



Media usage diminishes memory for experiences

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ABSTRACT

People increasingly use social media to record and share their experiences, but it is unclear whether or how social media use changes those experiences. Here we present both naturalistic and controlled studies in which participants engage in an experience while using media to *record* or *share* their experiences with others, or not engaging with media. We collected objective measures of participants' experiences (scores on a surprise memory test) as well as subjective measures of participants' experiences (self-reports about their engagement and enjoyment). Across three studies, participants without media consistently remembered their experience more precisely than participants who used media. There is no conclusive evidence that media use impacted subjective measures of experience. Together, these findings suggest that using media may prevent people from remembering the very events they are attempting to preserve.

1. Introduction

Each day, people share almost 5 billion posts to Facebook, 500 million tweets to Twitter, 70 million pictures on Instagram, and 12 years worth of video to YouTube (Krikorian, 2013; LePage, 2015; Zephoria, 2016). Mobile devices have allowed media to permeate our experiences—we take Facebook, Twitter, Instagram, and other social media services with us everywhere. The ubiquity of these practices belies their novelty; never before have people been able to use media to record and share their experiences so easily. This sea change in people's interaction with technology highlights a key question: does using media to record and share events change the way people experience those events?

People use media in myriad ways. Here, we examine how experiences change when people are experimentally induced to *not* use media, use media to *record* their experiences, or use media to *share* their experiences with others. In each study, we assess *memory* using a performance measure of how well participants retain the details of an experience. In addition, we measure self-reported feelings of *enjoyment* – the affective value of an experience – and *engagement* – how present and mentally focused participants felt during an experience. Previous research has investigated the consequences of media use on each of these factors largely independently. Here, we aim to provide a comprehensive assessment of the consequences of media using multiple measures concurrently.

Media use might impact experience for multiple reasons. First, using media can *interrupt* an experience by inducing multitasking (Bowman, Levine, Waite, & Gendron, 2010). Second, media allow people to *externalize* their experience by giving them a way to capture aspects of experience. Third, media allow people to *save* experiences in the form of photographs or posts. Fourth, social media allow people to *share* their experiences—to record and save experiences not just for themselves, but also for others. Study 1 explicitly tests how these four independent features of media use might impact memory, engagement, and enjoyment of an experience using a controlled computer-based experience; Studies 2 and 3 then tests how media use impacts a real-world experience.

1.1. Memory

To date, most research on media use suggests that both recording and sharing experiences should diminish the extent to which a person retains detailed memories of that experience, for at least two reasons. First, media use requires multitasking (e.g., recording and posting about an event while it occurs). Multitasking has been shown to decrease concentration (Fried, 2008) and reduce absorption in experiences (Ross, 2011). In academic environments, media multitasking (e.g., laptop use in classrooms) has been linked to decreases in academic success, presumably because multitasking impairs memory for

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lecture content (Dietz & Henrich, 2014; Gaudreau, Miranda, & Gareau, 2014; Hembrooke & Gay, 2003; Sana, Weston, & Cepeda, 2013). Together, these studies suggest that the broader impact of using media is that it should impair memory for that experience.

Second, people sometimes use such devices as a mnemonic “crutch,” offloading information onto them and then forgetting that information (Soares & Storm, 2017; Sparrow, Liu, & Wegner, 2011; Ward, 2013). Indeed, recent work provides direct evidence that taking photographs impairs memory (Henkel, 2014; Zauberman, Silverman, Diehl, & Barasch, 2015). In one study, participants who took photos of objects in a museum remembered fewer objects and fewer details about these objects (Henkel, 2014). Media use may further impair memory for the features of an experience one does not record. For example, in a study that allowed participants to freely take photographs, participants showed enhanced visual memory but impaired auditory memory for photographed events (Zauberman et al., 2015). This research provides converging support for our prediction that media use will impair memory for experiences.

1.2. Enjoyment and engagement

Media usage might also affect subjective experiences of an event, for example, how much a person enjoys or is engaged in an experience. However, previous research on how media might impact these aspects of experience provides a mixed picture.

For example, previous research suggests that media might both enhance and detract from *enjoyment* of an experience. A recent series of studies found evidence that taking pictures may bolster participants' enjoyment of the experiences they are photographing (Diehl, Zauberman, & Barasch, 2016). Social media may further boost enjoyment of an experience if people receive and enjoy positive social feedback on their posts (Lambert et al., 2016; Reis et al., 2010). However, media has also been shown to decrease enjoyment. To the extent that using media creates distraction and/or induces mind wandering (Ralph, Thomson, Allan, & Daniel, 2014), it could also decrease enjoyment (Killingsworth & Gilbert, 2010). Social media may be especially likely to decrease enjoyment when people use it as a forum for social comparison (Kross et al., 2013; Shakya & Christakis, 2017; Verdun et al., 2015). Individuals might worry about how to present themselves to audiences when posting to social media. Indeed, a recent study found that participants who took pictures with the intention of sharing them reported being concerned with how to present themselves, which in turn reduced their enjoyment of the experience (Barasch, Zauberman, & Diehl, 2016).

The effects of media usage on *engagement* with an experience are similarly unclear. On the one hand, using media can help direct attention toward an experience. Taking a picture may encourage the photographer to notice details she wouldn't have noticed otherwise. Participants assigned to take pictures during an experience report more engagement with that experience than participants who do not take pictures (Diehl et al., 2016). However, this effect disappears when taking a large number of photographs (Barasch, Zauberman, & Diehl, 2013) or when the photography interferes with the experience, for instance by obscuring one's view with a camera (Diehl et al., 2016). Multitasking, another feature of media usage, also reliably impairs engagement (Bowman et al., 2010; Fried, 2008; Hembrooke & Gay, 2003; Ross, 2011) and increases mind-wandering (Ralph et al., 2014).

