

# Time Perspectives in Technology-mediated Reminiscing: Effects of Basic Design Decisions on Subjective Well-being

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## Notes

**Background.** This article is based on two experimental vignette studies with 152 and 125 participants. It extends existing findings about technology-mediated reminiscing and relates reminiscence technologies with time perspective theory as well as measures of subjective well-being.

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# **Time Perspectives in Technology-mediated Reminiscing: Effects of Basic Design Decisions on Subjective Well-being**

**Running Head: Time Perspectives in Technology-mediated Reminiscing**

## **ABSTRACT**

Photographs, memorabilia, and digital “reminiscence technologies” highlight a certain part of our past and propose a way to interact with it. This central role of technology in shaping reminiscence has motivated researchers and designers to develop tools for pleasurable interactions with the past. Detailed accounts of specific reminiscence technologies exist, but a systematic comparison of different ways to reminisce and their effect on subjective well-being is still missing. Moreover, while it is widely acknowledged that personal memories are very personal, individual differences in positive or negative “time perspectives” on one’s past have not been researched in HCI yet. We present two comparative online studies (N = 152 and 125) about different modes of reminiscing and how they affect people with different time perspectives. Participants immersed in fictional reminiscing scenarios that we varied using the experimental vignette methodology. Overall, technology-mediation had a positive effect, especially for people with an unbalanced time perspective. Moreover, we found evidence indicating that the “rosy view” effect found in previous studies may be restricted to people with a balanced time perspective only. We close with specific design implications for different time perspectives and a call for more convergent research on remembering technologies.

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## 1. INTRODUCTION

Our life from today’s point of view can be understood as an elaborate story we tell ourselves. It is based on an abundance of past experiences and heavily influenced by the way we look back at them or what we believe they mean for our future. Given the overwhelming complexity of each experience, we have to focus on some aspects that we consider as most important and neglect others. This makes the question whether an experience was good or bad and our beliefs about which actions caused which effects fundamentally subjective and a vague approximation to the factual reality at best (Schneider, 2001). While this may seem like a human deficiency at first, it actually puts us in a powerful position. We do not need to simply accept our life story as the product of externally imposed circumstances, but we can take an active role in interpreting our experiences one way or another.

In their seminal article, Zimbardo & Boyd (1999) studied individual differences in this interpretative process of the personal past, present, and future, which they called “time perspectives”. Interestingly, they found people to have a relatively stable tendency to see their past, present, and future in a certain way. Some people tend to highlight the negative while others focus on the positive sides. These differences are associated with several other constructs. People with a strong negative perspective on the past also tend to be more aggressive, less self-confident, and have less impulse control. In contrast, people with a positive perspective on the past tend to be happier, more friendly, and more creative (Zimbardo & Boyd, 2008). It is important to note that these and later findings on time perspectives are mostly correlative, which means that we cannot say that the differences in perspectives on the past have *caused* differences in the other constructs. However, we see that these differences exist, that they are relatively stable over time, and that a more positive perspective is generally associated with more positivity in other aspects of life (e.g., Zimbardo & Boyd, 1999, 2008). In other words, the way we remember our past is linked with our present well-being.

Upon a closer look at how people engage with their past in their present everyday life, we find remembering practices to be embedded in the material surroundings. People set up their environment, whether consciously or not, as reflections of their personal history (Miller, 2008) and use physical and digital mementos to remember their past (Petrelli et al., 2008; van Gennip et al., 2015). This makes mementos central to our remembering practices. As a consequence, mementos have drawn the interest of Human-Computer Interaction (HCI) researchers and designers and led to a still growing body of literature on technology-mediated remembering (e.g., van den Hoven et al., 2012; van House & Churchill, 2008). These studies present detailed accounts of how individual users experience a specific remembering practice and study the impact of modality (including audio, image, and text; Mols et al., 2020), interaction patterns (Odom et al., 2020), or emotional valence of the remembered past experiences (e.g., Isaacs et al., 2013; Peesapati et al., 2010). However, individual differences in how people tend to construe their past (i.e., time perspectives), and how these differences may interact with different types of technologies to create positive or negative remembering experiences have not been studied yet.

