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DOES MOOD MODERATE THE RELATIONSHIP BETWEEN REFLECTION AND WELL-BEING?

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Table of Contents

List of Tables

List of Figures

Abstract

Does Mood Moderate the Relationship between Reflection and Well-being?

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Reflection is a systematic process of reviewing memories. Reflection on past positive and negative memories increases well-being, as does reflection that is mediated by technology to provide rich digital records of past personal experiences. Technology mediated reflection (TMR) is rapidly growing in popularity, with many deployed systems, however we know little about how one's mood when using TMR might influence well-being. I use theories of memory and emotion-regulation to motivate hypotheses about the relationship between reflection, mood, and well-being when using technology. I developed a web-based application called MoodAdaptor to test these hypotheses. MoodAdaptor prompted participants to reflect on positive or negative memories depending on current mood. I evaluated how mood and memory interact during written reflection and measured effects on well-being. Qualitative and quantitative data were collected via surveys, logfiles, and interviews. Follow-up assessments were also administered three months after the initial month-long study to measure potential long-term benefits. When participants reflected on memories with valences opposite to their current mood, their mood became more neutral. However this did not impact overall well-being. My findings also clarify underlying TMR mechanisms, showing that moods and memories competed with each other. When

positive moods prevailed over negative memories, people demonstrated classic mechanisms shown in prior work to influence well-being. When negative moods prevailed over positive memories, memories became negatively tainted. My results have implications for new well-being interventions and technologies that capitalize on the interconnectedness of memory and emotion.

Dedication

I dedicate this dissertation to my family and friends, who have been an unwavering source of support, guidance, and understanding throughout this process of chasing my dreams. I especially dedicate this work to my two girls: my beautiful wife Betsy, who has been an anchor through many ups and downs, and my sweet and silly daughter Callista, who reminds me of what's important in life.

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Does Mood Moderate the Relationship between Reflection and Well-being?

Our emotions and our memories are intertwined, each influencing the other. For example, *autobiographical memory*, which consists of personal memories from our lifetime, plays a critical role in enhancing positivity (Conway & Pleydell-Pearce, 2000). We are more likely to remember positive than negative experiences, and the details of remembered experiences also become more positive over time (Mitchell, Thompson, Peterson, & Cronk, 1997; Walker, Skowronski, & Thompson, 2003). There is a rich literature documenting many such memory biases that function to preserve well-being (D'Argembeau & Van der Linden, 2008). In turn, our current mood shapes memories by selecting the types of information that form new memories, and filtering the memories that we are likely to remember (Berntsen, 2002; Matt, Vázquez, & Campbell, 1992). *Mood-congruent memory*, for instance, biases us to remember past experiences that are emotionally consistent with current mood. In other words, we are more likely to remember joyful experiences when we are feeling happy, and depressing experiences when feeling blue. While mechanisms of mood-congruent memory are still being investigated, some theorists believe this phenomenon serves a behavioral purpose (Bower, 1981). Mood helps select memories that are similar to the experiences we are currently having, providing more relevant information to guide our actions. However, in some contexts, people remember *mood-incongruent* memories to regulate emotions, i.e. recalling positive past experiences to improve current negative moods (Erber & Erber, 1994).

Actively reviewing past memories, a process known as *reflection*, has also been shown to help regulate mood and enhance well-being. Reflection is the main behavior I wish to understand in this dissertation. Reflecting on *positive* memories increases positive affect, and is often evoked during negative emotional states (Wildschut, Sedikides, Arndt, & Routledge, 2006). Furthermore, reflecting on *negative* memories also has clear benefits in helping people *understand*, *overcome*, and *distance* themselves from past traumas (Campbell & Pennebaker, 2003; Smyth, True, & Souto, 2001; Wildschut et al., 2006). Over 200 studies have identified a broad range of benefits for reflection on negative experiences, such as physical and psychological improvements in well-being (Pennebaker & Chung, 2011).

Reflection can also be done using technology, in *technology mediated reflection* (TMR). For instance, TMR tools such as Timehop, MorningPics, Pensieve, and Echo, provide rich, detailed records of past personal memories in the form of videos, images and text to facilitate reflection. These systems are becoming more common, a prime instance being Facebook's Lookback Videos, which facilitates reflection on timeline posts and has been accessed by over 200 million people (Bandaru, 2014). TMR also leads to well-being benefits involving similar mechanisms to natural (unmediated) reflection (Isaacs et al., 2013; Peesapati et al., 2010).

While both unmediated and mediated reflection are now increasingly common and enhance well-being, it is unknown whether *mood* moderates these benefits. We know that mood primes congruent, and in some contexts, incongruent memories to

help modify behavior and emotions. But how does mood impact our ability to benefit from systematically reviewing the past? If we are in a positive rather than negative mood, is it easier for us to learn from and find the bright side of negative memories? Might we benefit more from revisiting enjoyable memories while in a negative mood when we are most in need of mood enhancement? Because mood-incongruent memory can aid emotion-regulation, does incongruent reflection offer greater well-being benefits? Furthermore, these are important and relevant questions to ask because of the popularity and frequency of TMR. Millions of people might currently be using technology to reflect when in a mood that impedes their ability to access full benefits. Yet TMR systems could harness these mood-memory relationships to deliver content at more optimal moments to help well-being.

To answer these questions about the relationship between mood, reflection, and well-being, I developed and deployed a web-based application called MoodAdaptor. MoodAdaptor first asked participants to write about recent, emotional, and relevant events in their lives, generating a database of personal memories that people were asked to reflect on later. In the main phase of the study, MoodAdaptor prompted participants to rate their current mood throughout the day, and then to reflect on a prior memory. I developed four different system versions which differed in the type of reflections they elicited depending on the mood of the participant. One version sent back a positive memory for reflection if the participant reported being in a positive mood. Another version also sent back a positive memory but only if the participant reported being in a negative mood. A third version sent back a negative

memory for reflection if the participant reported being in a positive mood. And a fourth version also sent back a negative memory but only if the participant reported being in a negative mood. By comparing mood-congruent with mood-incongruent reflection for each emotional valence, I hoped to learn whether mood mattered and how it impacted TMR, and well-being. Finally, follow-up assessments were administered to determine long-term benefits.

Related Work

First I review the functions of autobiographical memory and how specific memory biases enhance our positivity. Next I show that this relationship is bidirectional, i.e. that emotion impacts the types of memories we retrieve. This is followed by a discussion of unmediated reflection, a structured process of reviewing past memories without the use of technology. I describe some of the benefits of positive and negative reflection, but also a maladaptive style of reflection called rumination. Finally, I review different classes of TMR systems, suggesting that mood might critically influence their mechanisms and impacts.

Autobiographical Memory

Before exploring the intersection of emotion, reflection, and technology, I will first introduce some key properties of autobiographical memory. Autobiographical memory is a system that encodes, stores, and retrieves information about personal experiences. There is an extensive literature regarding its development, characteristics, and functions (Conway & Pleydell-Pearce, 2000; Nelson & Fivush, 2004; Pillemer, 1992; Rubin, Rahhal, & Poon, 1998; Schacter, 1999; Walker et al.,

2003). Here I focus on autobiographical memory functions since these will be critical when I review related bodies of literature. The three primary functions of autobiographical memory are: *directive, social* and *self-consistency* (Bluck, Alea, Habermas, & Rubin, 2005; Pillemer, 1992).

Directive functions help us plan and direct our future behaviors. Analysis of past autobiographical memory experiences helps us be successful in future behaviors. Our belief in our capability to perform new behaviors is called *self-efficacy*, a central component of most major behavior change theories (Ajzen, 1991; Bandura, 1977; Locke & Latham, 2002; Prochaska & DiClemente, 1994). Because our memories inform our self-efficacy, the directive function of autobiographical memory is a critical gear in the machine that drives behavior.

Social functions of autobiographical memory involve disclosing elements of one's past life to others to promote interpersonal relationships. Personal memories become material for conversations which serve to develop and nurture social bonds (Bluck et al., 2005; Williams, Conway, & Cohen, 2007). Reflecting on personal memories also motivates people to solicit social support (Kim, 2008; Pennebaker, Barger, & Tiebout, 1989). Using autobiographical memory to strengthen social bonds has clear well-being benefits and is considered to be evolutionarily adaptive (Neisser, 1988; Rook, 1985; Silk, Alberts, & Altmann, 2003).

A third function of autobiographical memory is *self-consistency*, where we remember our pasts to maintain self-coherence across time. Our memories of the past are important to preserving and enhancing our identity. Threats to this coherence are

adaptively edited to preserve our self-image (Conway & Pleydell-Pearce, 2000). We seek a positive sense of self, so that discrepancies are biased towards self-enhancement (D'Argembeau & Van der Linden, 2008). If memories conflict (such as emotionally positive and negative memories for the same event), then we retain the positive memory and edit or even entirely forget the negative memory (Mitchell et al., 1997). This focus on self-enhancement has been documented in a large body of literature on memory biases (D'Argembeau & Van der Linden, 2008). For instance, people remember about twice as many positive (50%) as negative events (25%), with the remainder being emotionally neutral (Walker et al., 2003). The *fading affect bias* explains a feature of memory where the emotion associated with negative events fades faster than emotions associated with positive events, enhancing well-being (Walker et al., 2003). Also, people have a "rosy view" of the past in that they remember past events more positively than their actual experience of the event (Mitchell et al., 1997).

Emotion and Memory

While adaptive memory biases enhance our positivity, emotion in turn has a profound effect on our memories. One avenue of research is concerned with how emotion influences the creation of new memories (encoding). Highly emotional events show enhanced memory of central aspects (that are important or meaningful to the event) as opposed to peripheral details (Berntsen, 2002; Burke, Heuer, & Reisberg, 1992; Christianson & Loftus, 1990; Safer, Christianson, Autry, & Österlund, 1998). For example, a victim of a crime might remember the details of an

assailant's gun (a phenomenon called 'weapon focus') rather than their car or clothing (Steblay, 1992). Thus, emotion acts as an attentional guide, narrowing our focus to central details when forming new memories. However the current paper is concerned with how one's present mood influences the *recall* of memories, so I will now shift my focus from mood and memory encoding to mood and memory retrieval.

Memory retrieval is the process of accessing and reconstructing stored memories. Retrieval is highly influenced by mood. For instance, mood-congruent memory is a phenomenon whereby memories become more accessible when their emotional content matches one's current mood. For example, in a depressed mood a person will have greater access to memories that have depressing content, such as failures and disappointments. The effect has been demonstrated in different settings, across a wide range of moods and for different types of memory (such as conscious explicit memories and unconsciously primed memories) (Bower, 1981; Matt et al., 1992; Watkins, Vache, Verney, & Mathews, 1996). A related phenomenon is mood-dependent memory, which is a tendency to retrieve memories that were encoded in the same emotional valence as one's current mood (Lewis & Critchley, 2003). Here, the content of the memories is not considered, and instead it is the mood the person is in when encoding the memory that influences retrieval. So for instance, if a person is in a highly positive mood, they would be more likely to remember the math theorem they learned (which might be emotionally neutral) if they were in a positive mood when they learned it. Because reflection (in both technology mediated and natural

contexts) is most often done on memories that have emotional content, mood-congruent memory is most applicable to the current work.

The exact mechanisms of mood-congruent memory are unknown, though Bower (1981) has proposed a network theory of memory and emotion to explain the phenomenon. He suggests that emotions are stored as nodes in an associative network of concepts in memory. A fearful encounter with a snake, for instance, will include a node for the emotion of fear, connected to semantic and episodic information about the snake and the experience. At any point in the future, if an event is appraised as fearful, it will activate the fear node and activation will spread to the snake content that had previously been stored. Thus, experiencing fear in the future will make the snake memory more accessible for retrieval.