Prior research does not paint a clear picture of how media use might impact more subjective aspects of people's experience, such as engagement and enjoyment. Indeed, people are notoriously ill-equipped to introspect (Nisbett & Wilson, 1977) and accurately forecast (Wilson & Gilbert, 2003) about their own experiences. As such, self-reports about how much a person enjoys or is engaged in an experience may be tenuous, especially in the noisy, naturalistic contexts within which people most often use media. While social media seem most likely to impair subjective experience, the research to date provides a mixed

picture, at best, for how these effects might apply to media use more generally.

1.3. Overview

Here, we examine the effects of media use on both memory and subjective experience, using two complementary approaches. First, we assessed the effects of media use in a controlled context by distilling “media use” into multiple components. In Study 1, participants watched a TED Talk on their computers. While watching the talk, some participants were asked to complete a task that either required media use (i.e., recording or sharing the experience) or elicited only one feature of media use (i.e., interrupting the experience or externalizing the experience); other participants simply watched the talk without completing any additional tasks. Next, we assessed the effects of media use during a naturalistic experience. In Studies 2 and 3, participants used media to record or share their experience of a self-guided tour of a landmark. As in Study 1, these participants were compared to those who experienced the tour without using any media. Participants in Study 2 completed the tour by themselves whereas participants in Study 3 completed the tour in pairs.

In all studies, participants reported on their experiences using comparable self-report and memory performance measures. This allowed us to compare the effects of media use across multiple contexts: controlled vs. naturalistic, and individual vs. social. Based on the existing literature, we predicted that media use would consistently impair memory across all contexts. It was less clear how media use would impact subjective measures of engagement and enjoyment.

2. Study 1

Across a variety of media platforms, people can record text, photos, or videos. These recordings can be kept personal or they can be shared with others. For our initial investigation of how media use impacts experiences, we attempted to isolate facets of media use that are common across a range of media platforms. Specifically, in Study 1, we test how four independent features of media use might impact experiences: interrupting, externalizing, saving, and sharing. We tested the impact of each media feature on participants' memory, engagement, and enjoyment of an experience.

In a pilot study, we found that media use disrupts memory specifically when people *externalize* an experience, and not simply due to other features of media such as saving experiences or sharing them with others (see Supplementary materials for details; data for this pilot study are posted on OSF). We sought to replicate these findings in Study 1 using a design preregistered on the Open Science Framework (osf.io/uwbwt/).

2.1. Methods

2.1.1. Participants

Participants ($N = 382$, 239 female, $M_{age} = 37.47$) were randomly selected to watch one of two TED talks (video one $N = 191$; video two $N = 191$). A total sample size of 396 participants was set a priori to match the sample size from the pilot study (see Supplement); data collection stopped once this target was reached. The automatic randomization procedure used by the online survey platform, Qualtrics, to assign participants to conditions resulted in slightly unequal sample sizes across conditions. The Institutional Review Board at Stanford University, the University of Texas at Austin, or Princeton University approved this study and all following studies. All participants in all studies provided informed consent.

2.1.2. Procedure

Participants were recruited through Amazon Mechanical Turk and completed the study using their personal computers for \$0.75.

Participation in Study 1 was restricted to mTurk workers in the US with > 95% approval ratings. Participants were randomly assigned to watch one of two 3-minute TED talks in one of six conditions: 1) In the *Control* condition, participants ($N = 64$) simply watched the TED talk with no further instruction. 2) In the *Reflect* condition, participants ($N = 66$) were asked to think about their experience during the TED talk. 3) In the *Write* condition, participants ($N = 68$) were asked to type their thoughts and experiences into a space provided onscreen. These participants were told that their responses would be erased at the end of the study. 4) In the *Record* condition, participants ($N = 66$) were also asked to type their thoughts and experiences into a space provided onscreen. These participants were told that their responses would be saved and provided as a personal transcript at the end of the study. 5) In the *Share* condition, participants ($N = 64$) were asked to type their thoughts and experiences into a space provided onscreen. These participants were told that their thoughts would be saved and shared with others as soon as the study was over. 6) Finally, in the *Distract* condition, participants ($N = 54$) were asked to write about whatever was physically around them while watching the TED talk (e.g., “my walls are blue”). Importantly, participants were instructed not to pause the video while responding to any prompt.

Together these six conditions allowed us to ask specific questions about how media use might impact objective and subjective measures of experience: 1) How does being *distracted* from an experience change this experience? This can be assessed by comparing the *Control* condition to the *Distract* condition and the *Reflect* condition to the *Distract* condition, to see the impact of removing one's attention from the task at hand in a way unrelated to media use. 2) How does simply *interrupting* an experience change this experience? This can be assessed by comparing the *Control* condition to the *Reflect* condition, which differ only in whether the experience was interrupted. 3) Given that one has interrupted their experience, how does *externalizing* it differ from simply reflecting on it? This can be assessed by comparing the *Reflect* condition to the *Write* condition, which differ only on whether participants' thoughts on an experience were written down or not. 4) How does *saving* an experience differ from not saving an experience? This can be assessed by comparing the *Write* condition to the *Record* conditions, which differ only in whether the responses were saved. 5) How does saving an experience for oneself differ from saving it for *others*? This can be assessed by comparing the *Share* condition to the *Record* condition, which differ only in whether participants believed their saved writing would be read by others in the future. As specified in our pre-registration plan, we focus our reporting on only these six contrasts. Thus, for each measure – memory, enjoyment, presence, and mind-wandering – we conducted these pre-registered planned contrasts to answer each question in turn.