The primary purpose of this article is to fill this gap by introducing time perspective theory to the field of technology-mediated remembering of personal experiences. We present two studies in which we compared the effects of basic design decisions for remembering technologies on users with different time perspectives. Given the variety of remembering processes (Sellen & Whittaker, 2010) and experiences that can be remembered, we set a more specific focus on technology-mediated *reminiscing* (i.e., a remembering process through which people “re-live past experiences for emotional or sentimental reasons”; Sellen & Whittaker,

2010), and on positive past experiences only. We chose reminiscing specifically, because previous research indicated that it can lead to short-term positive effects (Lyubomirsky et al., 2006; Westerhof et al., 2010). Thus, we expected that small differences in the design of a reminiscing technology would influence the reminiscing experience even after a short interaction. This allowed us to test multiple factors simultaneously. Furthermore, we restricted our studies to (subjectively) positive experiences, because we considered them as especially beneficial for reminiscing and as typical material for reminiscence technologies given their positive emotional value. In addition, this helped avoid negative side effects of our studies based on accidentally uncovered, possibly traumatic, experiences.

## **2. THEORETICAL BACKGROUND**

### **2.1. Time Perspective Theory**

Time perspective theory is a framework to describe how people evaluate past experiences, how they experience life in the moment, and how they look forward to their future. Zimbardo & Boyd (1999) developed a model with five temporal dimensions based on U.S. American samples that have later been replicated in over twenty different cultures (Reuschenbach et al., 2013; Sircova et al., 2014; Takahashi et al., 2013). The “past positive” dimension describes a nostalgic and positive attitude towards one’s past. “Past negative”, in contrast, is associated with negative rumination and a negative view on the past. For present experiences, Zimbardo & Boyd identified two further dimensions: “Present hedonistic” is associated with enjoyment of present experiences and “living in the moment”, while “present fatalistic” describes an attitude of resignation and the belief that one’s current actions have little effect on the future. The fifth dimension (“future”) measures optimistic planning for future achievements and considering future consequences of current actions.

For the past and present, there is one more positive and one more negative temporal dimension which could be understood as different ends of the same scale. However, all five dimensions are conceptually and statistically independent. This means that a person can have e.g., both a high past positive and a high past negative time perspective simultaneously, meaning that this person has a habit of both nostalgic remembering and negative rumination. In contrast, a person with low scores on both scales does not think about the past very often. The different dimensions formulated by time perspective theory are strongly associated with several health- and well-being-related constructs and behaviors. For example, a past positive time perspective is associated with higher levels of creativity, conscientiousness, and self-esteem. Past negative is associated with higher levels of aggression, lack of impulse control, and a positive attitude towards gambling. As a general pattern, lower past negative and higher past positive perspectives are associated with higher well-being (see Zimbardo & Boyd, 2008, for an extensive list of associated constructs).

In addition, Zimbardo & Boyd (1999) suggested the concept of a “balanced time perspective” as an optimal level of each time perspective with regards to psychological and physiological health as well as societal functioning. This includes lower values on the past negative and present fatalistic dimensions, and higher values on the past positive, present hedonistic, and future dimensions. However, different situations may demand different temporal foci, so they already suspected that extreme scores may not be optimal. For example, a present hedonistic perspective (“living in the moment”) can be appropriate at a party, but balancing it by not losing track entirely of future plans may be beneficial in the long run. In a later work, the “Deviation from a Balanced Time Perspective” (DBTP) scale has been introduced as a comprehensive measure for this balanced time perspective. It was developed based on previous data sets (Stolarski et al., 2011) and optimized to predict health and societal functioning. People with a low deviation from a balanced

time perspective tend to have higher well-being and are happier (Zhang et al., 2012). Gender differences in balanced time perspective have not been found in all but one study so far, but a tendency towards a less balanced time perspective was found in some studies with elderly participants (see Stolarski et al., 2020, for an overview).

In the context of technology-mediated remembering, time perspective theory can prove useful for several reasons. First, the associated questionnaire is a reliable and valid measure that can be integrated in HCI studies with little effort, e.g., through its online version (Zimbardo, 2020). This would help to put findings of technology-mediated remembering into the broader context of the general remembering habits of a participant, and to contrast them with other participants. Second, time perspective theory offers some approaches to change a person's time perspective towards the more desirable (in terms of well-being), balanced pattern (Boniwell et al., 2014; Sword et al., 2014). HCI research and design could adopt some of these methods and make them available in technologically enhanced ways. Third, the theory can bridge the gap between two common approaches to research on remembering technologies in HCI. On the one hand, detailed, qualitative research and studies based on a design research approach can account for individual differences in remembering. However, the results can become difficult to transfer to other contexts, because these differences remain unexplained. On the other hand, quantitative, controlled experimental studies provide more generalizable results but often neglect individual differences. Time perspective theory allows to account for individual differences while keeping experimental rigidity. And fourth, the theory may direct our attention on situations where remembering certain past experiences in a specific way could prove harmful for some participants but may be unproblematic for others. In these cases, different technologies could be developed for users with different time perspectives to avoid negative outcomes.