Because autobiographical memory has a directive function, we can see the utility of recalling similarly valenced events from the past to help guide current behavior (Levine & Pizarro, 2004; Pillemer, 1992). Seeing a snake induces fear which brings to mind memories of previous encounters with snakes to help the person navigate the current situation. However, this would suggest that negative moods would automatically trigger all negative memories in the associative network, without any mechanisms in the model to help regulate these memories and our well-being. This is a criticism of Bower's network theory. The theory addresses how mood-congruent memory can guide our behaviors, but does not consider regulation strategies and the self-enhancing biases of memory (Levine & Pizarro, 2004; Rusting & DeHart, 2000).

There is some evidence that these regulatory mechanisms need to be taken into account. As I noted, network theory predicts that *all* emotionally congruent memories are more accessible as long as their emotional content matches one's current mood. However, the mood-congruent effect is more robust for positive moods and memories, than negative moods and memories (Isen, Shalker, Clark, & Karp, 1978; Nasby & Yando, 1982). Favoring the retrieval of positive memories over negative memories is a natural memory bias previously discussed (Walker et al., 2003). Furthermore, in some contexts, people selectively retrieve *mood-incongruent* memories to regulate current mood (Erber & Erber, 1994; Parrott & Sabini, 1990; Rusting & DeHart, 2000). For example, in a naturalistic class setting, Erber and Erber (1994) found that students typically recalled mood-congruent memories after class, and mood-incongruent memories before class. They concluded that the students were motivated to regulate their emotions to prepare for class for more level-headedness around their peers, but reverted back to the default mood-congruent processes when they no longer had to socially perform. Also, Parrott and Sabini (1990) showed across five studies that their participants retrieved happier memories when in a negative mood than a positive mood. These mood-incongruent strategies are the opposite of what Bower's network theory would predict. Lastly, adaptive mood-incongruent strategies can be induced by providing people with specific instructions to engage in positive reappraisal (reinterpreting negative memories to extract positive outcomes) a strategy called a redemption sequence (described in the next section) (Rusting & DeHart, 2000). Thus, while mood-congruent memory is a

well-documented effect, which may function to guide our behavior, mood-incongruent strategies in both natural and structured contexts provide potential for emotion-regulation and well-being.

However, there could be consequences to mood-incongruent memory. For example, while positive memories help regulate negative mood, the negative mood in turn could taint the positive memory. This is called *kill-joy thinking*, *fault finding,* or a *contamination sequence* and involves re-assessing positive memories to uncover overlooked negative aspects (Bryant & Veroff, 2007; McAdams, Reynolds, Lewis, Patten, & Bowman, 2001; Quoidbach, Berry, Hansenne, & Mikolajczak, 2010). Kill-joy thinking correlates with reductions in well-being (Larsen & McKibban, 2008; Polman, 2010; Schwartz et al., 2002).

Unmediated Reflection

Unmediated reflection is the process of mentally reviewing our memories of past experiences. By unmediated I mean that this style of reflection does not employ technology to help facilitate the process. Unmediated reflection benefits both physical and psychological health. Reflecting on positive memories (e.g. thinking about past successes, friendships) is adaptive and increases perceived enjoyment of life (Bryant, Smart, & King, 2005). Positive reflection also increases positive affect and is often invoked to cope with painful affective states like loneliness (Wildschut et al., 2006).

Counter-intuitively, reflecting on negative memories (which I call negative reflection) can promote general well-being. The *emotional writing* paradigm was devised by Pennebaker and Beall (1986) to explore the effects of negative reflection

by having participants repeatedly write about past traumas. A meta-analysis of 13 emotional writing studies revealed high effect sizes of improved well-being (mean weighted effect size of *d*=.47) (Smyth, 1998). However, these benefits seem to occur over the long-term, as Sloan and Marx (2004) have shown that emotional writing induces an immediate negative reaction, although this reduces over time and repeated writing sessions.

The exact *mechanism* for the success of emotional writing remains unclear. Different theories suggest that emotional writing is effective because of increased *understanding, redemption, and distancing.*

Understanding. Emotional writing helps structure traumatic experiences into a coherent life narrative and imposes an organization on one's understanding of the trauma (Pennebaker & Chung, 2007; Pennebaker, Mayne, & Francis, 1997). This structuring allows painful experiences to be better understood, reducing their emotional intensity and improving well-being (Smyth et al., 2001). Also, words that are indications of insight (e.g. 'think', 'know', 'consider') and causal reasoning (e.g. 'because', 'reason', 'hence') increase across writing sessions and as they do, intrusive thinking such as the recall of unwanted negative thoughts is reduced (Boals & Klein, 2005; Klein & Boals, 2001; Petrie, Booth, & Pennebaker, 1998).

Redemption. I have already described how negative memories are viewed more positively over time (Mitchell et al., 1997). By contrasting one's current feelings about such past negative situations, with past feelings about those situations, people see that they have overcome difficult experiences. Identifying this contrast

helps form a *redemption sequence*, which is a shift in perception of a negative experience to a more positive, triumphant evaluation (McAdams et al., 2001). The construction of redemption sequences is associated with increased well-being (Wildschut et al., 2006).

Distancing. Over time, the way people write about past negative experiences becomes less self-focused, representing adaptive distancing (Campbell & Pennebaker, 2003; Rude, Gortner, & Pennebaker, 2004). When people experience emotional or physical pain, their attention tends to be focused on themselves, and this is reflected in their language use. For example, depressives use more first-person pronouns (Niederhoffer & Pennebaker, 2009; Rude et al., 2004). Furthermore, shifting from first- to third-person event descriptions over time promotes health improvements (Campbell & Pennebaker, 2003). However, there are individual differences, and those who do not shift in pronoun usage display static thinking patterns, experiencing poorer health and a tendency to ruminate about negative aspects of events (Francis & Pennebaker, 1992; Nolen-Hoeksema, Wisco, & Lyubomirsky, 2008). I now discuss these individual differences in responding to distress.

Rumination

One maladaptive style of reflection called "rumination" is characterized by perseverating about negative experiences that would normally be edited or forgotten via self-enhancement processes. Ruminators repetitively and passively focus on the *symptoms* of a distressing experience, such as one's negative emotions (e.g. 'I feel so sad, I just can't concentrate'), rather than devising solutions, such as how to avoid

that experience in the future (Nolen-Hoeksema, 1991). This narrow focus on symptoms rather than solutions can be detrimental to health, leading to depression and anxiety (Nolen-Hoeksema et al., 2008). Lyubomirsky, Kasri, Chang, and Chung (2006) demonstrated the seriousness of this symptom bias, showing that breast cancer ruminators delay reporting their initial symptoms to a doctor two months longer than breast cancer non-ruminators.

I have summarized how natural memory functions, and both adaptive and maladaptive processes of reviewing past memories. I now review technologies built to mediate memory.

Technology Mediated Reflection

As described earlier, unmediated reflection is the process of mentally reviewing our memories of past experiences. Similarly, TMR systems facilitate remembering of autobiographical memories, but such systems also enhance this process by capturing rich records in the form of images, videos, or textual descriptions of past personal experiences.. These detailed records potentially allow more accurate and comprehensive reflection. For example, some systems such as Timehop, Askt, Echo, My Wonderful Days, Live Happy, MorningPics, 1 Second Everyday, and Everyday.me send back past records to system users allowing them to reflect on recorded events after time has passed. Other tools such as PosiPost Me, Moodmill, MobiMood, CaraClock, and eMoto support the social function of autobiographical memory by sharing emotional data with friends. Facebook has also explored TMR on past posts with On This Day, Year in Review, Timeline

Moviemaker, Lookback videos and Say Thanks. Recently, there have been multiple studies of users' moods when engaging with technology (Fowler & Christakis, 2008; Kramer, 2012; Kramer, Guillory, & Hancock, 2014; Rosenquist, Fowler, & Christakis, 2011; Turkle, 2012). While both mood and reflection are being investigated, to my knowledge none of these studies have explored their intersection and underlying mechanisms, the primary objective of this dissertation.

One of the best studied TMR systems is Pensieve. It provides users with past Facebook status posts, asking them to write their current reactions to those memories (Peesapati et al., 2010). Participants reported that they enjoyed this reflective process and that it improved their mood. In a similar study, Isaacs et al. (2013) created Echo to facilitate recording of events as they happened (rather than retrospectively providing past Facebook posts as with Pensieve). The researchers found that capturing three experiences per day for one month, and reflecting on these by writing about them, significantly increased participant well-being. Echo also supported other classic reflection benefits (Isaacs et al., 2013). For example, redemption sequences were identified through increased positive affect words (e.g. 'love', 'nice', 'sweet') and words indicating acceptance (e.g. 'ok', 'yes', 'agree') used by participants when reflecting on past negative experiences. And understanding was expressed via insight words (e.g. 'think', 'know', 'consider') and words signaling cognitive processing (e.g. 'cause', 'know', 'ought'). In a follow-up study with Echo, distancing was observed in the reduction of first-person pronoun usage across time (Konrad, Isaacs, & Whittaker, 2016).

Research Questions

We have seen how both mediated and unmediated reflection can improve well-being. However, prior work has not addressed whether well-being benefits are influenced by *current mood*. We know that mood triggers memories in opposing ways, where memory can either be mood-congruent (Bower, 1981), or mood-incongruent to regulate current mood (Erber & Erber, 1994; Parrott & Sabini, 1990; Rusting & DeHart, 2000). However, little is known about how mood influences the benefits derived from reflection. For example, Pennebaker and Chung (2007) argued that people learn by reflecting on past traumas, but it may be that such learning critically depends on one's current mood. Current mood may determine how open or resilient one is to processing such negative information (for example one might be more open to reflecting on past negative events when one is in a positive mood). In the same way, there may be critical well-being benefits from reflecting on positive experiences when one is feeling down.

My research questions therefore include: Does people's current mood influence the well-being benefits they derive from reflecting on their pasts? Additionally, does reflection valence influence one's current mood?

My goal was to understand how mood and reflection interact by comparing congruent with incongruent reflection strategies. However, because positive and negative memories are so different in the ways they influence well-being (and are researched), I formulated different hypotheses for each. For positive memories, I hypothesized that incongruent reflection would have greater benefits for current mood

but be more harmful for general well-being as compared to congruent reflection. And for negative memories, I hypothesized that incongruent reflection would be more harmful for current mood but have greater benefit for general well-being as compared to congruent reflection. Next, I explain the motivations for each of these hypotheses.

I predicted that negative reflection (i.e. reflecting on a negative memory) when in a positive mood would increase general well-being more than negative reflection when in a negative mood. These well-being increases should be driven by three mechanisms: understanding, distancing, and redemption. Negative reflection when in a positive mood introduces a different emotional state from the initial experience, which may encourage new insights and perspective. "Thinking outside the box" from new emotional perspectives may contribute to increased understanding (Boals & Klein, 2005; Pennebaker & Chung, 2007; Petrie et al., 1998). Also, positive moods might encourage less self-focus than the discomfort associated with negative moods, allowing for adaptive distancing from negative memories (Campbell & Pennebaker, 2003; Rude et al., 2004). Lastly, contrasting one's current positive emotional state with prior negative feelings about a negative event, may help people see they overcame the difficult experience, contributing to redemption sequences (Rusting & DeHart, 2000; Wildschut et al., 2006). However, I also predicted a side-effect to these adaptive mechanisms, namely that negative reflection would contaminate one's currently positive mood (Sloan & Marx, 2004). Thus, I expected general well-being benefits (consistent with Pennebaker and Beall (1986)) due to increased distancing, redemption and understanding, but short-term costs to one's

currently positive mood (consistent with the negative short-term responses demonstrated by Sloan and Marx (2004)).

Furthermore, because rumination is a repetitive focus on the symptoms of a distressing event, such a one's negative emotions, it is possible that being in a positive mood reduces the likelihood that negative reflection will elicit rumination (Nolen-Hoeksema, 1991). Rumination is a symptom of being in a depressed mood, because of the greater access to negative thoughts (Lyubomirsky & Nolen-Hoeksema, 1993). In fact, a primary intervention for reducing rumination is to evoke a positive mood via pleasant distractor activities (Nolen-Hoeksema, 1991). Thus, providing negative reflection when already in a positive mood should reduce the likelihood of ruminating more than when in a negative mood.