Participants in this study first completed a training phase to familiarize themselves with the task structure. During training, participants watched a 1-minute video, and were instructed to practice a secondary task (solving word jumbles) while watching the video. The training session familiarized participants with the process of doing a task while watching a video, without allowing them to practice their *specific* task. After training, participants received the condition-specific instructions described previously, then began watching the TED talk. During the talk, participants in the *Distract*, *Write*, *Record*, and *Share* conditions were provided with a web-based form in which to write about their thoughts and experiences. Participants were free to engage in their condition-specific activity at their own pace.

Immediately after watching the TED talk, participants completed a set of surveys designed to measure aspects of their subjective and objective experiences. First, they reported on their *engagement* during the experience with two measures, presence and mind-wandering. We used a modified version of the Telepresence Scale (e.g., “I felt immersed in the video”; Nowak & Biocca, 2003) and a three-item mind-wandering scale (e.g., “My mind wandered during the video”). They also reported on their *engagement* of the experience with a modified version of the

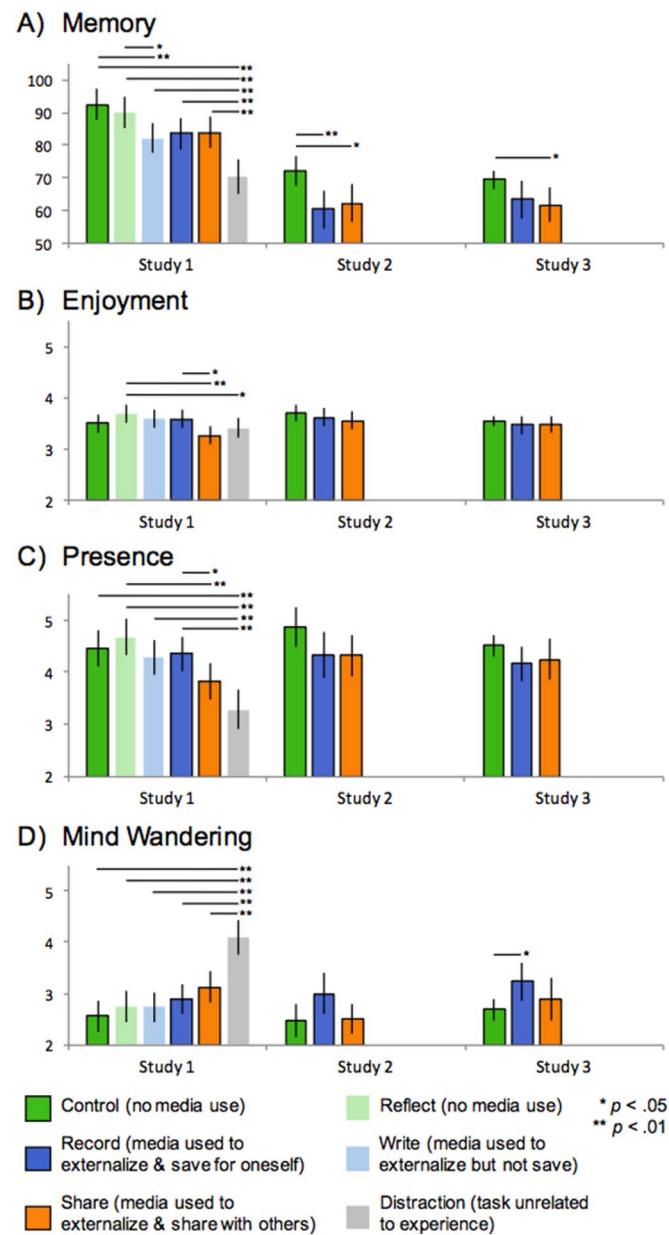


Fig. 1. Results from all studies, for each dependent variable, (A) Memory, (B) Enjoyment, (C) Presence, and (D) Mind Wandering. Media impaired memory for an experience in Studies 1–3. Significance is indicated between all preregistered pairwise contrasts in Study 1, as well as all pairwise contrasts that surpass Tukey HSD correction in Studies 1–3. Error bars represent 95% confidence intervals.

Positive and Negative Affect Schedule (e.g., “How happy do you feel right now?” cf. Watson, Clark, & Tellegen, 1988) as well as questions that asked about their opinion of the video itself (e.g., “I enjoyed watching the video”). Finally, they completed a five-item multiple-choice memory test about the content of the video. See Supplementary Materials for the complete list of questions used in Study 1. In this and all studies, we report all measures, manipulations, and exclusions.

2.2. Results

We first conducted four 6 (condition: Control, Reflect, Write, Record, Share, Distract) \times 2 (video variant: one, two) ANOVAs, one for each experience measure: memory, enjoyment, presence, and mind-wandering (Fig. 1). All four analyses revealed a significant effect of condition, so we proceeded with the four contrasts of interest (Table 1;

Table 1
Results Study 1.