Taken together, time perspective theory provides a framework to describe the subjective dimensions of how people experience their past, present, and future. Balanced time perspective profiles are strongly associated with several health-related measures, such as happiness and well-being. HCI research on remembering technologies can profit from time perspective theory as an easy to integrate, individual profile of remembering habits, by a) using existing methods to develop more positive time perspective profiles, b) connecting different strands of research, and c) as an indicator for possibly harmful effects of technology-mediated remembering.

## **2.2. Positive Effects of Reminiscence**

We have previously defined reminiscing as a remembering process through which people “re-live past experiences for emotional or sentimental reasons” (based on Sellen & Whittaker, 2010). Conceptually, we think of it as a form of “mental time travel” (Quoidbach et al., 2010) that brings a past experience to the present in an immersive, emotional, and experiential way. This can be differentiated from “reflection”, which we understand as a complementary, more analytical remembering process (Baumer et al., 2014).

The major positive outcome of reminiscence is its contribution to “subjective well-being”. Subjective well-being has been defined as the frequent experience of positive affect, rare experience of negative affect, and high “life satisfaction” (Busseri, 2018; Diener et al., 1985; Martela & Sheldon, 2019). The increasing research on well-being in psychology since the 1980's was an attempt to complement the traditional focus on illnesses with a positive perspective (Seligman & Csikszentmihalyi, 2000). Its first two components, positive and negative affect, stand for immediate emotional consequences of being in the world. They are influenced by the degree of experienced psychological need fulfillment in everyday activities (Sheldon et al., 2001; Hassenzahl et al., 2010). While they may seem volatile, frequent experience of positive affect leads to more stable, long-term positive consequences such as increased sociability, strong physiological health, and

liking of self and others (Lyubomirsky et al., 2005). The third component of well-being, life satisfaction, is a global, subjective judgment of the quality of one's life (Diener et al., 1985). It is a more evaluative construct, sometimes also referred to as "cognitive well-being" (e.g., Quoidbach et al., 2010). Over the past decade, the notion of designing technology to support subjective well-being has received increasing attention in HCI research and design, broadening the idea of Experience Design into one of designing for well-being (Desmet & Pohlmeier, 2013; Hassenzahl, 2010, 2018; Klapperich et al., 2019).

Reminiscence is especially interesting as a means to improve affect. More specifically, reminiscing about positive experiences can lead to more positive affect (Lyubomirsky et al., 2006). This effect can be partially explained as a form of reliving psychological need fulfillment from the past experience (Houle & Philippe, 2017; Philippe & Bernard-Desrosiers, 2017). Moreover, people who reminisce habitually report more positive affect than others (Quoidbach et al., 2010). Consequently, reminiscence can be used as a tool in psychotherapy to reduce depressive symptoms (Bohlmeijer et al., 2003) and it is also used in the treatment of dementia, to mitigate sensory, motor, and cognitive impairments (Lazar et al., 2014).

As already mentioned, reflection complements reminiscence and delineates a conceptual boundary. This also transfers to their respective positive effects on subjective well-being. While reminiscing is a suitable process to improve affect, it is less suited to improve life satisfaction (Westerhof et al., 2010; Subramaniam & Woods, 2012). In contrast, reflection can lead to higher life satisfaction, but also reduces (positive and negative) affect (see Isaacs et al., 2013; Konrad, Isaacs, & Whittaker, 2016, for findings from an HCI context). Taken together, reminiscing about positive experiences has a positive effect on the short-term, affective component of subjective well-being, but unlike reflection it does not improve life satisfaction.

### **2.3. Reminiscence Technologies**

The impact of technology-mediated reminiscence on subjective well-being has not been measured so far, although the goal to support well-being has motivated a few earlier studies (e.g., Caprani et al., 2005; van Gennip et al., 2015; Wei et al., 2019). However, several different types of memory and forms of interacting with them have been studied that we will outline here.

Pensieve (Cosley et al., 2009, 2012; Peesapati et al., 2010) is a reminiscence technology based on email. A central design goal for Pensieve was to integrate it smoothly into everyday life. To that end, it sent memory triggers in unexpected moments as a way to provoke natural ways of reminiscing. The triggers contained personalized but also generic photos and short texts. Moreover, Pensieve contained a diary function, allowing users to write about their memories. A second version of Pensieve was integrated in a facebook app. In contrast to the first version, it required users to intentionally engage with the app to reminisce (rather than having memories triggered externally). The analysis of the 5 months study was primarily qualitative, and additional linguistic data from the diary entries revealed that they tended to be more positive than negative, on average. This was mirrored by a follow-up questionnaire where people indicated that Pensieve generally improved their mood. However, some of the text-based memory triggers elicited negative memories and emotions. An additional analysis compared the two different versions of Pensieve (email versus facebook app). The facebook app was used less often, which could have been caused by the differences in the "trigger", but also because of other differences between the two versions (e.g., degree of personalized content, different interfaces). Thus, although the incidental reminiscing worked, a clear recommendation for or against spontaneous memory triggers cannot be made.