I also predicted that positive reflection (i.e. reflecting on a positive memory) when in a negative mood would have greater momentary benefits than when in a positive mood. Positive reflection is often invoked naturally as an emotion-regulation strategy in response to negative affective states such as loneliness (Bryant et al., 2005; Erber & Erber, 1994; Wildschut et al., 2006). In contrast, if already in a positive mood, there may be reduced room for improvement, experiencing a ceiling effect for positive reflection.

However, positive reflection when in a negative mood may have undesirable side-effects. It may uplift emotion in the moment, but the reflector may see that memory from a new (negative) perspective (Bryant & Veroff, 2007). In other words, the reflector might experience momentary mood benefits, but the memory itself may

become tainted with newly identified negative details. While improving our emotional stance on past traumas may genuinely benefit general well-being, positive reflection while in a negative mood may have the opposite effect through the maladaptive mechanism of kill-joy thinking. Thus I predicted that positive reflection when in a negative mood would have momentary mood benefits, but general negative well-being consequences.

Additionally, because rumination is a symptom of being in a depressed mood, it is possible that people might ruminate more in a negative mood, even on positive events. By seeing positive events from a new, negative perspective (i.e. kill-joy thinking), people may perseverate more on these details. I predicted that positive reflection when in a negative mood would increase rumination more than when in a positive mood.

Following my previous studies (Isaacs et al., 2013; Konrad et al., 2015; Konrad et al., 2016), I ran a month-long reflection intervention (the start of which I will denote as "Time 1" and the end as "Time 2"). I chose this duration to allow enough time for initial benefits to emerge without the study becoming an imposition on participants, leading to participant attrition. But I was also interested in long-term effects. Pennebaker et al. (1997) suggested that the greatest benefit for reflecting on traumas typically occurs two to four months after reflection. Therefore, mood-based reflection might influence well-being even after the intervention. To assess the long-term influence of mood-incongruent vs. mood-congruent reflection, I used Pennebaker's observation as a guide for the design of Experiment 2, and followed up

with participants 3 months after the intervention. I predicted that increases and reductions in general well-being (depending on mood and memory valence) would continue to be observed 3 months after the intervention (which I will call "Time 3"). To summarize, here are my 8 hypotheses:

Negative reflection when in a positive mood (incongruently) versus negative mood (congruently) will:

Hypothesis 1: Reduce momentary mood.

Hypothesis 2: Increase general well-being, through greater distancing, understanding, and redemption.

Hypothesis 3: Reduce rumination

Hypothesis 4: Increase general well-being (following Hypothesis 2) and these increases will be even greater at Time 3 as compared to Time 2. In other words, well-being will be greater at Time 3 than Time 2 which will be lesser than Time 1

Positive reflection when in a negative mood (incongruently) versus positive mood (congruently) will:

Hypothesis 5: Increase momentary mood

Hypothesis 6: Reduce general well-being, through greater kill-joy thinking

Hypothesis 7: Increase rumination

Hypothesis 8: Reduce general well-being (following Hypothesis 6) and these reductions will be even lesser at Time 3 as compared to Time 2. In other words, well-being will be lesser at Time 3 than Time 2 which will be lesser than Time 1.

Approach

Prior work has investigated reflection in lab based manipulations (Wildschut et al., 2006) and naturalistic interventions (Bryant et al., 2005; Pennebaker & Beall, 1986), both of which have advantages and disadvantages. However an important novel aspect of my approach is to use technology to systematically explore questions about mood and reflection. Many social media technologies are already causing people to reflect on their pasts in ways that may affect their emotions, so understanding how people's current mood affects this process is critical. Systems like TimeHop, MorningPics and 1 Second Everyday provide opportunities to review past events but currently don't consider one's current mood. Social media tools such as Facebook's Lookback videos and On This Day are aimed at providing emotionally uplifting exposure to past experiences. However, if different mood states influence how people can benefit, these tools might not have their desired impact. For instance, millions of people might receive boosts to their momentary mood due to Lookback videos, but also experience general well-being detriment if Hypothesis 6 is correct because their current negative mood undermines their experiences of that reflection. Using a technologically mediated approach allows me to control what experiences people reflect on, but to do this in relevant contexts with naturalistic data, that have implications for deployed technology.

Lastly, unmediated memory already has a tendency to recall events that are mood-congruent, although some contexts trigger mood-incongruent strategies for emotion regulation (Erber & Erber, 1994; Matt et al., 1992). Technology has potential

to facilitate these incongruent strategies effortlessly (e.g. by providing reminders to reflect), providing potential benefits that are currently accessed less frequently in unmediated contexts.

While some TMR systems like Askt, Echo, and My Wonderful Days are designed to facilitate reflection on written memories, many also facilitate picture memories as well (Lookback, Timehop etc.). I chose to focus on *written* event descriptions for this dissertation as a starting point since this is most similar to my past work with Echo, and because of the benefits found by other written reflection studies (Bryant et al., 2005; Isaacs et al., 2013; Pennebaker & Beall, 1986). Furthermore, once a written memory was presented for reflection, my system facilitated this reflection by asking the user to write about the event. This feature is common to some current technologies like Echo, Live Happy, and Pensieve, and gives the user a formal opportunity to explore and learn from their written past (Pennebaker et al., 1997). Other systems like Facebook's On This Day and Timehop have an option for written reflection (via sharing on social media) but without directly encouraging users to do so. Written reflections provide valuable qualitative data about how one's memory of the past has changed over time. While not all TMR systems facilitate written reflection, my findings could speak to the potential benefits (or risks) of building written reflection into these interfaces.

To evaluate my hypotheses, I developed MoodAdaptor, a web-based application accessible from any smartphone browser. MoodAdaptor elicits reflection based on current mood. Four different versions of MoodAdaptor were deployed so

that each of 4 experimental groups had a different version: an Incongruent Positive version, Congruent Positive, Incongruent Negative, and Congruent Negative. The Incongruent Positive version provided positive reflections when the participant was in a negative mood. The Congruent Positive version provided positive reflections when the participant was in a positive mood. The Incongruent Negative version provided negative reflections when the participant was in a positive mood. And the Congruent Negative version provided negative reflections when the participant was in a negative mood. A note to the reader to help clarify the condition names I used throughout this paper: the second word in the condition refers to the valence of the memory reflected on (e.g. Incongruent Negative means people reflected on negative memories). Thus I was able to compare the benefits derived from mood-incongruent reflection against mood-congruent reflection for each emotional valence.

I now describe two studies. The first evaluates hypotheses about short-term effects (i.e. hypotheses 1-3 and 5-7), and the second evaluates longer-term effects (hypotheses 4 and 8).

Experiment 1: Mood-Incongruent Vs. Mood-Congruent Intervention

Method

The first part of this section describes participant demographics and recruitment, followed by the survey materials and an in depth description of MoodAdaptor. The section concludes with an overview of the procedures and steps of the entire study.

Participants. I recruited 131 participants through Facebook, UC Santa Cruz email lists and official Facebook groups, using a snowball recruiting strategy where participants could recruit others. Following experiences in prior studies, they were paid $50 for completing Experiment 1, and an additional $30 for each person they recruited who also completed the study. Participants were randomly assigned to a group, roughly balanced across gender and age, and were not informed there were different groups. Three dropped out because of unexpected family emergencies, and becoming too busy to continue. This left 128 participants who completed the study (91 female), aged 18 to 62 (M= 24.56, SD= 8.87). There were 34 in the Incongruent Negative (23 female, age M=23.94, SD=7.70), 34 in the Congruent Negative (25 female, age M=24.85, SD=9.06), 30 in the Incongruent Positive (22 female, age M=25.60, SD=11.58), and 30 in the Congruent Positive group (21 female, age M=23.90, SD=6.90).

Materials. Participants were assessed using four validated standard scales at pretest and posttest. These are the Subjective Happiness Scale, Satisfaction With Life Scale, Ryff Scales of Psychological Well-Being, and the Ruminative Responses Scale. Because there is no universal measure of well-being, I included both hedonic and eudaimonic scales to triangulate different measurement perspectives. The first two scales are measures of *hedonic* well-being which focuses on happiness as defined by satisfaction with life, the attainment of pleasure, and absence of pain (Diener, Lucas, & Oishi, 2002; Kahneman, Diener, & Schwarz, 1999). The Ryff Scales measure well-being from a divergent research paradigm called *eudaimonic*, that does

not assess affective state and subjective happiness but instead focuses on meaning, personal growth, and the degree to which a person is functional (Ryan & Deci, 2001; Ryff & Keyes, 1995). Lastly, the Ruminative Responses Scale is a standard measure of rumination to address Hypotheses 3 and 7, and identify individual differences in a person's proclivities to fixate on past negative experiences. The scales were presented in the same order at pretest and posttest for all groups. See the Appendix for all items in the four scales.

Subjective Happiness Scale (SHS). The SHS consists of 4 items to assess global subjective happiness using absolute ratings as well as ratings of self, relative to perception of others (Lyubomirsky & Lepper, 1999). An example of an item in the scale is, "Compared to most of my peers, I consider myself…" which has response categories ranging from "less happy" to "more happy."

Satisfaction With Life Scale (SWLS). The SWLS consists of 5 items to assess satisfaction with life as a whole (Diener, Emmons, Larsen, & Griffin, 1985). It does not query specific life domains but instead allows participants to weigh these domains overall. An example item is, "If I could live my life over, I would change almost nothing," which has response categories ranging from "strongly disagree" to "strongly agree."

Ryff's Scales of Psychological Well-Being (RPWB). The RPWB is a theoretically grounded instrument reflecting six facets of eudaimonic well-being: autonomy, environmental mastery, personal growth, positive relation with others, purpose in life, and self-acceptance. Responses are totaled for each of the 6 subscales

(higher scores representing more mastery in that area) and a total score is formed by either summing or averaging these scores. The original RPWB consists of 120 questions, and shows high internal consistency, test-retest reliability as well as convergent and discriminant validity (Ryff, 1989). Newer versions have been developed that contain 18, 54, and 84 items, with recommendations for using the longer versions over the shorter, less reliable 18 item version (Ryff & Keyes, 1995; Van Dierendonck, 2004). I used the 54 item version to reduce participant burden taking the surveys, and because this version is being used in large ongoing studies (Hauser et al., 1992) as well as one of my recent studies (Hollis, Konrad, Tucker, & Whittaker, 2016). An example item is, "When I look at the story of my life, I am pleased with how things have turned out," which has response categories ranging from "strongly disagree" to "strongly agree."

Ruminative Responses Scale (RRS). The RRS consists of 22 items designed to assess individual differences in rumination. Rumination is defined as a self-focused method for coping with negative mood that involves repetitive and passive focus on one's negative emotions (Treynor, Gonzalez, & Nolen-Hoeksema, 2003). A total rumination score is formed by summing the scores on each item. An example item is, "How often do you think about all your shortcomings, failings, faults, mistakes," which has response categories ranging from "almost never" to "almost always."

The MoodAdaptor System. MoodAdaptor prompted participants to write about their past memories, asked participants to rate their mood 3 times per day, and

then sent back specific memories for written reflection depending on their mood state and experimental condition. I now discuss each of these features.