Question	Contrast	Measure			
		Memory	Enjoyment	Presence	Mind-Wandering
How does <i>distraction</i> from an experience change this experience?	Control vs. Distract	F(1,370)=36.937, p<.001, partial $\eta^2=0.091$	F(1,370)=.516, p=.473, partial $\eta^2=.001$	F(1,370)=20.814, p<.001, partial $\eta^2=.053$	F(1,370)=44.767, p<.001, partial $\eta^2=.108$
	Reflect vs. Distract	F(1,438)=30.010, p<.001, partial $\eta^2=0.075$	F(1,370)=4.619, p=.032, partial $\eta^2=0.012$	F(1,370)=30.034, p<.001, partial $\eta^2=.075$	F(1,370)=35.055, p<.001, partial $\eta^2=.087$
How does <i>interrupting</i> an experience change this experience?	Control vs. Reflect	F(1,370)=0.460, p=.498, partial $\eta^2=0.001$	F(1,370)=2.233, p=.136, partial $\eta^2=0.006$	F(1,370)=0.856, p=.356, partial $\eta^2=.002$	F(1,370)=0.744, p=.389, partial $\eta^2=.002$
	Reflect vs. Write	F(1,370)=5.354, p=.021, partial $\eta^2=.014$	F(1,370)=.537, p=.464, partial $\eta^2=.001$	F(1,370)=2.901, p=.089, partial $\eta^2=.008$	F(1,370)=0.004, p=.949, partial $\eta^2=.000$
How does <i>saving</i> an experience differ from not saving an experience?	Write vs. Record	F(1,370)=0.205, p=.651, partial $\eta^2=.001$	F(1,370)=0.007, p=.932, partial $\eta^2=.000$	F(1,370)=0.128, p=.721, partial $\eta^2=.000$	F(1,370)=0.529, p=.467, partial $\eta^2=.001$
	Share vs. Record	F(1,370)=0.005, p=.945, partial $\eta^2=.000$	F(1,370)=6.514, p=.011, partial $\eta^2=.017$	F(1,370)=4.854, p=.028, partial $\eta^2=.013$	F(1,370)=1.170, p=.280, partial $\eta^2=.008$

Note: Findings that pass a preregistered threshold of $p < 0.05$ are written in bold. Preregistered hypotheses are presented inside double bordered cells.

see Supplementary Materials for all pairwise comparisons). There were no main effects of video for presence and mind-wandering. However, there were significant main effects of video for enjoyment and memory. There were significant condition \times video interactions for our subjective measures of experience (engagement and enjoyment). However, we did not find a condition by video interaction for memory. All analyses were conducted across both video variants.

Our preregistration included a plan to report 6 specific planned contrasts, as well as specific hypotheses about which of the 6 planned contrasts should show significant differences, and which ones should not. To test whether correcting for multiple comparisons would be appropriate in this study, we conducted a simulation (available on OSF) that assessed Type I and Type II error rates with and without correction. The simulation demonstrated that correction inflates Type II error more than the lack of correction would inflate Type I error. For this reason, we did not apply a multiple comparison correction to any results in Study 1.

2.2.1. Memory

First, we investigated the effect of task *distraction* on experience by comparing the Distract condition to the Control and Reflect conditions. Participants in the Distract condition had significantly lower memory scores than participants in both conditions (Control: $F(1,370) = 36.937$, $p < 0.001$, partial $\eta^2 = 0.091$, Reflect: $F(1,438) = 30.010$, $p < 0.001$, partial $\eta^2 = 0.075$).

Next, we assessed the effects of *interrupting* an experience by contrasting the Control and Reflect conditions. This analysis revealed that simply interrupting the TED talk for purposes of internal reflection does not impact memory ($F(1,370) = 0.460$, $p = 0.498$, partial $\eta^2 = 0.001$).

We assessed the effects of *externalizing* one's reflections by contrasting the Reflect and Write conditions. This analysis revealed that externalizing an experience by writing down one's reflections, even if that text will soon be deleted, did have a significant negative impact on how well participants remembered the experience ($F(1,370) = 5.354$, $p = 0.021$, partial $\eta^2 = 0.014$).

In order to assess whether the impact of externalizing the experience depended on whether that text was *saved* or not, we next contrasted the Write and Record conditions. This analysis revealed no significant effects of saving on subsequent memory ($F(1,370) = 0.205$, $p = 0.651$, partial $\eta^2 = 0.001$).

Finally, we assessed the effects of *sharing* one's experience with

others by contrasting the Share and Record conditions. Here we found that recording an experience with the intent of sharing for others did not impact memory over and above recording an experience for oneself ($F(1,370) = 0.005$, $p = 0.945$, partial $\eta^2 = 0.000$).

Together, these results support our hypothesis that media use impairs memory specifically when that media is used to *externalize* an experience. We found no evidence that media use further impairs memory by merely interrupting, saving, or sharing that experience. The Distract condition likewise impaired memory, and this particular distraction task seemed to do so to a greater extent than media use. This pattern of results was also replicated in an additional study (see Supplementary Materials).

2.2.2. Enjoyment and engagement

We next ran the same set of planned comparisons to examine the impact of media use on subjective measures of experience, namely participants' self-reports of their engagement (presence and mind-wandering) and enjoyment.

First, we investigated the impact of task *distraction* on experience by comparing the Distract condition to the Control and Reflect conditions. Participants in the Distract condition reported less presence (Control: $F(1,370) = 20.814$, $p < 0.001$, partial $\eta^2 = 0.053$; Reflect: $F(1,370) = 30.034$, $p < 0.001$, partial $\eta^2 = 0.075$), and more mind-wandering (Control: $F(1,370) = 44.767$, $p < 0.001$, partial $\eta^2 = 0.108$; Reflect: $F(1,370) = 35.055$, $p < 0.001$, partial $\eta^2 = 0.087$) than participants in both conditions. Participants in the Distract condition also reported less enjoyment than participants in the Reflect condition ($F(1,370) = 4.619$, $p = 0.032$, partial $\eta^2 = 0.012$).