MUSE is a different email-based reminiscence technology (Hangal et al., 2011). Unlike Pensieve, MUSE uses content from the personal email archive as material for reminiscing, instead of using (external) photo collections and memory triggers. Another difference is that it is meant to be used intentionally by launching

a program, thus contrasting the incidental reminiscing in Pensieve’s email version. MUSE allows to browse through emails arranged by social groups, content tags, automatic sentiment cues, and attached pictures. The preliminary user study indicated that MUSE can help rediscover forgotten memories and reassert users of a general positive conduct of their lives. It was also useful as a reminder for renewing relationships with people one has lost contact with. Overall, experiences with MUSE were positive as well.

In relation to the decision for spontaneous or intentional reminiscing, van Gennip et al. (2015) studied different types of cues that elicit “involuntary” memories. In a diary study, people were asked to note cues that reminded them of their past, which later served as material for a follow-up interview. They found that spontaneous reminiscing was mostly triggered by non-digital cues (e.g., locations, food), although this may in part be because participants understood e.g., “browsing digital photo collections” as an intentional trigger, as the authors remark. Furthermore, they argue that timing, media type and the specific presentation should be considered for reminiscence technologies. All in all, based on the three studies outlined above it still remains unclear whether reminiscing is best promoted proactively by technology or should be used intentionally.

A second aspect that fundamentally shapes the reminiscing experience concerns the selection of past experiences. Pensieve, MUSE, and several other systems (e.g., Chen et al., 2019; Odom et al., 2012, 2020) draw their content from existing digital archives, such as photo collections or music listening history. These archives can contain prompts for a wide range of past experiences that differ in their temporal dimension (long time ago to recent), and personal importance, as well as in valence. In other projects, new data is recorded for later reminiscing (e.g., Petrelli et al., 2010; Wei et al., 2019). The content can impact remembering in different ways. For example, in unmediated, autobiographical remembering, emotional intensity of an experience and its importance for one’s current goals are central factors that influence the ability to remember them (Conway & Pleydell-Pearce, 2000). This “filter” is changed when using personal archives with possible consequences for the reminiscing experience.

The exploration of subjective value of different digital memory cues inspired the provocative design of the Reflexive Printer (Lee et al., 2014; Tsai et al., 2014). It randomly prints out photos and then deletes them from the digital archive. Users then have to decide whether to keep them or not (and, with the photo, a potential memory trigger). Other projects explored ways to let the user browse through existing material, e.g., based on different temporal frames (Chen et al., 2019; Odom et al., 2020). Yet another approach is to use algorithms to select appropriate material to display, as studied in digital photography (e.g., Ceroni et al., 2015; Kuzovkin et al., 2018). While these studies indicate that the choice of material and memory cues is important for reminiscing, recommendations based on effects of different materials on subjective well-being are still missing.

Finally, the question whether technology-mediation is appropriate for reminiscing in the first place has not been studied yet. The several previous studies outlined above indicate that reminiscence technologies can have positive effects. However, Bryant et al. (2005) compared reminiscence based on cognitive imagery (unmediated) and reminiscence with a memorabilia (mediated) and found that *both* practices led to increased happiness. In their setup, the memorabilia had been non-interactive objects. In contrast, a study on technology-mediated *reflection* (Konrad, Isaacs, & Whittaker, 2016) found a positive effect of mediated, compared with unmediated, reflection. Thus, whether reminiscing benefits at all from technology-mediation compared with unmediated forms remains open.

Taken together, reminiscence technologies, in contrast to reflection technologies, often target a more spontaneous, passing remembering practice (Peesapati et al., 2010; Tsai et al., 2013; van Gennip et al., 2015). However, their relation to subjective well-being has not been studied systematically yet. Moreover, the impact of different modes of reminiscence, such as incidental or intentional reminiscing, and the influence



of different past experiences on people with different time perspectives has not been studied yet. In the following, we present two studies to further explore these open questions.