Pool of Memories. On the first day of the study, all participants logged-in to MoodAdaptor online and were asked to write about 15 positive memories and 15 negative memories. In my pilot study of 30 participants, generating 15 memories of each valence was the largest number of memories people felt they could accurately and comfortably generate that also met particular criteria. Participants were asked to complete this step on their computer to allow for easier text entry. Following my pilot study, participants were given the following instructions, which were written on the survey and emphasized in a phone call prior to taking the survey:

"Now we'd like you to write about some of your memories. Please describe in detail 15 recent events or experiences that made you feel good when they occurred, and 15 that made you feel bad when they occurred. These events should be within the past year, and the more RECENT and EMOTIONAL the better. Also, please favor events that you consider OPEN. Open events have current relevance and are unresolved. Please write about 2 to 3 sentences with details such as where it occurred, what exactly happened, who were the protagonists, how you felt, and why you felt that way. Here is an example of a positive memory: 'Finally, after dating for almost a decade, I married the man of my dreams and best friend. The wedding went smoothly, and I distinctly remember how much laughter there was. I felt so content and hopeful.' Here is an example of a negative memory: 'I got in a car accident and I remember seeing fear on the faces of onlookers, and I panicked. There was a point

where I almost felt like fleeing the scene. There was so much broken glass and confusion.'"

Each memory had an open ended text box to describe the memory, but participants were asked to complete a minimum length requirement of 90 characters (including spaces) for each memory as I wanted to ensure each memory had sufficient detail for when people later reflected about it. This length requirement was again determined from examining my pilot data. Next, participants generated an emotional rating of the memory:

"How much positive or negative emotion did you experience at this event's occurrence?" (with response categories on a 9 point scale ranging from "extremely negative" (1) to "extremely positive" (9) and a neutral response of "neither negative nor positive." (5)).

Personal Emotion Scale. Participants rated their emotions at multiple points in the study and I wanted them to be consistent when they did this. I therefore used a rating method that we have deployed in other studies (Isaacs et al., 2013; Konrad et al., 2016). When participants first logged-in to MoodAdaptor, they were prompted to create a personal emotion scale so they could consistently calibrate their emotional reactions. This was a 1 to 9 scale where I asked them to assign each number an actual experience from their lives that corresponded with that number. So for instance, 1 (extremely negative) might have been "our house burned down", and 9 (extremely positive) might have been "the birth of our son." On completion, the results were saved and accessible via a hyperlink. That way, if they clicked the hyperlink they

were able to read what they wrote and refer back to this scale throughout the study. Additionally, I encouraged participants to consult this scale in our weekly check-in interviews.

Mood Probe and Reflection. For the duration of the study (30 days), participants received three daily mood probes at random times between 10am and 9pm. This procedure of thrice daily probes is common in experience sampling studies, such as LeFevre, Hendricks, Church, and McClintock (1985),which also probed mood 3 times per day for one month. These probes arrived via a link sent by SMS text messaging to the participant's phone. If a participant didn't respond to a mood probe within an hour, they received a follow-up text reminder. Clicking on the link took participants to MoodAdaptor online and the following mood probe:

"How positive or negative do you feel right now, at this moment?" (with response categories on a 9 point scale ranging from "extremely negative" to "extremely positive" and a neutral response of "neither negative nor positive"). See Figure 1 for a screenshot of a mood probe.

Figure 1. ***Interface of a mood probe in MoodAdaptor***

How participants responded to this probe (positively or negatively) determined which memory they received for reflection. However, even if they were eligible for receiving a memory because of the mood they reported, they didn't always get one. There were fewer memories in the pool than mood probes in the intervention, requiring that I ration memories so participants wouldn't use them up prematurely. However, if a memory was selected for reflection, it was presented directly after the mood probe to allow the participant to read the memory description they had previously written, along with its accompanying emotion rating. Below this description and emotion rating were instructions to reflect on the memory by re-writing about it (again with a 90 character requirement):

"After reading and thinking about the above reflection, please write 2 to 3 sentences about your current feelings regarding the event." Following this, they were given another 9 point emotion scale and asked to:

"Rate how positive or negative you *now* feel about the event." Reflecting on a memory removed it from the pool so that it was not received again. Lastly, after reflecting, participants were given a second mood probe to assess momentary changes in mood due to reflection.

System Version 1- Incongruent Positive Group. When this group responded *negatively* to the mood probe (i.e. choosing a 1, 2, 3, or 4 on the emotion scale), they sometimes received a *positive* memory for reflection. A positive memory was defined as any memory in the pool with an emotion rating of 6 or above. In other words, if this group responded negatively to the mood probe, they might next see a description

of a positive memory they had generated, along with the emotion rating they assigned it. Below the description was an opportunity to reflect by re-writing about it. Whenever participants using this version rated their mood as neutral or above (5 or above), they received nothing back (no system behavior).

System Version 2- Congruent Positive Group. This version was similar to version 1, except when participants responded to the mood probe *positively* (6 or above), they sometimes received a *positive* memory (6 or above). They received no memories if they responded negatively or neutrally to the mood probe.

System Version 3- Incongruent Negative Group. When this group responded to the mood probe *positively* (6 or above), they sometimes received a *negative* memory (4 or below). They received no memories if they responded negatively or neutrally to the mood probe.

System Version 4- Congruent Negative Group. When this group responded to the mood probe *negatively* (4 or below), they sometimes received a *negative* memory (4 or below). They received no memories if they responded positively or neutrally to the mood probe.

Balancing Reflections Across Groups. The goal was to roughly balance the number of reflections across the 4 groups. However, the negative mood groups (Incongruent Negative and Congruent Positive) had less opportunity for reflections because people generally are more often in a positive than negative mood. For example, my pilot study found that 60% of mood probes were positive, 13% were negative, and 27% were neutral. To balance number of reflections, I made it more

likely that negative mood groups received a reflection when they responded negatively to the mood probe.

Procedure. The experiment was a randomized pretest-posttest field study with group (Incongruent Positive, Congruent Positive, Incongruent Negative, Congruent Negative) as the manipulation, and four validated measures as the dependent variables (see Materials section). Participants completed the pretest (Time 1) survey online remotely (through www.surveymonkey.com), and the same survey at posttest (Time 2) after working with MoodAdaptor for 30 days.

After completing the pretest survey, participants were randomized to a group and then sent an instruction document that explained in detail their responsibilities for the study. Research assistants also called each participant to go over the instructions verbally. Participants were instructed to log-in to MoodAdaptor on their computer, and created their personal emotion scale. Following this, they generated 15 positive memories, and 15 negative memories (see the Personal Emotion Scale, and Pool of Memories sections). This triggered the start of the 30 day intervention, where MoodAdaptor probed mood 3 times a day, providing memories depending on the group the participant was assigned to. My team and I called participants weekly to check-in and encourage compliance. After completing the intervention, participants took the posttest survey and were paid $50. In the final check-in phone call, we interviewed a subset of participants about their experiences.

Results

First, I present descriptive statistics followed by a test of each hypothesis.

Hypotheses 4 and 8 regarding long-term well-being are addressed in Experiment 2.

Overall Descriptive Statistics. Throughout the study, participants received 3 initial mood probes per day. If they received a memory, and completed a reflection, they would be given a second mood probe to assess any mood changes following the reflection. Consistent with positivity biases of self-enhancement, the initial mood probes were responded to positively overall, (M=5.89, SD=1.35, with 5 being neutral). There was also a high degree of compliance with responding to mood probes; participants completed on average 87.16 (SD= 4.98) out of the 90 possible initial mood probes. And for reflections, participants made on average 9.43 (SD=4.60) out of the total 15 possible reflections, although this varied by condition (Incongruent Negative: M=12.62, SD=2.43, Congruent Negative: M=6.97, SD=4.48, Incongruent Positive: M=6.17, SD=4.25, Congruent Positive: M=11.87, SD=2.98).

I also looked at the emotion ratings of initial memories and their reflections (recall that this was a rating on a 1 to 9 scale of how they felt about the experience, with 9 being most positive). Positive memories on average were initially rated 7.45 (SD=1.15), whereas their reflections had an average rating of 7.00 (SD=1.19). And for negative memories, their average initial rating was 2.45 (SD=.80), with their reflections being rated as 3.44 (SD=.14) on average. I investigated this change in emotionality, to see if negative memories became more neutral than positive memories, following the well-documented phenomenon of fading affect bias (Walker et al., 2003). I calculated the change in emotion ratings from initial memory to

reflection for each experience. For each person, I compared the average magnitude of change of negative emotion ratings with the average magnitude of change for positive emotion ratings. Change was measured relative to predicted affect fading, so that positive events were expected to become less positive and negative events less negative. I scored change positively when it conformed to the fading affect bias and negatively when it didn't. For example, an average emotion rating of 2 that became a 4 was a +2 change, and an 8 that became a 6 was also a +2 change, as both conformed to fading affect predictions. However a 6 that became a 7 was a -1 change because it did not conform. Consistent with fading affect bias, I found that negative memories changed more than positive memories, $t(126)=-3.91$, $p<.001$, $d=.70$ (Positive: MΔ=.45, SD=.63. Negative: MΔ=.98, SD=.86).

Hypothesis Testing

Hypothesis 1: Negative reflection when in a positive versus negative mood will reduce momentary mood.

For each reflection, there was a pre- and post-reflection mood probe. The difference between these scores was the change in mood, likely due to reflection. To assess Hypothesis 1, I ran an independent samples t-test comparing groups (Incongruent Negative vs. Congruent Negative) on the average change in mood rating (with negative scores representing a detriment to momentary mood). Negative reflection when in a positive versus negative mood affected mood differently, $t(62)=-5.24$, $p<.001$, $d=.89$ (Incongruent Negative: MΔ= -.53, SD= .53 , Congruent Negative: MΔ= .10, SD= .43). A one-sample t-test comparing average change in

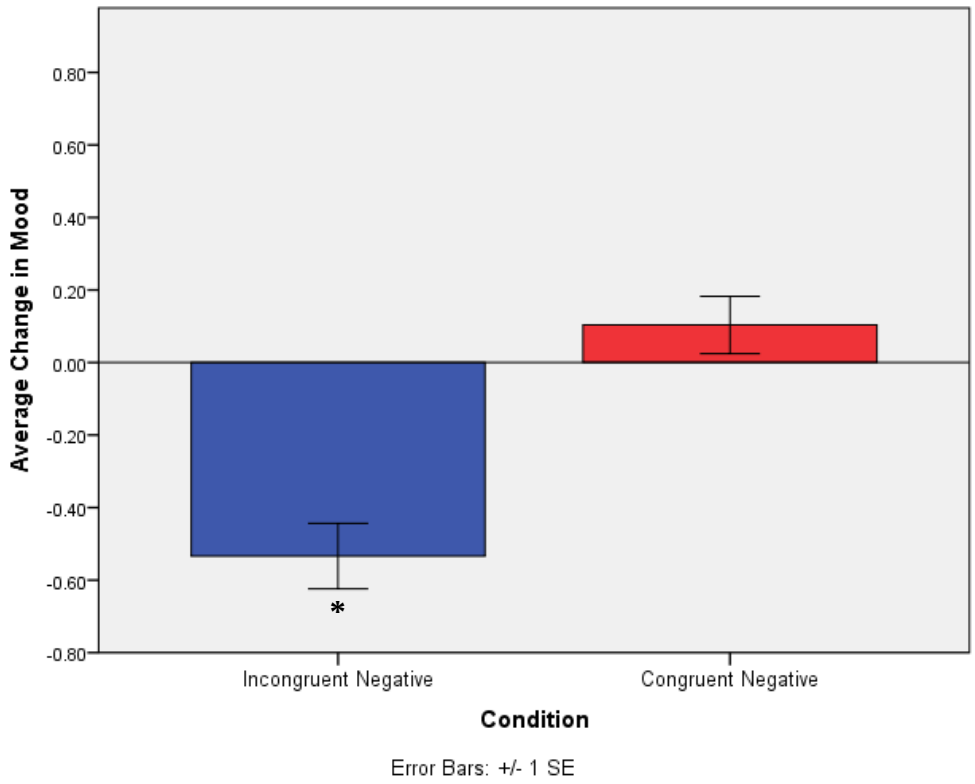

Figure 2. ***Average change in mood between pre versus post reflection mood probes for Incongruent Negative versus Congruent Negative groups, showing a significant reduction in mood after reflection for the Incongruent Negative group. Note: Significant findings are denoted by *.***

mood to 0 revealed that the reduction in mood experienced by the Incongruent Negative group was significant with a large effect size, $t(33)= -5.90$, $p<.001$, $d=1.01$ (see Figure 2). In contrast there were no significant mood changes in the Congruent Negative group, $t(29)=1.31$, $p=.20$. Hypothesis 1 was supported. In other words, reflecting on negative memories when in a positive mood reduces mood after reflection, whereas those in a negative mood showed unchanged mood.