Next, we assessed the effects of *interrupting* an experience by contrasting the Control and Reflect conditions. We found no significant effect of *interrupting* an experience on enjoyment ($F(1,370) = 2.233$, $p = 0.136$, partial $\eta^2 = 0.006$), presence ($F(1,370) = 0.856$, $p = 0.356$, partial $\eta^2 = 0.002$), or mind-wandering ($F(1,370) = 0.744$, $p = 0.389$, partial $\eta^2 = 0.002$).

We assessed the effects of *externalizing* one's reflections by contrasting the Reflect and Write conditions. Externalizing an experience by writing down one's reflections did not impact enjoyment ($F(1,370) = 0.537$, $p = 0.464$, partial $\eta^2 = 0.001$) or engagement (presence: $F(1,370) = 2.901$, $p = 0.089$, partial $\eta^2 = 0.008$; mind-wandering: $F(1,370) = 0.004$, $p = 0.949$, partial $\eta^2 = 0.000$) over and above the effects of interrupting the experience.

In order to assess whether the impact of externalizing an experience depended on whether that text was *saved* or not, we next contrasted the Write and Record conditions. This analysis revealed no significant effects of saving on enjoyment ($F(1,370) = 0.007, p = 0.932$, partial $\eta^2 = 0.000$), or engagement (presence: $F(1,370) = 0.128, p = 0.721$, partial $\eta^2 = 0.000$; mind-wandering: $F(1,370) = 0.529, p = 0.467$, partial $\eta^2 = 0.001$).

We next assessed the effects of *sharing* one's experience with others by contrasting the Share and Record condition. Here we found that writing about an experience with the intent of sharing for others, as opposed to no such intent, exerted a negative impact on presence ($F(1,370) = 4.854, p = 0.028$, partial $\eta^2 = 0.013$) and enjoyment ($F(1,370) = 6.514, p = 0.011$, partial $\eta^2 = 0.017$), but not mind-wandering ($F(1,370) = 1.170, p = 0.280$, partial $\eta^2 = 0.008$).

Together, these findings suggest that media impacts presence and enjoyment specifically by creating an audience for individuals' transmission of an experience. Participants in the Distract condition also fared worse on all of our experience measures. This suggests that deleterious effects of media use are not as severe as pure distraction. Media use may take people "out of the moment," but the experience-related nature of this activity may continue to keep participants focused on aspects of their experience.

Overall, the results of Study 1 provide initial evidence that media use may negatively impact enjoyment of, engagement with, and memory for experiences. We find that media has the strongest impact on memory. Memory impairments arise from *externalizing* an experience, for example by writing about that experience. Whether the externalized experience is temporary, saved, or shared doesn't seem to matter; they all impair memory. Media use likewise reduced enjoyment and engagement, but for different reasons. Here, only sharing one's experience held negative consequences for presence and enjoyment, but not mind-wandering.

These results suggest that *any* media use should impair memory, but only using media to share should impact engagement and enjoyment. Distraction likewise impaired memory, enjoyment, and engagement, suggesting that any media use that distracts one from an experience might have such negative consequences. In Study 2, we aim to further test these hypotheses about the consequences of media use during a more naturalistic experience.

3. Study 2

Study 1 provides evidence that media use impairs memory through externalizing experiences. To determine the generalizability of these findings in a naturalistic context, Study 2 investigated the impact of media use on experiences while participants took a tour of Stanford's Memorial Church, a non-denominational church on the Stanford University campus. During the tour, participants either took photos for themselves, took photos to post on Facebook, or took no photos. Once again, we assessed participants' memory, and their self-reported engagement, and enjoyment.

3.1. Methods

3.1.1. Participants

Participants in Study 2 ($N = 132$) took a self-guided tour of Stanford's Memorial Church. A sample size of 40 participants per condition was set a priori; data collection stopped once that target was reached for all conditions. This sample size allows for 70% power to detect an effect size of $\eta^2 = 0.06$ and 97% power to detect an effect of $\eta^2 = 0.13$. Three participants were excluded from analyses because they did not complete the task, leaving 129 participants in the final analysis.

3.1.2. Procedure

Participants took a self-guided tour of Stanford Memorial Church

using the brochure "Stanford Memorial Church Self-Guided Tour", published by the Office of Religious Life at Stanford University, as their guide. This brochure directs participants to highlights of the church and describes the importance of each feature. Participants were randomly assigned to take the tour in one of three conditions: 1) in the absence of any digital or social media (*control* condition; $N = 44$), 2) while taking pictures but in the absence of social media (*record* condition; $N = 43$), or 3) while taking pictures with the intention of posting them to their Facebook accounts (*share* condition; $N = 41$). All participants indicated, via a prescreen survey, that they would feel comfortable posting photos of campus to their personal Facebook accounts. Therefore, although participants were randomly assigned to their conditions, all participants would have been willing to complete any condition, minimizing concerns about selection bias.