### 3. STUDY 1: TECHNOLOGY-MEDIATED REMINISCING

In our first study, we asked our participants to reminisce in an imagined scenario for which we systematically varied the configuration of the situation to explore the open questions outlined above. As a first factor, we compared mediated and unmediated reminiscing. The overall impact of technology-mediation has not been studied for reminiscence technologies yet, but a positive effect of mediation was found for *reflection* technologies (Konrad, Isaacs, & Whittaker, 2016). For reminiscence technologies, such a comparison is still missing. Second, we varied two types of “triggers” for reminiscing. This was a central design decisions in previous studies, but a clear recommendation for either intentional or incidental reminiscing cannot be made yet (Peesapati et al., 2010; Hangal et al., 2011). Third, the type of past experiences included in reminiscence technologies in previous studies were mostly determined by the existing material. From research about autobiographical memory we know that remembering is strongly influenced by the type of past experience, especially its emotional intensity and personal relevance (Conway & Pleydell-Pearce, 2000; Conway et al., 2019). Thus, to account for differences between memory content, we varied between two different types of past experiences: The happiest memory of one’s “entire life” (emotionally intense and personally relevant) and of one’s “past week” (less intense and less relevant). Fourth, we measured time perspective profiles (Zimbardo & Boyd, 1999) to assess their effect on using remembering technologies, which has not been studied yet. Finally, based on previous findings (Westerhof et al., 2010), we expected effects of reminiscing on immediate positive and negative affect, but less on general life satisfaction. In sum, our hypotheses for Study 1 were:

- H1:** Technology-mediated reminiscing leads to more positive affect than unmediated reminiscing (based on Isaacs et al., 2013).
- H2:** Technologies supporting spontaneous, externally triggered reminiscing lead to more positive affect than those requiring intentional interaction (based on Peesapati et al., 2010).
- H3a:** Reminiscing about more intense positive experiences leads to more positive affect than reminiscing about less intense positive experiences (based on Houle & Philippe, 2017).
- H3b:** Psychological need fulfillment is higher for more intense positive experiences than for less intense positive experiences (based on Houle & Philippe, 2017).
- H4:** Participants with a more balanced past time perspective experience more positive affect during reminiscing about positive experiences than participants with a less balanced past time perspective (based on Zimbardo & Boyd, 1999).

#### 3.1. Participants

Participants were recruited through student mailing lists at several universities in Germany as well as through social media, and provided with a link to the online study hosted on SurveyMonkey.com. We chose this recruiting method because it allowed us to access a relatively large sample although we could only offer a small compensation (the research was conducted as an unfunded project). In addition, we had no specific hypotheses concerning different demographic groups in using reminiscing technologies, so we considered

this method appropriate. One hundred and seventy six people started participating. We filtered out incomplete cases, leaving 152 complete replies. Out of the 152 participants, 125 (82%) identified as female, 25 (17%) as male, and 2 (1%) as “other/no reply”. The median age was 23.5 ( $Min = 19$ ,  $Max = 56$ ). Seventy-five (49%) participants had finished high school, 44 (29%) had finished undergraduate studies, and 20 (13%) had finished their Masters or Diploma. Nine (6%) had finished a professional training, 3 (2%) a PhD, and 1 participant (1%) had a general certificate of secondary education.

### 3.2. Material and Methods

We conducted our experimental online study in May 2018. On the welcome page, participants were informed that the data were anonymized before analysis and that they could abort the study at any time. Moreover, they were also informed about a raffle for a 30 € voucher in which they could participate. Finally, we informed them that the study would take around 15 minutes to complete.

This was followed by the past positive and past negative scales of the Zimbardo Time Perspective Inventory (ZTPI, Zimbardo & Boyd, 1999) in a German translation by Reuschenbach et al. (2013). The ZTPI is the central questionnaire in studies on time perspective theory and is used as a measure of individual differences in time perspectives. The German adaptation differs slightly in that a few items have been reassigned between the dimensions to improve reliability (e.g., an item from the past negative scale has been moved to the past positive scale based on its connotation after translation). We included all items necessary to calculate both the original and the adapted variants, so that the questionnaire consisted of 25 items in total. The order of the items in this and all following questionnaires was randomized between participants. Internal consistencies of the original variant (past positive: *Cronbach's*  $\alpha = .36$ , past negative: *Cronbach's*  $\alpha = .81$ ) was lower than for the adapted one in the German translation (past positive: *Cronbach's*  $\alpha = .62$ , past negative: *Cronbach's*  $\alpha = .82$ ). Thus, we proceeded with the adapted version. We excluded items until we reached an acceptable (Nunnally, 1975) internal consistency above *Cronbach's*  $\alpha = .70$  (see Table 1 for an overview of intercorrelations and internal consistencies of all measures used in Study 1). The stepwise item exclusion process is described in Appendix A1.