We saw this contrast between Incongruent Negative and Congruent Negative in the exit interviews and participants' logfiles of memories and reflections. For

example, in her interview, this participant mentioned noticing how negative memories reduced her positive moods:

Incongruent Negative Exit Interview: *It was hard to be reminded of some of the negative memories that I selected… If I was a 6 [on the emotion scale] I noticed it would bring me down to like a 5.*

And we can also see examples of this in the logfiles, such as this participant who was in a positive mood, but reflected on a negative memory that resurfaced feelings of anger:

Incongruent Negative Initial Memory: *That bitch. She has no right to demand money from us when she hasn't done anything for this house. Does she not understand sunk costs?*

Incongruent Negative Reflection: *I really dislike her. So much. She was a terrible house mate and a terrible person* ***and it makes me angry just thinking about her***.

Whereas this participant who was already in a negative mood realized that negative reflection had no impact on her mood:

Congruent Negative Initial Memory: *On the way back from San Diego, there was some serious traffic on the road. When we were driving past the accident, I saw a body on the floor covered with a sheet…*

Congruent Negative Reflection: *That's still very sad, but I am preoccupied with the drama between [L] and I right now.* ***I don't think reflecting on this would make my emotions worse than they already are***.

Hypothesis 2: Negative reflection when in a positive versus negative mood will increase general well-being, through greater distancing, understanding, and redemption.

I assessed this hypothesis first by measuring general well-being changes, then exploring the predicted mechanisms by analyzing the content of memories and reflections. Survey data was analyzed using a mixed-design multivariate analysis of variance (MANOVA) with one between factor (Incongruent Negative vs. Congruent Negative) and one within factor (Time 1:Pretest vs. Time 2:Posttest). The dependent variables were the three well-being scales (SHS, SWLS, and RPWB). See Table 1 for the means and standard deviations for the well-being scales by group at Time 1 and Time 2. The MANOVA results showed no significant main effects for time (V=.03, F(3,64)=.54, p=.66) or condition (V=.02, F(3,64)=.41, p=.74), and no significant interaction effect (V=.02, F(3,64)=.47, p=.71). Because these overall effects were not significant, I did not follow-up with univariate ANOVAs or specific subscales of the RPWB.

However, some participants were rarely in a negative mood, reducing the average number of reflections completed for the Congruent Negative group, but increasing it for the Incongruent Negative group (Incongruent Negative: M=12.62, SD=2.43, Congruent Negative: M=6.97, SD=4.48). I therefore examined whether overall differences in number of reflections affected results. I anticipated this concern (based on my pilot data) by providing a more frequent reflection strategy for the negative mood groups so that they would be more likely to receive reflections when

Table 1. ***Means and standard deviations for three survey measures of well-being for Incongruent Negative versus Congruent Negative at Time 1 and Time 2. All scores are normalized to a 100 point scale.***

Well-being Survey		Incongruent Negative (n = 34) Time 1	Incongruent Negative (n = 34) Time 2	Congruent Negative (n = 34) Time 1	Congruent Negative (n = 34) Time 2
SHS	*Mean*	75.29	75.29	70.86	71.86
	Std Dev	17.71	17.00	17.57	14.00
SWLS	*Mean*	71.6	71.09	69.31	68.40
	Std Dev	17.33	17.23	18.86	19.34
RPWB	*Mean*	76.97	75.79	74.96	74.94
	Std Dev	11.43	11.38	10.42	9.94

the opportunity arose. I also planned a priori to remove atypical participants within each group that skewed the number of reflections. To do this, I computed the mean and standard deviation of both groups combined (Incongruent and Congruent Negative). I excluded Congruent Negative participants who completed fewer reflections than 1 standard deviation from the mean. Incongruent Negative participants who completed more reflections than 1 standard deviation from the mean were also removed. This removed the opposite tails of each group's distribution that fell outside of a standard deviation, providing greater homogeneity in number of reflections. An independent t-test comparing Incongruent Negative to Congruent Negative on the number of reflections showed that there were no differences in number of reflections after these participants were removed, $t(40)=1.62$, $p=.11$ (Incongruent Negative: $M=11.48$, $SD=2.15$, Congruent Negative: $M=10.26$, $SD=2.73$). I ran a follow-up MANOVA on the change in survey scores in the same

manner as above after removing the atypical reflectors. I again found no significant main effects or interactions.

This procedure for balancing number of reflections between groups was only employed when comparing group differences in survey scales and will be stated where applicable. This was because the survey scales were administered across time, measuring the cumulative effects of multiple reflections. In contrast, analyses that involved current mood included all participants since the change in current mood is a circumscribed event sensitive to one specific reflection. For the same reason, the linguistic analysis to examine mechanisms included all participants because it analyzed the percentage of certain types of words in reflections, irrespective of the number of reflections.

To investigate underlying mechanisms, for each memory and reflection I used Linguistic Inquiry Word Count (LIWC) to analyze words that related to known well-being mechanisms. LIWC is a widely used linguistic analysis tool that calculates the percentage of words used in different linguistic categories (Pennebaker, Booth, & Francis, 2007). It has good internal reliability and external validity (as compared with human judges) (Kahn, Tobin, Massey, & Anderson, 2007; Pennebaker et al., 2007; Pennebaker & Francis, 1996; Tausczik & Pennebaker, 2010). Although the LIWC dictionaries are able to measure up to 72 different linguistic categories, I focused here only on categories that directly concerned my hypotheses and that have been demonstrated to relate to emotional well-being in previous reflection studies. Specifically, I targeted word categories that provided evidence of distancing,

understanding, and redemption. Distancing was measured through usage of personal pronouns ('I', 'you', 'we') and tense (past, present, future) (Campbell & Pennebaker, 2003; Konrad et al., 2016). Understanding was measured through usage of insight words ('think', 'know', 'consider') and cognitive processes (e.g. 'cause', 'know', 'ought') (Klein & Boals, 2001; Petrie, Booth, Pennebaker, 1998). And redemption was measured through usage of affect words ('happy', 'joy', 'love') and indicators of acceptance ('ok', 'yes', 'agree') (Isaacs et al., 2013; Konrad et al., 2016).

First I compared the Incongruent Negative and Congruent Negative groups for differences in words used in their reflections. The Incongruent Negative group used a greater percentage of words indicating redemption such as acceptance words (e.g. 'ok', 'yes' and 'agree'), $t(49)=2.03$, $p=.048$, $d=.50$, using Levene's correction for heterogeneity of variance (Incongruent Negative: M= .19, SD= .30, Congruent Negative: M= .07, SD= .15). (Note that I used Levene's correction for all t-tests with unequal variances). The Incongruent Negative group also used a greater percentage of words indicating distancing such as third-person plural pronouns (e.g. 'they', 'their', and 'they'd'), $t(52.24)=3.01$, $p=.004$, $d=.74$ (Incongruent Negative: M= .73, SD= .71, Congruent Negative: M= .30, SD= .39). In contrast, the Congruent Negative group used a greater percentage of words demonstrating an inability to distance such as first-person plural pronouns (e.g. 'we', 'us', and 'our'), $t(43.05)=-2.07$, $p=.04$, $d=.53$ (Incongruent Negative: M= .43, SD= .56, Congruent Negative: M= .88, SD= 1.05). I also computed the change scores in the percentage of words used between the initial memory and its reflection. An independent t-test of these change scores again

revealed greater percentage increases in acceptance words for the Incongruent Negative group, $t(62)=2.08$, $p=.04$, $d=.53$ (Incongruent Negative: M= .12, SD= .27, Congruent Negative: M= -.01, SD= .22).

In the exit interviews, Incongruent Negative participants described experiencing redemption and distancing. For example, this participant discussed a key feature of redemption in seeing that she triumphed over past negative experiences:

Incongruent Negative Exit Interview: *I was able to look back at some of the memories and see* ***that I've gotten past it****.*

Redemption was a common occurrence in the logfiles of reflections as well:

Incongruent Negative Initial Memory: *I got a D on my last Econ 197 test. It's terrible, but I also know that most of the class is failing too. It's even worse because I am trying very hard.*

Incongruent Negative Reflection: ***It all turned out okay*** *and I got a good grade in the class. I am no longer worried as much and feel better!*

In their interviews, Incongruent Negative participants also discussed distancing from negative memories as a result of their positive moods:

Incongruent Negative Exit Interview: *I think that when I'm in a more positive state* ***I tend to distance myself from negative things*** *in order to stay in a positive state.*

Distancing was evident in their logfiles as well. For example, this person rates her initial memory as a 3 on the emotion scale, but her positive mood when reflecting distances her from the experience:

Incongruent Negative Initial Memory: *I hate it when there is a problem and someone is super passive aggressive about it. And she does it, ALL THE TIME. Like just come out and say what you need to say so we can at least attempt to solve the issue you know? I am only stubborn with certain things because I know I am right.*

Incongruent Negative Reflection: *It's my birthday so I am feeling really good tbh! So I don't really care about this,* ***it's in the past****, and its whatever! I was never really that upset about it anyway.*

Lastly, I examined how target word categories used in reflections correlated with responses to specific well-being scales. For the Incongruent Negative group, reductions in Satisfaction with Life were correlated with a greater percentage of words that convey negative emotion ('hurt', 'ugly', 'nasty'), $r(32)=-.38$, $p=.03$. In contrast for the Congruent Negative group, increases in Satisfaction with Life were correlated with percentage of past tense words, $r(28)=.38$, $p=.04$. Overall, although my well-being predictions for Hypothesis 2 were not supported, there was evidence of two predicted mechanisms (redemption and distancing).

Hypothesis 3: Negative reflection when in a positive versus negative mood will reduce rumination.

I ran an independent samples t-test comparing groups (Incongruent Negative vs. Congruent Negative) on the change in Ruminative Responses Scale scores from Time 1 to Time 2 (with negative scores representing a reduction in rumination). All participants were initially included. There were no significant group differences in the average change in rumination from Time 1 to Time 2, $t(66)=-.80$, $p=.43$ (Incongruent

Negative: M=1.38, SD=9.02, Congruent Negative: M=3.68, SD=14.12). Additionally, a one-sample t-test comparing average change in rumination to 0 for each group revealed that neither group experienced changes in rumination across time (Incongruent Negative: t(33)=.89, p=.38, Congruent Negative: t(33)=1.52, p=.14). Next I employed the same procedure as in Hypothesis 2 for removing atypical reflectors to homogenize the number of reflections. I found the same pattern of results that there were no significant group differences in rumination change, and neither group experienced changes across time. Hypothesis 3 was not supported.

Hypothesis 4*:* See Experiment 2.