All participants left their personal belongings, including their cell phones, in a testing room before leaving for the tour. Participants in the Record and Share conditions received an iPod touch to use as a camera. Participants in the Record condition accessed the camera via the camera icon on the lock screen; the iPod remained locked so they did not have access to any other features. Participants in the Record condition were told that the experimenters would print out their pictures after the tour. The experimenters encouraged participants in the Record condition to take as many photos as they liked, at minimum 5 photos ($M = 10.23, SD = 7.45$). Participants in the Share condition logged into their personal Facebook accounts on the iPod before leaving for the tour. These participants could unlock the phone to access Facebook and post their pictures. Participants in the Share condition posted photos to Facebook after completing the tour but before completing the survey packets. They could not post during the tour itself as Wi-Fi does not work inside Memorial Church. Thus, participants in both the Record and Share conditions completed the same media-related actions during the tour experience (taking pictures); the only difference was that participants in the Share, but not Record, condition intended to post their pictures to Facebook. When participants in the Share condition returned to the testing room, a researcher verified that they had posted at least two photos on their personal Facebook accounts and then logged them out of the Facebook app (Pictures taken: $M = 11.10, SD = 6.36$; pictures posted: $M = 4.32, SD = 4.18$).

3.1.3. Measures

Immediately after the tour, participants completed a packet of surveys while still inside Memorial Church. These surveys probe their subjective experience using similar measures of engagement and enjoyment as in Study 1. First, they reported on their *engagement* during the tour with a modified version of the Telepresence Scale (e.g., "I felt present inside of the church"; Nowak & Biocca, 2003) and a three-item mind-wandering scale (e.g., "I was distracted by other thoughts on this tour"). They reported on their *enjoyment* of the tour with a modified version of the Positive and Negative Affect Schedule (e.g., "How happy do you feel right now?" cf. Watson et al., 1988) as well as questions that asked about their opinion of the tour itself (e.g., "I enjoyed the tour"). For the complete list of questions used in Study 2, see Supplementary Materials.

All participants were asked to complete a follow-up survey between 7 and 14 days after the tour, in order to probe an objective measure of their experience: a 10-item surprise memory test comprised of multiple-choice questions about the tour. Scores on this test reflected participants' memory for the tour's details. For the complete list of questions asked during this follow-up, see Supplementary Materials. After completing the follow-up survey, participants were debriefed and compensated for their time. Participants who failed to complete the follow-up survey were compensated for their participation in the first part of the survey. Five participants failed to complete the follow-up survey. Their data are included in analyses of their subjective experience on the day of the tour, but not their memory.

3.2. Results

Participants spent on average 36.55 min completing the tour and survey packet ($SD = 11.50$). Due to the nature of the task, it was not possible to record the amount of time that participants spent completing the tour itself so we asked them to give us their best estimate. Participants' estimates of how long they spent on the tour did not differ between conditions ($F(2,125) = 1.27, p = 0.285, \eta^2 = 0.02$).

3.2.1. Memory

Participants completed a follow-up survey after a delay of at least one week (M delay = 8.42 days, $SD = 1.73$). Follow up delay did not differ across conditions ($F(2,120) = 1.41, p = 0.249, \eta^2 = 0.02$). This survey included a surprise 10-item memory test about the content of the tour.

Results of an ANOVA on the memory test replicated the findings from Study 1: media use significantly impaired how well participants remembered their tour ($F(2,120) = 5.40, p = 0.006, \eta^2 = 0.08$; Fig. 1a). Post hoc comparisons were corrected for multiple comparisons using Tukey HSD. Results indicated that participants in the Control condition ($M = 7.20, SD = 1.40$) had significantly better memory for the experience than those in the Record ($M = 6.02, SD = 1.82, p = 0.007, d = 0.73$) and Share conditions ($M = 6.22, SD = 1.92, p = 0.032, d = 0.58$). Participants in the Record and Share conditions did not perform differently on the memory test ($p = 0.866$). An ANCOVA on the surprise memory test with follow up delay included as a covariate showed that the effect of condition on memory persists ($F(2,119) = 5.14, p = 0.007, \eta^2 = 0.08$) when controlling for amount of time between the tour and the memory test.

3.2.2. Enjoyment and engagement

We next investigated differences in participants' *enjoyment* of the tour. An ANOVA over this measure of *enjoyment* revealed no significant differences in enjoyment of the experience across conditions ($F(2,125) = 0.85, p = 0.432, \eta^2 = 0.01$; Fig. 1b).

We next investigated differences in participants' *engagement* during the tour by examining their self-reported presence and mind-wandering during the tour. There were no significant differences in presence across conditions ($F(2,125) = 2.57, p = 0.080, \eta^2 = 0.04$; Fig. 1c). The assumption of homogeneity of variances was violated for the mind-wandering measure, so we used the Brown-Forsythe test as opposed to a one-way ANOVA. This test revealed no significant differences in mind-wandering ($F(2,116.66) = 2.99, p = 0.054, \text{est. } w^2 = 0.03$; Fig. 1d) across conditions.

Together, these results suggest that, even in naturalistic contexts, media use continues to impair memory for an experience. However, in contrast to Study 1, media use did not significantly impact either enjoyment or engagement with of the experience.

4. Study 3

Study 2 offers further evidence that media may consistently impair memory for an experience, but that the effects of media on subjective measures of an experience may dissipate in more naturalistic contexts. Thus, we next endeavored to create an even more naturalistic setting for media use. People regularly take and post pictures in the presence of others. Study 3 sought to replicate the findings in Study 2 within a social context. Participants completed the same tour of Stanford's Memorial Church as in Study 2, but now completed the tour in dyads, rather than by themselves. We expected to replicate earlier findings, such that recording and sharing impaired memory, but left enjoyment and engagement intact.