Following the ZTPI, participants were randomly assigned to one of two conditions. Either they were asked to describe the happiest memory of their entire life or the happiest memory of the past week. We also asked them to briefly describe why it is their happiest memory. We expected the happiest memory of the entire life to be more emotionally intense than the happiest memory from the past week (see H3) and assumed that it has played a more important role in their lives. Thus, we included two items to characterize the memories. First, we asked participants “How joyful was this experience?” on a 10 point scale ranging from 1 (“not joyful”) to 10 (“extremely joyful”), and second “How important was this experience for your life?” on a scale ranging from 1 (“not at all important”) to 10 (“very important”).

The Experimental Vignette Methodology (EVM, Aguinis & Bradley, 2014; Atzmüller & Steiner, 2010) formed the core of our study. EVM allows for experimental rigidity in fictional but immersive usage scenarios. It typically includes short descriptions of a situation and its context factors in text form. In these descriptions or “vignettes”, the experimenter can vary certain aspects to measure their distinct influence on the judgments or experiences of the participants. It is often used in social science and psychological research to study attitudes, beliefs, or behavior (e.g., Aguinis & Bradley, 2014; Tversky & Kahneman, 1981), and it has also been used in more recent HCI research (e.g., Krawczyk et al., 2019; Uhde et al., 2020).

We chose EVM for the present study for several reasons. First, by using imagined scenarios, EVM does not restrict participants to reminisce about memories for which material is available. This allowed participants to more freely choose a memory appropriate to their assigned condition, rather than selecting

Measure	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Positive Affect	(.89)													
2. Negative Affect	-.18*	(.88)												
3. Affect Balance	.88**	-.62**	(-)											
4. Autonomy	.65**	-.09	.56**	(.82)										
5. Competence	.60**	-.13	.54**	.74**	(.83)									
6. Relatedness	.49**	-.12	.45**	.48**	.39**	(.93)								
7. Stimulation	.63**	-.04	.53**	.64**	.46**	.53**	(.79)							
8. Security	.48**	-.13	.44**	.62**	.59**	.45**	.44**	(.64)						
9. Popularity	.53**	-.04	.44**	.70**	.63**	.44**	.54**	.56**	(.79)					
10. SHS	.28**	-.08	.27**	.33**	.34**	.24**	.18*	.16*	.34**	(.84)				
11. SWLS	.35**	-.13	.34**	.28**	.40**	.33**	.20*	.30**	.28**	.67**	(.84)			
12. Past Positive	.18*	-.15	.21**	.17*	.16*	.30**	.19*	.21*	.22**	.21*	.34**	(.72)		
13. Past Negative	-.19*	.25**	-.27**	-.08	-.12	-.12	-.04	-.14	-.06	-.48**	-.56**	-.12	(.82)	
14. DBTP	-.21**	.26**	-.30**	-.12	-.15	-.29**	-.16*	-.24**	-.19*	-.38**	-.54**	-.77**	.67**	(-)

**Table 1.** Intercorrelations of all measures used in Study 1. The diagonal line (in brackets) shows the internal consistencies measured with Cronbach’s alpha. SHS = “Subjective Happiness Scale”; SWLS = “Satisfaction With Life Scale”; DBTP = “Deviation from Balanced Time Perspective”

from an already restricted personal photo or audio archive. Second, it allowed us to include unmediated reminiscing scenarios in a comparable way, which can be difficult when using physical prototypes or apps. Third, we were interested in the effect of a specific arrangement of mediation, trigger, memory type, and time perspective profile in a single instance of reminiscing. As outlined above, reminiscing mainly addresses the short-term, affective well-being (Westerhof et al., 2010). Physical prototypes, in contrast, are often used for studying longer-term effects through repeated use, which justifies the high costs for preparing them. And fourth, EVM allowed us to reach a relatively large sample, which is necessary for systematically comparing individual differences in time perspectives. Naturally, we are aware that imagined interaction is not the same as real interaction. But for our goal to systematically compare different modes of reminiscing and to complement findings from previous studies, EVM was a viable choice.