Hypothesis 5*: Positive reflection when in a negative versus positive mood will increase momentary mood.*

Now I turn to an investigation of positive memories. Hypothesis 5 was tested in the same manner as Hypothesis 1. I ran an independent samples t-test comparing groups (Incongruent Positive vs. Congruent Positive) on the average change in mood scores (with negative scores representing a detriment to momentary mood). Positive reflection when in a negative versus positive mood affected mood differently, $t(38.7)=-5.39$, $p<.001$ (Incongruent Positive: MΔ= .75, SD= .65 , Congruent Positive: MΔ= .04, SD= .29). A one-sample t-test comparing average change in mood to 0 for each group revealed that the improvement in mood experienced by the Incongruent Positive group was significant with a large effect size, $t(28)=6.21$, $p<.001$, $d=1.15$ (see Figure 3). In contrast there were no significant mood changes in the Congruent Positive group, $t(29)=.70$, $p=.49$. Hypothesis 5 was supported. In other words people

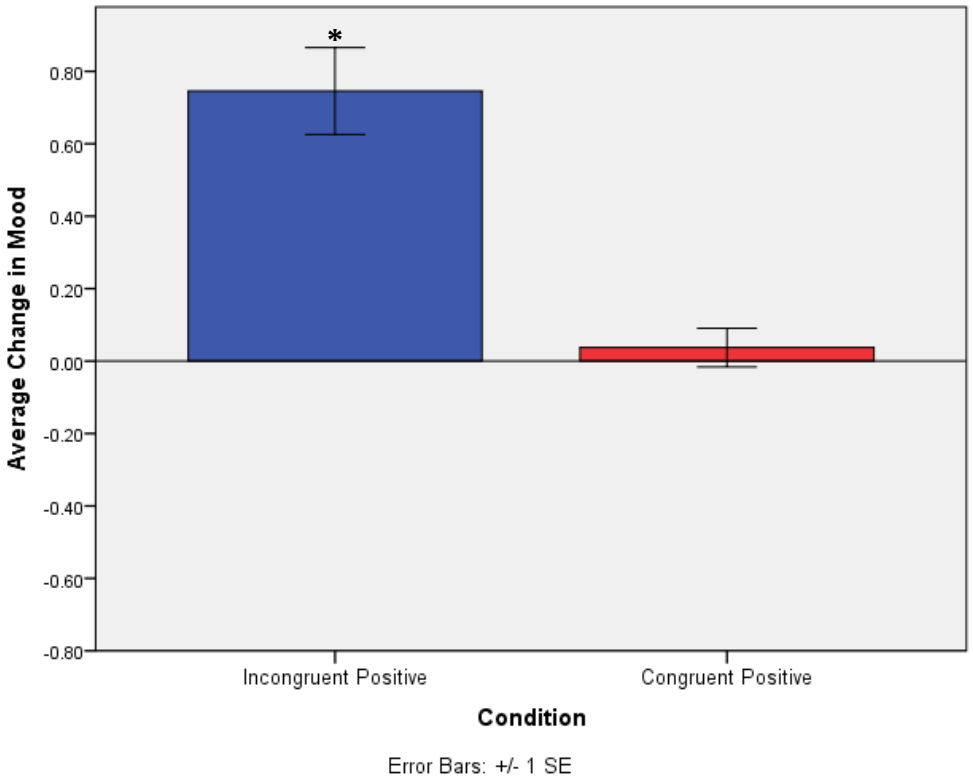

Figure 3. Average change in mood between pre versus post reflection mood probes for Incongruent Positive versus Congruent Positive groups, showing a significant increase in mood after reflection for the Incongruent Positive group. Note: Significant findings are denoted by *.

who reflected on positive memories when in a negative mood experienced improvements in mood after reflection, whereas those in a positive mood showed unchanged mood.

We see this contrast in the exit interviews and logfiles of memories and reflections. For example, positive reflection when in a negative mood provided mood-elevation for this participant:

Incongruent Positive Exit Interview: *I would be in a bad mood, I would be stressed at work, and you guys would surface something up that was really a bright*

spot for me and then instead of maybe a three, ***I would bump up to a four*** *[on the emotion scale]*.

Whereas this participant observed that positive reflection rarely had any impact on his positive moods:

Congruent Positive Exit Interview: *From the prompt before the reflection and the prompt after the reflection…* ***there were very few times that was different****.*

Lastly, here is a logfile example that illustrates the mood improvements for incongruency:

Incongruent Positive Initial Memory: *About once a month, my best friend [R] and I make the time to meet up and counsel each other. It's always very therapeutic to me and to him to discuss recent life events and try to work things out based on our experiences and what we know about each other…*

Incongruent Positive Reflection: *Taking time to reflect back on a positive experience* ***really can help improve your mood****. After reading this I thought about how what I'm annoyed about [in the current moment] doesn't really matter all that much…*

Hypothesis 6: Positive reflection when in a negative versus positive mood will reduce general well-being, through greater kill-joy thinking.

Survey data was analyzed using a mixed-design multivariate analysis of variance (MANOVA) with one between factor (Incongruent Positive vs. Congruent Positive) and one within factor (Time 1:Pretest vs. Time 2:Posttest). The dependent variables were the three well-being scales (SHS, SWLS, and RPWB). All

participants were initially included in this analysis. See Table 2 for the means and standard deviations for the well-being scales by group at Time 1 and Time 2. The MANOVA results showed no significant main effects for time (V=.07, F(3,56)=1.31, p=.28) or condition (V=.01, F(3,56)=.16, p=.93), and no significant interaction (V=.05, F(3,56)=.94, p=.43). Because these overall effects were not significant, I did not follow-up with univariate ANOVAs or specific subscales of the RPWB.

Some participants were rarely in a negative mood, leading to group differences in the number of reflections completed (Incongruent Positive: M=6.17, SD=4.25, Congruent Positive: M=11.87, SD=2.98). As for Hypothesis 2, I employed the same procedure to remove atypical reflectors. Participants in the Incongruent Positive group who completed fewer reflections than 1 standard deviation from the mean were removed from the following analysis. Participants in the Congruent Positive group who completed more reflections than 1 standard deviation from the mean were also removed. An independent t-test comparing Incongruent Positive to Congruent Positive on the number of reflections showed that there were no differences after these participants were removed, t(26.17)=1.28, p=.21 (Incongruent Positive: M=8.76, SD=3.88, Congruent Positive: M=10.16, SD=2.41). I ran a follow-up MANOVA on the change in survey scores in the same manner as above after removing the atypical reflectors. I again found no significant main effects or interactions.

Table 2. ***Means and standard deviations for three survey measures of well-being for Incongruent Positive versus Congruent Positive at Time 1 and Time 2. All scores are normalized to a 100 point scale.***

		Incongruent Positive (n = 30)		Congruent Positive (n = 30)	
Well-being Survey		**Time 1**	**Time 2**	**Time 1**	**Time 2**
SHS	*Mean*	73.14	74.57	77.43	75.14
	Std Dev	14.86	13.71	14.71	14.29
SWLS	*Mean*	68.29	70.86	70.00	72.86
	Std Dev	17.71	17.46	17.63	14.69
RPWB	*Mean*	75.26	76.09	77.13	77.04
	Std Dev	9.04	10.79	9.92	8.92

Once again, I used LIWC to dive deeper into mechanisms by examining word usage and well-being. First I compared group differences in words used in reflections. The Incongruent Positive group used a greater percentage of words conveying negative emotion than the Congruent Positive group, $t(40.15)=2.53$, $p=.02$, $d=.66$ (Incongruent Positive: M= 1.90, SD= 1.42, Congruent Positive: M= 1.16, SD= .69). I also computed change scores in the percentage of words used in the initial memory compared with its reflection. An independent t-test of these change scores revealed greater percentage increases in negative emotion words for those already in a negative mood, $t(41.06)=2.79$, $p=.01$, $d=.73$ (Incongruent Positive: M= 1.24, SD= 1.70, Congruent Positive: M= .26, SD= .86). This is evidence of kill-joy thinking whereby positive memories become tainted due to one's negative mood. I also examined how the language used in reflections correlated with responses to specific well-being scales. For the Incongruent Positive group, reductions in RPWB were correlated with

greater percentage of past tense words, $r(27)=-.45$, $p=.01$. There were no significant correlations for the Congruent Negative group. My well-being predictions for Hypothesis 6 were not supported, though there was evidence of the predicted kill-joy mechanisms.

In the exit interviews, Incongruent Positive participants described experiencing kill-joy thinking. For example, this participant described how negative moods influenced how he perceived positive memories:

Incongruent Positive Exit Interview: *[There's an] initial bias where if you're feeling really low it's hard to jump up and look at something with a clean slate or fresh eyes. So I think there's some natural spill over there.*

There were many examples of kill-joy thinking in the logfiles of reflections as well:

Incongruent Positive Initial Memory: *I just recently had a couple of people say that they wanted to [be] beta testers with my new coaching offering. Very excited that people like my idea and are willing to help me with it by being guinea pigs. I feel good knowing I am making a difference and I am having fun in the process, and it's something that people are interested in! Feel accomplished!*

Incongruent Positive Reflection: *Feeling a little like so what? A little sad about my abilities at the moment,* ***so that clouds my judgement****.*

Hypothesis 7: Positive reflection when in a negative versus positive mood will increase rumination.

I ran an independent samples t-test comparing groups (Incongruent Positive vs. Congruent Positive) on the change in Ruminative Responses Scale scores from Time 1 to Time 2 (with negative scores representing a reduction in rumination). There were no significant group differences in the average change in rumination from Time 1 to Time 2, t(58)=-.39, p=.70 (Incongruent Positive: M=-1.73, SD=10.72, Congruent Positive: M=-.67, SD=10.42). Additionally, a one-sample t-test comparing average change in rumination to 0 for each group revealed that neither group experienced changes in rumination across time (Incongruent Positive: t(29)=-.89, p=.38, Congruent Positive: t(29)=-.35, p=.73). Next I employed the same procedure as in Hypothesis 2 for removing atypical reflectors. I found the same pattern of results that there were no significant group differences in rumination change, and neither group experienced changes across time. Hypothesis 7 was not supported.

Hypothesis 8: See Experiment 2.

Discussion

In Experiment 1, I set out to test multiple hypotheses about the relationship between mood, reflection, and well-being using technology. For negative memories, I hypothesized that incongruent reflection would be more harmful for current mood than congruent reflection. But I also predicted that incongruent reflection would be more beneficial for general well-being and reduce rumination. I found that incongruent reflection was indeed more harmful for current mood, but I did not find evidence of overall changes or group differences in well-being or rumination.

Investigating the words used in memories and reflections uncovered some of the mechanisms underlying mood-reflection relationships. Negative reflection when in a positive mood seemed to encourage redemption (as indicated by acceptance words) and reduce self-focus (i.e. third-person plural pronouns) which may signal distancing from negative memories that involved other people.

Thus, as predicted I found evidence of redemption and distancing (though there was no evidence of greater understanding) when reflecting on negative memories in a positive mood. However, memories that resurfaced feelings of negativity (triggering negative emotion words in reflections) led to reductions in one well-being scale. It may be that a positive mood helps with adaptive processing of negative memories but only if the negativity of the memory doesn't outweigh one's currently positive outlook. This potential for the negativity of memories to overwhelm the positivity of one's current mood could be a driving force behind the reductions in mood this group experienced. In contrast, negative reflection when already in a negative mood seemed to discourage distancing (i.e. first-person plural pronouns) but this worked in participants' favor, as remaining focused on the past (i.e. past tense usage) was associated with increases in one well-being scale.

For positive memories, I hypothesized that incongruent reflection would have greater benefits for current mood than congruent reflection. But I also predicted a cost where incongruent reflection would be more harmful for general well-being and increase rumination. I found that incongruent reflection did improve current mood, but again there was no evidence of well-being or rumination changes or group

differences. Investigating the words used in memories and reflections revealed that negative moods induced greater kill-joy thinking (i.e. negative emotion words) about positive memories than for participants already in a positive mood. This was as predicted. It seems that reflecting on the positive past when in a negative mood may taint the memory, which can reduce one aspect of well-being if reflections are focused on the past (i.e. past tense usage). In other words, positive reflection when in a negative mood improves current mood, but at a cost to the positivity of the memory. Negative mood states may overshadow positive memories if we re-construe these memories through the lens of our currently negative perspective. This contrasts with negative memories which seem to benefit from past-focus reflections when in a negative mood state when there is no positivity to taint.

