different cognitive processes and result in different memory effects of photo taking. Future work should examine this possibility both in the laboratory and in more naturalistic photo-taking situations.

In the changing digital landscape, the interactions between memory and technology will likely only grow more complicated (Storm & Soares, 2023). Digital devices can accompany us everywhere and hold a lifetime of information. How we choose to curate that information may become an increasingly personal and impactful decision.

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CONFLICT OF INTEREST STATEMENT

The author declares no conflict of interest.

DATA AVAILABILITY STATEMENT

Full materials and data are available online at <https://osf.io/h8zqn/>.

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APPENDIX

TABLE A1 Multiple choice answer options offered for participant coding

Code	Multiple choice option
Social	Social reasons—to share with someone else (including through text, in person, or online), post online (including to social media) or to document or celebrate a social bond
Self	To represent myself, boost my confidence, take a progress photo, or make note of my appearance (e.g., hair, an outfit)
Esthetic	For artistic reasons or because something in the environment was esthetically interesting or beautiful
Offloading	To hold on to information in case I did not remember it myself
Memento	A memento—to create a cue to help me remember later on or enhance my experience of remembering
Social-Completed*	I shared it with the person or people I intended and no longer need it
Self-Inverse*	I did not like how I looked in the photo
Esthetic-Inverse*	The photo turned out poorly (e.g., blurry, bad lighting, etc.)
Offloading-Completed*	The information captured in the photo is now stored somewhere else (e.g., wrote it down, remember it for myself) or I completed the task the photo held information about
Memento-Inverse*	I no longer want to remember what was documented in this photo or the photo evokes negative emotions
Other*	My storage was full, it was a duplicate photo, or I was concerned about my privacy

Note: Codes that appear without an asterisk correspond to answer options provided for the question: “Which of the following best describes the primary reason you took this photo?”. Codes that appear with an asterisk correspond to answer options provided for the question: “Which of the following best describes the primary reason why you deleted this photo?”