For the different experimental conditions, we created four vignettes that differed in the factors “mediation” (technology-mediated vs. unmediated reminiscing) and trigger (“external trigger” vs. “intentional reminiscing”). Moreover, the scenarios either referred to the event from participants’ entire life or from the past week (see Appendix A2 for all vignettes). As an example, the vignette for “technology-mediated” and “externally triggered” reminiscing was:

*You are sitting at your work place around noon and do a lot of paper work. Probably this work will last for the rest of the day. You take your smartphone out briefly and you see a reminder of your new “memory trace” app, suggesting you take a short break. With this app you can look at nice events from your life. You click “start” and it shows you some images from the experience you have just described. While you browse through the images, you feel vividly put back into the situation, with all its facets. After you have stayed in this memory for long enough, you put your smartphone aside and continue your work.*

When constructing the vignettes, we paid attention to several context factors. First, the scenario should be realistic for most participants. We referred to earlier work by Bryant et al. (2005), who reported that reminiscing often happens when people are bored and want to “escape the present”. The abstract “work place” and “paper work” include typical activities of office workers, but can also be read more broadly to include common activities such as writing a tax return or other household paper work. Moreover, we selected

smartphones as a widespread technology to avoid that people are not familiar with the type of technology itself. No other individuals played a role in the vignettes. Following the vignette, we asked participants how well they could immerse into that situation on a 7-point scale from 1 (“not at all”) to 7 (“very well”), as is common practice in EVM. The average immersiveness of the vignettes was high ( $M = 5.78$ ,  $SD = 1.08$ ).

Next, we included the Positive and Negative Affect Schedule (PANAS, Watson et al., 1988) in a German translation (Krohne et al., 1996) as a measure for situated affect. The PANAS measures positive and negative affect with 20 attributes. The positive attributes include, for example, “interested”, “excited”, and “proud”; the negative attributes include “upset”, “scared”, and “afraid”. Participants were asked to rate how well each of these attributes described their feelings in the situation at the work place, on a 5-point scale ranging from 1 (“not at all”) to 5 (“extremely”). Internal consistencies of both scales were good (see Table 1). Consequently, we calculated a scale value for positive affect (PA) as the average of all ten positive attributes and a scale value for negative affect (NA) as the average of all ten negative attributes per participant.

To measure psychological need fulfillment, we included the need satisfaction scales (Sheldon et al., 2001) in a German translation (Diefenbach & Hassenzahl, 2010). More specifically, we included the scales for the six psychological needs previously found to be particularly relevant for interactive technologies (Hassenzahl et al., 2010, 2015), i.e., relatedness, competence, autonomy, stimulation, security, and popularity. Each need was measured with three items and we asked participants how they felt at their work place in the scenario. An example item for relatedness is: “I felt ... close to people who are important to me.” Answers could be given on a 5-point scale ranging from 1 (“not at all”) to 5 (“extremely”). Internal consistencies were sufficient for all but the security scale. Here, item exclusion could not be used to increase internal consistency (*Cronbach's*  $\alpha = .64$ ). We calculated a scale value for each need as the average of the three respective items.

This was followed by the Satisfaction With Life Scale (SWLS, Diener et al., 1985) in a German translation by Schumacher (2003). The SWLS is a measure of life satisfaction and contains five items, such as “In most ways my life is close to my ideal”. Participants could answer on a 7-point scale ranging from 1 (“strongly disagree”) to 7 (“strongly agree”). Internal consistency was good (*Cronbach's*  $\alpha = .84$ ).

Next, we included the Subjective Happiness Scale (SHS, Lyubomirsky & Lepper, 1999) in a German translation (Swami et al., 2009) as a measure of happiness. The SHS consists of four items measuring general happiness on item-specific 7-point scales. For instance, one item is “In general, I consider myself: 1 (“not a very happy person”) to 7 (“a very happy person”)”. Happiness is a construct related to subjective well-being (“a global, subjective assessment of whether one is a happy or unhappy person”, Lyubomirsky & Lepper, 1999). Both the SWLS and SHS were included mainly to provide a comprehensive measure for subjective well-being and to make the results comparable with earlier studies on reflection technologies (Isaacs et al., 2013; Konrad, Isaacs, & Whittaker, 2016; Konrad, Tucker, et al., 2016). For the SHS, internal consistency was good as well (*Cronbach's*  $\alpha = .84$ ).

Finally, we collected demographic data (age, gender, education) and asked participants to leave their email address in case they wanted to participate in the raffle.