Experiment 2: Long Term Benefits

The primary goal of Experiment 2 was to assess whether additional well-being differences would emerge after time has passed from completing Experiment 1. Understanding these changes will give us a better idea of the timescale of potential mood-influences. I re-administered the survey instrument 3 months after stopping with MoodAdaptor because this is when Pennebaker et al. (1997) suggests the greatest benefits would be received and I wanted to allow enough time to pass to establish longer term benefits. I predicted the Incongruent Negative group would have increased well-being over the Congruent Negative group (Hypothesis 4). I also predicted the Incongruent Positive group would have reduced well-being over the Congruent Positive group (Hypothesis 8).

Method

Participants. The same participants from Experiment 1 were told in advance they could take the survey assessment 3 months after the 30 day intervention, and receive an additional $15 incentive for their time (plus any additional referral compensation). All 128 participants took the Time 3 survey.

Materials. This experiment used exactly the same scales as in Experiment 1.

Procedure. The scales were administered online one final time (Time 3), three months after the end of Experiment 1 (Time 2).

Results

Hypothesis 4: Negative reflection when in a positive versus negative mood will increase general well-being (following Hypothesis 2) and these increases will be even greater at Time 3 as compared to Time 2. In other words, well-being will be greater at Time 3 than Time 2 which will be less at Time 1.

Longevity of the well-being findings was analyzed using a MANOVA with one between factor (Incongruent Negative vs. Congruent Negative) and one within factor (Time 1:Pretest, Time 2:Posttest, Time 3:Follow-up). The dependent variables were the three validated measures (SHS, SWLS, and RPWB). See Table 3 for the means and standard deviations for the well-being scales by group at Time 1, Time 2, and Time 3. The MANOVA results showed no significant main effect for time (V=.07, F(6, 61)=.80, p=.57), or condition (V=.02, F(3, 64)=.36, p=.78), and no significant interaction (V=.07, F(6, 61)=.74, p=.62). I also ran a follow-up MANOVA after removing atypical reflectors. I found no significant main effects or

Table 3. ***Means and standard deviations for three survey measures of well-being for Incongruent Negative versus Congruent Negative at Time 1, Time 2, and Time 3. All scores are normalized to a 100 point scale.***

		Incongruent Negative			Congruent Negative		
			(*n* = 34)			(*n* = 34)	
Well-being Survey		Time 1	Time 2	Time 3	Time 1	Time 2	Time 3
SHS	*Mean*	75.29	75.29	74.14	70.86	71.86	72.43
	Std Dev	17.71	17.00	16.43	17.57	14.00	16.71
SWLS	*Mean*	71.6	71.09	72.60	69.31	68.40	67.97
	Std Dev	17.33	17.23	17.51	18.86	19.34	20.34
RPWB	*Mean*	76.97	75.79	75.08	74.96	74.94	74.24
	Std Dev	11.43	11.38	10.90	10.42	9.94	12.04

interactions. Hypothesis 4 was not supported.

Hypothesis 8: Positive reflection when in a negative versus positive mood will reduce general well-being (following Hypothesis 6) and these reductions will be even lesser at Time 3 as compared to Time 2. In other words, well-being will be less at Time 3 than Time 2 which will be greater at Time 1.

I ran a similar MANOVA to Hypothesis 4 except the groups were Incongruent Positive versus Congruent Positive. See Table 4 for the means and standard deviations for the well-being scales by group at Time 1, Time 2, and Time 3. The MANOVA results showed no significant main effects for time (V=.70, F(6, 53)=.67, p=.68) or condition (V=.01, F(3, 56)=.11, p=.95), and no significant interaction (V=.12, F(6, 53)=1.21, p=.32). I also ran a follow-up MANOVA after removing atypical reflectors. I found no significant main effects or interactions. Hypothesis 8 was not supported.

Table 4. ***Means and standard deviations for three survey measures of well-being for Incongruent Positive versus Congruent Positive at Time 1, Time 2, and Time 3. All scores are normalized to a 100 point scale.***

		Incongruent Positive			Congruent Positive		
			(*n* = 30)			(*n* = 30)	
Well-being Survey		Time 1	Time 2	Time 3	Time 1	Time 2	Time 3
SHS	*Mean*	73.14	74.57	76.00	77.43	75.14	74.86
	Std Dev	14.86	13.71	16.71	14.71	14.29	13.71
SWLS	*Mean*	68.29	70.86	70.37	70.00	72.86	73.51
	Std Dev	17.71	17.46	21.26	17.63	14.69	16.09
RPWB	*Mean*	75.26	76.09	76.37	77.13	77.04	77.31
	Std Dev	9.04	10.79	11.06	9.92	8.92	9.03

General Discussion

This thesis sought to address whether mood plays a critical role in mediating the relationship between reflection and well-being. I also examined how the memory valence during reflection influences one's current mood state. We know from prior literature that autobiographical memory enhances our positivity through well-documented self-enhancement biases (Conway & Pleydell-Pearce, 2000; D'Argembeau & Van der Linden, 2008; Mitchell et al., 1997; Walker et al., 2003). Our current mood also influences our memories by selecting events that are emotionally congruent (and sometimes incongruent) with our current mood (Bower, 1981; Erber & Erber, 1994). However, prior work has not addressed fundamental questions about how mood might influence reflection, and in turn how reflection might influence mood. Using MoodAdaptor I tested eight hypotheses and the results inform research and practice in both mediated and unmediated reflection. As

predicted, I found that incongruent reflection is useful for mood-regulation. Negative reflection when in a positive mood reduces one's current mood, while positive reflection when in a negative mood enhances it. This is consistent with prior work on unmediated memory showing that people sometimes select incongruent memories for mood-regulation (Erber & Erber, 1994; Parrott & Sabini, 1990; Rusting & DeHart, 2000). For example, Erber and Erber (1994) found that students were more likely to recall incongruent memories before class for more level-headedness, but reverted back to their mood-congruent default after class. The current paper makes a contribution to memory and emotion literature by showing that the mood-regulating effects of incongruency can be induced in mediated contexts, and identifying the mechanisms underlying these effects. Returning to the classroom example, students could benefit from natural incongruency before class, but maintain level-headedness or other desired mood-states after it by actively reflecting on incongruent memories. Thus while incongruent mood-regulation seems to occur naturally in rather limited contexts, there may be strategic opportunities with technology to apply this technique more broadly. Technology might provide control over when and how mood is regulated in ways that regular memory doesn't, i.e., people might receive targeted automatic prompts for positive reflection if they are in a negative mood.

This technique of structured incongruent reflection might benefit people seeking more equanimity in their moods. Always providing incongruent memories will move the extremes of mood closer to neutral, offering more balance. Mood-

regulation of both positive and negative moods is an adaptive cognitive skill that has been explored in depth (Gross, 1998; Masters, 1991; Parrott, 1993; Sutton, 1991; Tucker, Luu, & Pribram, 1995). For example, a bearer of bad news may downgrade their positive mood to be appropriate for delivering unwelcome news (Tesser, Rosen, & Waranch, 1973) And conversely, if delivering positive news they may elevate their negative mood to show reciprocal happiness for the recipient. TMR may aid these scenarios through strategic incongruent mood-regulation.

Should elevating mood be preferred to equanimity, such as to ameliorate depression or dysphoria, positive memories could be reflected on when in a negative mood for mood-enhancement. A couple of participants even mentioned this being useful for depression. For example, one participant told us that, "A lot of the memories had a theme of hope in them. I suffer from mild depression in general in my life and I think that the big part of my depression is hopelessness, and so seeing the hope … that was the aspect that I would say brought me up the most." Additionally, while mood-incongruent reflection on negative memories might be useful for mood-regulation, for mood-enhancement these could be reflected on when already in a negative mood (or not at all) so that positive moods are not impaired. I found that negative reflection when in a negative mood does not reduce current mood, and is associated with one aspect of well-being when reflections are past-focused.

However, this work suggests other important new implications that extend beyond simple mood adjustments. For example, I found that current mood affects how we *remember* past experiences, and in some cases can be associated with

improvements (or reductions) in well-being. I found evidence of predicted mechanisms previously shown to influence well-being in prior mood-agnostic unmediated reflection contexts (Campbell & Pennebaker, 2003; Petrie et al., 1998; Wildschut et al., 2006). For example, there was evidence of greater redemption and distancing for negative reflection when in a positive mood. Conversely, there was evidence of kill-joy thinking for positive reflection in a negative mood. However, an important new result is my demonstration that each of these incongruent reflection strategies had a cost, whereby negativity posed a threat to positivity and specific well-being aspects. For example, the Incongruent Negative group experienced greater redemption and distancing, but this did not improve general well-being, and in fact negative memories that overcame one's currently positive outlook were associated with reductions in one well-being scales. And although the Incongruent Positive group received a boost to their negative mood, this was at the cost of contaminating the positive memory, reducing one aspect of well-being if reflections were focused on this contaminated past. Thus while considering incongruent reflection as a strategy for mood-regulation, one must also consider possible consequences of negative moods and memories. Negative memories can reduce positive moods, and negative moods can contaminate positive memories. In other words, negativity can trigger kill-joy thinking in two ways: *Kill-joy memory*, and *kill-joy mood*. And both can detract from well-being.

While I predicted the Congruent Negative group would have trouble distancing themselves from memories (as compared to the Incongruent Negative

group), I was surprised that they also experienced increases in one of the well-being scales when their reflections were past-focused. Why then might it be adaptive to focus our reflections on the negative past when in a negative mood, rather than seeking to put distance between where we were then, and where we are now? A phenomenon called *depression realism* (Alloy & Abramson, 1979) might shed light on this finding, whereby those in a depressed mood are more likely to be accurate and realistic in their inferences. While the theory is not without criticism (Benassi & Mahler, 1985; Dunning & Story, 1991), support for it has been found in lab settings, naturalistic settings, and even brain imaging studies (Alloy & Abramson, 1979; Keller, Lipkus, & Rimer, 2002; Seidel et al., 2012). For example, those in a depressed mood are more accurate at estimating their risk of getting breast cancer than non-depressives (Keller et al., 2002). Because negative memories can represent a problem to be solved (Bohanek, Fivush, & Walker, 2005), it's possible that solutions are more accessible when a negative mood can provide an accurate outlook, contributing to well-being. Whereas a positive mood might provide a positively-biased perspective that interferes with problem-solving, or makes revisiting the negative past more challenging. There may be resistance to taking an honest inventory of the past to identify solutions if this is at the expense of reducing one's currently positive mood. A negative memory might be easier to work through if already in a negative mood where there is nothing left to lose.

This contrasts with studies that have found rumination, which is correlated with negative mood states (Nolen-Hoeksema, 1991), interferes with effective problem

solving because of a repetitive and passive focus on the symptoms of a distressing event, rather than devising solutions (Nolen-Hoeksema, 1991). Earlier I discussed an example of impaired problem solving where ruminators delayed reporting breast cancer symptoms to doctors two months longer than non-ruminators (Lyubomirsky et al., 2006). Thus while negative mood and rumination are correlated, the former might provide a more realistic outlook, while the latter might act as a blinder from seeing solutions. Furthermore, people who dispositionally ruminate may approach problem solving differently than those who are in a transient negative mood, as in this study. This juxtaposition is one area future research could explore more deeply.

There is also an alternative explanation for why focusing on past negative memories when in a negative mood was associated with increases in one of the well-being scales. It is possible that these memories served as distractors from the current situations that were causing a negative mood. When the negative memory was effective at taking one's mind off the present moment (as indicated by past tense words in reflections) this was associated with one aspect of well-being. However, when one was swept up in the drama of the moment, the negative memory failed as a distractor. The latter scenario was described in an exit interview by a participant who said negative memories "would come when I was in a bad mood so I was more focused on my present bad mood than my past." Interestingly, while positive memories might be thought of as exemplary distractors for negative moods (Nolen-Hoeksema, 1991), this group showed reductions in one of the well-being scales when

focused on the past. Thus the kill-joy aspects of the Incongruent Positive group seemed to outweigh any potential distractor benefits.