4.1. Methods

4.1.1. Participants

Participants ($N = 238$) began the tour in dyads. Like Study 2, a sample size of 40 participants per condition was set a priori; data collection stopped once that target was reached for all conditions. Eighteen participants (9 dyads) were unable to complete the study due to activities in Memorial Church or failure to follow instructions, leaving a total of 220 participants. The majority of participants ($N = 181$) reported no familiarity with their study partner. Twenty-six participants reported having some familiarity with their study partner and 13 participants reported being very familiar with their study partner. The patterns of results do not change when restricting our sample to participants who have no familiarity with their study partners.² As such, all reported analyses include all participants.

4.1.2. Procedure

Participants completed the same tour as in Study 2; unlike in Study 2, however, they completed this tour in pairs. There were three types of dyads. In the Control dyad, both participants were in the Control condition ($N = 48$) and did not use a camera on the tour. In the Record dyad, one participant was in the Record condition and took photos during the tour for future personal use ($N = 43$), whereas the second dyad member was in the Control condition ($N = 43$). In the Share dyad, one participant was in the Share condition and took photos during the tour with the intention of posting them to their Facebook account ($N = 43$), and the other dyad member was in the Control condition ($N = 43$). As in Study 2, no participant had their own phones with them on the tour. Participants were instructed to complete the tour in silence, without any verbal communication with their partners.

4.1.3. Measures

After the tour, participants were instructed to sit separately from their partners in order to have privacy while filling out their respective surveys. The survey packets included the same measures of engagement and enjoyment as in Study 2; the follow-up survey 7–14 days later likewise contained the same measure of memory. We also measured participants' sense of connection with their study partners. These results can be found in the Supplementary Materials.

4.2. Results

Participants spent on average 42.68 min ($SD = 12.89$) completing the tour and survey packet. Due to the nature of the task, it was not possible to record the amount of time that participants spent completing the tour itself so we asked them to give us their best estimate. Participants' estimates of how long they spent on the tour itself did not differ between conditions ($F(2,217) = 1.10, p = 0.336$).

To assess the effects of media use on experience, we first conducted separate linear mixed effects-models to predict each of our measures of experience, entering condition (i.e., Control in every dyad, Record, Share) as a fixed effect, and dyad as a random effect. These analyses were designed to assess individual experiences, so participants were categorized by their individual tasks (Control, Record, or Share), rather than the task enacted within their dyad. This means that Control participants paired with Record and Share participants are included in the Control condition, as their experiences using media most closely resembled the Control participants in Study 2. Thus, the Control condition has disproportionately more participants than the Record and Share conditions. We used a mixed model to account for the fact that members of each dyad may share a "common experience" unique to each

² Memory: $F(2,148.98) = 4.830, p = 0.009$; Enjoyment: $F(2,144.61) = 1.845, p = 0.162$; Presence: $F(2,155.69) = 1.630, p = 0.199$; Mind-Wandering: $F(2,146.09) = 4.181, p = 0.017$.

dyad. This allows us to compare participants in each of the three conditions, over and above experiences unique to each dyad. An ANOVA with no random effects reveals the same pattern of results.

4.2.1. Memory

In this naturalistic social context, media use impaired participants' memory ($F(2,177.87) = 4.931, p = 0.008$; Fig. 1a). Post hoc comparisons using the Tukey HSD test indicated that control participants performed significantly better on the memory test ($M = 6.932, SD = 1.549$) than Share participants ($M = 6.163, SD = 1.717, t(176.25) = 2.795, p = 0.016, d = 0.470$), though not significantly better than Record participants ($M = 6.333, SD = 1.752, t(181.67) = 2.018, p = 0.111, d = 0.362$).

Memory scores for Control participants in a Control dyad did not differ from Control participants in a Record or Share dyad ($F(2,95.35) = 1.412, p = 0.249$).

4.2.2. Engagement and enjoyment

As in Study 2, media use did not significantly impact enjoyment ($F(2,217.44) = 0.514, p = 0.599$; Fig. 1b) nor presence ($F(2,217) = 1.608, p = 0.203$; Fig. 1c). However, we found that media use did significantly impact mind-wandering ($F(2,180.62) = 3.627, p = 0.029$; Fig. 1d). Participants in the Control condition reported significantly less mind-wandering ($M = 2.682, SD = 1.159, t(181.48) = -2.651, p = 0.024, d = -0.469$) than participants in the Record condition ($M = 3.233, SD = 1.190$).

Control participants in a Control dyad did not differ from Control participants in a Record or Share dyad in terms of mind-wandering ($F(2,100.69) = 0.303, p = 0.739$), presence ($F(2,86.159) = 0.405, p = 0.668$), or enjoyment ($F(2,90.093) = 0.581, p = 0.561$).

5. General discussion

Despite its prevalence, we know very little about how media usage impacts people's experiences. Here we conducted controlled (Study 1) and naturalistic (Studies 2 and 3) experiments to assess the effects of media use on three aspects of experience: memory, engagement, and enjoyment.

Across all three studies, we found evidence that media use impairs memory, irrespective of whether memory was tested soon after the experience or over a week later. We found no conclusive effects on engagement and enjoyment. Media use impaired memory for both computer-based and real-world experiences, in both solo and social contexts. These findings suggest that there may be a real, objective consequence of using media. Creating a hard copy of an experience through media leaves only a diminished copy in our own heads.

Study 1 suggests that media use impacts memory specifically by *externalizing* the experience. The act of recording an event is sufficient to impair memory, irrespective of whether that recording is saved or shared with others. This builds on previous findings that taking pictures impairs memory (Henkel, 2014), by showing that media use impairs memory even when participants have the freedom to take pictures of whatever they want (vs. being assigned to selectively photograph objects). This finding also dovetails with evidence that multitasking during an activity will impair memory for that experience (Bowman et al., 2010). Indeed, a distraction condition that did not involve media use (Study 1) likewise impaired memory.