Also, unexpectedly, I did not find group differences or overall changes in well-being or rumination. This was the case across the 30 day intervention (from Time 1 to Time 2), as well as 3 months after the intervention at Time 3. And yet I did find evidence of redemption and distancing, two mechanisms shown in prior unmediated research to drive well-being and general health improvements (Campbell & Pennebaker 2003; Wildschut et al. 2006). I have also demonstrated in past studies with similar methodologies the well-being benefits of TMR (Isaacs et al., 2013; Konrad et al., 2016). Why then did I not find these changes in the current studies? There are at least two possibilities stemming from methodological differences.

First, my prior TMR studies had participants reflect more frequently, yielding 53.42 reflections each (Isaacs et al., 2013; Konrad et al., 2016) compared with 9.43 times in Experiment 1 of the current paper. My decision to reduce the number of reflections was motivated by my pilot study which showed people were comfortable writing up to 15 memories of each valence. Any more than that and participants felt they would need to write about memories that weren't recent, open, and emotional. I required memories to be recent to provide an opportunity for distancing, open so that they could benefit from greater understanding, and emotional to allow for redemption (or kill-joy thinking). Thus I was constrained by the limits of how many memories people could generate that fulfilled these requirements. Finding no overall well-being

changes in my current studies might result from participants experiencing fewer reflections compared with prior work.

My second methodological choice was for participants to generate a pool of memories at the start of the study, with some memories being selected later for reflection. In prior studies, participants recorded experiences as they occurred over the course of the study. This concurrent strategy yields a larger pool of memories that tend to be less emotional, since the window of time to capture emotional experiences is limited to the study length. For the current study, I needed memories that were clearly emotional, as mildly emotional memories might not evoke measurable effects. Thus, generating a memory pool at the start of the current studies was preferable, allowing participants to self-select highly emotional memories from their recent past. However, there are limitations with the current approach in that these past memories might be less open and recent than a memory that is recorded as it is happening. Yet I found evidence of redemption and distancing in reflections, which might suggest that memories were emotional and recent enough to undergo these changes. One reason why I did not find evidence of understanding (e.g. words that indicate insight and cognitive processing) might be that the pool contained memories that weren't still open enough to need further processing and insight. Enough understanding might have already been extracted from the memories before they had even been generated for the pool. Alternatively, the act of writing memories for the pool might itself have imposed a structuring to allow the event to be better understood *before* the intervention. For example, one participant mentioned in his exit interview that he

chose open events for the memory pool, but by the time they came back for reflection it was "like a closed deal and there wasn't much more to reflect on." Thus, not finding well-being changes in my studies could have been due to less exposure to memories, as well as memories that might not have been open enough for learning opportunities.

The current studies have other limitations as well. For example, caution must be taken when generalizing my findings to other TMR systems. There is a broad spectrum of different TMR systems such as those designed to be lightweight that don't require any writing (e.g. 1 Second Everyday, Facebook's Lookback videos, Timehop), those that are integrated with complex environments such as social media (e.g. Facebook's On This Day, Moodmill, PosiPost Me), as well as those that operate very similarly to MoodAdaptor (e.g. Echo, Pensieve). My findings speak to the mechanisms behind various mood-reflection relationships and their associations with well-being, though future research should confirm whether the same results hold in differing system environments.

The current work provides many new opportunities for future research. For example, a longer-term study could have participants record many experiences as they happen over a couple of months. This would generate a larger pool of memories that are recent so that participants are exposed to a greater number of reflections. Such a study would help resolve observed inconsistencies in well-being mechanisms

without well-being results, though at the risk of higher participant dropout due to an extended study length.

My work also suggests multiple interesting opportunities for redesigning current TMR systems to harness the influence of mood. For example, systems could strategically select specific types of memories to be reflected on when users are in particular moods. So, if the goal of Facebook's On This Day is to provide users with a small amount of enjoyment and upliftment, positive memories would likely be more effective when the user is in a negative mood. Current mood might be assessed by providing lightweight mood probes (as in Experiment 1) or algorithmically by analyzing affect words used in various online behaviors (Kramer et al., 2014). However, there may be a cost of kill-joy memory and reduced well-being if the user's reflection is past-focused. Now, when a user shares an On This Day memory, they are prompted to "Say something about this…" but this could be restructured to prompt a style of reflection that facilitates benefits while circumventing costs. For example, On This Day might prompt the user to think about how the memory applies to their life either currently or in the future, to help reduce devolvement into past-focused contamination.

If a TMR system resurfaces negative memories, users might receive a boost to their well-being if they are already in a negative mood and the system prompts reflections written in the past tense. When in a positive mood, if the system detects negative emotion words as the user reflects, it might intervene by encouraging greater distancing and redemption from negative memories so as to resist kill-joy mood, and

preserve well-being. This might be accomplished by encouraging writing in third person (for distancing) or prompting positive reappraisal (for redemption). Future research could uncover whether such structured prompts have the desired impact and how to do this subtly so as not to undermine the user's experience.

However, systems that select memories for negative moods shouldn't rely on this feature centrally. MoodAdaptor selected memories for negative moods more actively than positive moods, but the total frequency of such reflections was still low due to the sparsity of people's negative moods. Designing for negative moods is a challenge for normal populations, although Experiment 1 provides some insights for which memories to select when negative moods do occasionally occur. Additionally, there may be extreme cases where negative memories require a realistic outlook only accessible in a negative mood state for them to be fully processed. As with all mood-adapting TMR systems, short-term mood adjustments need to be carefully weighed against more general well-being effects.

Conclusion

By designing and deploying MoodAdaptor, I was able to answer theoretically-motivated questions about the relationship between mood, reflection and well-being when using technology. A systematic analysis of the words people used in their memories and reflections uncovered the mechanisms behind these relationships. My findings reveal a competition between positivity and negativity in our moods and memories, yielding adaptive mechanisms when positivity prevails, and contamination when negativity overshadows. This extends theories of well-being and opens up

exciting new opportunities for future research. Lastly, my findings provide new insights about how to design impactful TMR systems that harness mood.

Appendix

Four Survey Instruments

1. Subjective Happiness Scale (SHS)

For each of the following statements and/or questions, please circle the point on the scale that you feel is most appropriate in describing you.

1. In general, I consider myself:

1 2 3 4 5 6 7

Not a very happy person A very happy person

2. Compared to most of my peers, I consider myself:

1 2 3 4 5 6 7

Less happy More happy

3. Some people are generally very happy. They enjoy life regardless of what is going on, getting the most out of everything. To what extent does this characterization describe you?

1 2 3 4 5 6 7

Not at all A great deal

4. Some people are generally not very happy. Although they are not depressed, they never seem as happy as they might be. To what extent does this characterization describe you?

1 2 3 4 5 6 7

Not at all A great deal

2. Satisfaction With Life Scale (SWLS)

Below are five statements that you may agree or disagree with. Using the 1 - 7 scale below, indicate your agreement with each item by placing the appropriate number on the line preceding that item. Please be open and honest in your responding.

All responses are on a 1 to 7 scale with 1 being “strongly disagree” and 7 being “strong agree.”

1. In most ways my life is close to my ideal.

2. The conditions of my life are excellent.

3. I am satisfied with my life.

4. So far I have gotten the important things I want in life.

5. If I could live my life over, I would change almost nothing.

3. Ryff Scales of Psychological Well-Being (RPWB)

The following set of statements deals with how you might feel about yourself and your life. Please remember that there are neither right nor wrong answers. Circle the number that best describes the degree to which you agree or disagree with each statement.

All responses are on a 1 to 6 scale with 1 being "strongly disagree" and 7 being "strong agree."

1. Most people see me as loving and affectionate.

2. I am not afraid to voice my opinion, even when they are in opposition to the opinions of most people.

3. In general, I feel I am in charge of the situation in which I live.

4. I am not interested in activities that will expand my horizons.

5. I live life one day at a time and don't really think about the future.

6. When I look at the story of my life, I am pleased with how things have turned out.

7. Maintaining close relationships has been difficulty and frustrating for me.

8. My decisions are not usually influenced by what everyone else is doing.

9. The demands of everyday life often get me down.

10. I don't want to try new ways of doing things—my life is fine the way it is.

11. I tend to focus on the present, because the future always brings me problems.

12. In general, I feel confident and positive about myself.

13. I often feel lonely because I have few close friends with whom to share my concerns.

14. I tend to worry about what other people think of me.

15. I do not fit very well with the people and the community around me.

16. I think it is important to have new experiences that challenge how you think about yourself and the world.

17. My daily activities often seem trivial and unimportant to me.

18. I feel like many of the people I know have gotten more out of life than I have.

19. I enjoy personal and mutual conversations with family members or friends.

20. Being happy with myself is more important to me than having others approve of me.

21. I am quite good at managing the many responsibilities of my daily life.

22. When I think about it, I haven't really improved much as a person over the years.

23. I don't have a good sense of what it is I'm trying to accomplish in my life.

24. I like most aspects of my personality.

25. I don't have many people who want to listen when I need to talk.

26. I tend to be influenced by people with strong opinions.

27. I often feel overwhelmed by my responsibilities.

28. I have a sense that I have developed a lot as a person over time.

29. I used to set goals for myself, but that now seems a waste of time.

30. I made some mistakes in the past, but I feel that all in all everything has worked out for the best.

31. It seems to me that most other people have more friends than I do.

32. I have confidence in my opinions, even if they are contrary to the general consensus.

33. I generally do a good job of taking care of my personal finances and affairs.

34. I do not enjoy being in new situations that require me to change my old familiar ways of doing things.

35. I enjoy making plans for the future and working to make them a reality.

36. In many ways, I feel disappointed about my achievements in my life.

37. People would describe me as a giving person, willing to share my time with others.

38. It's difficult for me to voice my own opinions on controversial matters.

39. I am good at juggling my time so that I can fit everything in that needs to be done.

40. For me, life has been a continuous process of learning, changing, and growth.

41. I am an active person in carrying out the plans I set for myself.

42. My attitude about myself is probably not as positive as most people feel about themselves.

43. I have not experienced many warm and trusting relationships with others.

44. I often change my mind about decisions if my friends or family disagree.

45. I have difficulty arranging my life in a way that is satisfying to me.

46. I gave up trying to make big improvements or change in my life a long time ago.

47. Some people wander aimlessly through life, but I am not one of them.

48. The past has its ups and downs, but in general, I wouldn't want to change it.

49. I know that I can trust my friends, and they know they can trust me.

50. I judge myself by what I think is important, not by the values of what others think is important.

51. I have been able to build a home and a lifestyle for myself that is much to my liking.

52. There is truth to the saying that you can't teach an old dog new tricks.

53. I sometimes feel as if I've done all there is to do in life.

54. When I compare myself to friends and acquaintances, it makes me feel good about who I am.

4. Ruminative Responses Scale (RRS)

People think and do many different things when they feel depressed. Please read each of the items below and indicate whether you almost never, sometimes, often, or almost always think or do each one when you feel down, sad, or depressed. Please indicate what you *generally* do, not what you think you should do.

All responses are on a 1 to 4 scale with 1 being "almost never" and 4 being "almost always."

1. think about how alone you feel
2. think "I won't be able to do my job if I don't snap out of this"
3. think about your feelings of fatigue and achiness
4. think about how hard it is to concentrate
5. think "What am I doing to deserve this?"
6. think about how passive and unmotivated you feel.
7. analyze recent events to try to understand why you are depressed
8. think about how you don't seem to feel anything anymore
9. think "Why can't I get going?"
10. think "Why do I always react this way?"
11. go away by yourself and think about why you feel this way
12. write down what you are thinking about and analyze it
13. think about a recent situation, wishing it had gone better
14. think "I won't be able to concentrate if I keep feeling this way."

15. think “Why do I have problems other people don’t have?”

16. think “Why can’t I handle things better?”

17. think about how sad you feel.

18. think about all your shortcomings, failings, faults, mistakes

19. think about how you don’t feel up to doing anything

20. analyze your personality to try to understand why you are depressed

21. go someplace alone to think about your feelings

22. think about how angry you are with yourself

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