The costs of using media for memory were not outweighed by any benefits in our more subjective measures of experience. Instead, we found no consistent evidence that media use affected engagement and enjoyment. Social media use decreased engagement and enjoyment in our more controlled study (Study 1); however, this effect did not replicate in more naturalistic contexts (Studies 2 and 3). In contrast, previous work has found that picture-taking *increases* enjoyment of an experience (Diehl et al., 2016). We propose that future work should resolve these discrepancies by carefully characterizing the features of

an experience that might modulate the effects of media use. For example, we suggest that the nature of the experience may impact the effect of media use on that experience. If an experience is not sufficiently engaging or enjoyable on its own, using media might be more likely to increase enjoyment of that experience.

Future studies should also incorporate measures of engagement and enjoyment beyond self-report, such as behavioral indices of enjoyment. Should subjective reports diverge from objective measures, this might explain why people persist in using media, even without any notable subjective impact. It is possible that media usage comes with other benefits – or perceived benefits – that outweigh any negative effects. For example, people might enjoy future benefits from recording their experiences for an audience or for their future selves. That is, we might expect to see a boost in remembered enjoyment when people review their media (which we did not ask participants to do explicitly), or when reporting on their remembered experiences at different time-scales (e.g., one year later). Future work should endeavor to identify any such benefits not explored in the current work.

These studies leave many important questions unanswered. Most notably, we do not know through which mechanisms media might impact memory. Study 1 suggests that media may impair memory specifically because it externalizes an experience. However, we do not yet know the extent to which distraction contributes to impaired memory over and above the externalization process. The results of Study 1 suggest that mere distraction may have a significantly negative impact on an experience. More than ever, the media available in our pocket at all times may serve as a near constant source of distraction—even when our devices are not in use (Ward, Duke, Gneezy, & Bos, 2017). Thus, we hope future research will fully assess which aspects of media, including its distracting nature, impact experience. As is, a full characterization of the mechanism by which media might impacts memory remains unresolved. In Study 1, we conducted exploratory analyses of two mechanisms proposed in earlier research: that media changes memory by encouraging an “observer perspective” (Nigro & Neisser, 1983) and that media reduces engagement and enjoyment by raising self-presentational concerns. However, we found no evidence in support of either mechanism (see Supplementary Materials). The fact that we don't find evidence for self-presentational concerns puts our results at odds with previous findings (Barasch et al., 2016), though we do not wish to over interpret a null effect.

Another open question is the extent to which the effects of media use observed here might apply to other types of media use. We were specifically interested in investigating the impact of using media to share with a general audience (e.g., posting on Facebook). However, people similarly use media to share experiences with a *specific* audience (e.g., a close friend via WhatsApp). Previous research has suggested that people are highly motivated to engage in social sharing (Tamir & Mitchell, 2012; Tamir, Zaki, & Mitchell, 2015), particularly for highly emotional events, and that doing so both enhances emotional experience and memory (Rimé, 2009). In contrast to Rimé's (2009) studies, ‘social sharing’ in our studies was non-naturalistic, in that individuals shared with an audience that was not immediately present, and not well-defined (i.e., anyone in a participant's social media network may view their posts). While this reflects “normal” social media use, like posting on Facebook, it is certainly distinct from many other types of interactions. Thus, we predict that future studies investigating the impact of posting information toward a general audience will find that participants remember less of the experience itself. That said, it remains an open question how “social” direct-communication via media might be; its impact on experience may indeed be predicated on the extent of that sociality. If so, we might expect to see enhanced memory when people choose to use media to share experiences with a close friend, as in more naturalistic sharing studies (Rimé, 2009). However, the current investigations aimed to capture a distinctly different type of sharing in these studies – namely using a media platform to share with a general, impersonal, audience. Indeed, we find that media use across our studies

does not result in the memory boosts found in more intimate, face-to-face, social sharing.

Many of our main findings suggest that the effects of media use on experience may be more nuanced or context-dependent than previously thought. Though our results tell a more complicated story than prior research, we believe they also tell a more comprehensive one. To our knowledge, these are the first sets of studies that compare conditions where people use media to record experiences, use media to share experiences, and do not use media at all. Previous studies have compared two such conditions at a time. Including all three in one study reveals some inconsistencies in results across contexts. These nuances highlight the complexity of this phenomenon and underscore the importance of examining media effects across a range of experiences, using a range of measures. As researchers begin to better understand how media impacts experiences, we hope this will shed light on how researchers can also develop media in order to enhance experiences (e.g., using guided museum tours, augmented reality to drive engagement and learning).

6. Conclusion

Everyday moments are fleeting, but media allow us to hold onto these moments by saving them for ourselves and sharing them with others. These studies highlight ways in which using media impacts our personal experiences, both in the moment and in memory. Ironically, our results suggest that using media to preserve these moments may prevent people from fully experiencing them in the first place. These effects can be both substantial and sustained: media distract us from our experiences – limiting our ability to remember the moments we so wish to hold on to. The near ubiquitous presence of media in society underscores the importance of understanding its effects on our lives.

Open practices

Materials and data for all experiments are available at <https://osf.io/uqh5d/>. Preregistration report for Study 1 available at <https://osf.io/uwbwt/>.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.jesp.2018.01.006>.

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