We further processed the measures for the main analysis. First, we created a compound measure of affect balance by subtracting negative affect from positive affect. This served as our measure for situational overall affect. Second, we summarized the time perspective scores with the Deviation from Balanced Time Perspective measure (DBTP, Stolarski et al., 2011). This is the recommended measure for well-being related studies on time perspectives (Zhang et al., 2012). It is the geometric mean of the deviation of an individual score from an optimal score (optimal in terms of psychological and physiological health as well as societal functioning, Zimbardo & Boyd, 1999; Stolarski et al., 2011). A smaller deviation (smaller value) relates to higher well-being. Given that we had only measured the past positive and past negative scales (no present

Measure	Overall			"low DBTP"			"high DBTP"		
	M	SD	95% CI	M	SD	Range	M	SD	Range
Positive Affect	3.23	0.81	[3.10, 3.36]	3.44	0.72	[1.90, 5.00]	3.01	0.85	[1.30, 4.30]
Negative Affect	1.32	0.48	[1.24, 1.40]	1.23	0.34	[1.00, 2.90]	1.42	0.58	[1.00, 3.80]
Affect Balance	1.90	1.02	[1.74, 2.06]	2.21	0.84	[0.10, 4.00]	1.60	1.09	[-1.50, 3.30]
Autonomy	3.33	0.98	[3.17, 3.49]	3.47	0.92	[1.00, 5.00]	3.19	1.02	[1.00, 5.00]
Competence	3.38	1.04	[3.21, 3.55]	3.57	0.98	[1.33, 5.00]	3.19	1.07	[1.33, 5.00]
Relatedness	3.77	1.22	[3.58, 3.96]	4.09	1.09	[1.00, 5.00]	3.46	1.26	[1.00, 5.00]
Stimulation	3.16	1.11	[2.98, 3.34]	3.40	1.09	[1.33, 5.00]	2.93	1.08	[1.00, 5.00]
Security	3.13	0.92	[2.98, 3.28]	3.32	0.90	[1.00, 5.00]	2.95	0.91	[1.00, 5.00]
Popularity	2.88	1.00	[2.72, 3.04]	3.07	0.96	[1.00, 5.00]	2.69	1.01	[1.00, 4.67]
SWLS	5.12	1.08	[4.95, 5.29]	5.68	0.70	[3.60, 7.00]	4.57	1.12	[1.80, 6.60]
SHS	4.74	1.30	[4.53, 4.95]	5.24	0.96	[3.60, 7.00]	4.25	1.40	[1.25, 7.00]
Past Positive	3.79	0.56	[3.70, 3.88]	4.11	0.32	[3.67, 4.89]	3.47	0.56	[2.00, 4.56]
Past Negative	2.70	0.54	[2.61, 2.79]	2.37	0.39	[1.36, 3.00]	3.01	0.48	[2.00, 4.09]
Immersiveness	5.78	1.08	[5.61, 5.95]	5.99	0.97	[3, 7]	5.58	1.15	[2, 7]
Happiness	8.98	1.08	[8.81, 9.15]	9.20	0.92	[7, 10]	8.80	1.18	[5, 10]
Importance	7.11	2.48	[6.72, 7.50]	7.11	2.33	[1, 10]	7.12	2.62	[1, 10]
Age	24.65	4.85	[23.88, 25.42]	24.57	5.11	[19, 56]	24.73	4.62	[19, 43]

**Table 2.** Summary statistics of Study 1, overall and for the two levels of the median split. M = "Mean"; SD = "Standard Deviation"; CI = "Confidence Interval"; DBTP = "Deviation from Balanced Time Perspective"; SWLS = "Satisfaction With Life Scale"; SHS = "Subjective Happiness Scale"

or future scales), we calculated the DBTP only based on the two scales available. After calculating a DBTP score for each participant, we divided them in two groups via median split for quasi-experimental analysis. Participants with a small DBTP have a more positive and less negative past time perspective. In the following, we will refer to them as past positive (PP) participants. In contrast, participants with a large DBTP will be referred to as past negative (PN) participants. We verified statistical independence of the median split factor from the other experimental factors (Iacobucci et al., 2015) using Chi-squared tests. Moreover, we also checked for equal gender balance between the two groups using Fisher's exact test and found no difference (see Appendix A3 for all test results). Summary statistics for the overall sample and the two DBTP groups can be found in Table 2.

### 3.3. Results

#### Memories

We begin the presentation of results by characterizing the memories our participants reported. Sixty-six participants were asked to describe the most positive memory of their entire life and 86 were asked to describe the most positive memory of the past week.

We summarized the qualitative descriptions of the experiences in two ways. First, one coder developed inductive categories of the type of memory described. A second coder then used the same categories and independently assigned the experiences to them. Multiple coding was allowed. Inter-rater reliability was good (Krippendorff's  $\alpha = .80$ ). Remaining differences were sorted out in a follow-up discussion. Additionally, the same two coders independently assigned each memory deductively to the six psychological needs (Hassenzahl et al., 2010), again with multiple coding and based on the same descriptions with an inter-rater reliability of Krippendorff's  $\alpha = .69$ . As before, disagreements were sorted out in a follow-up discussion. We ran undirected Chi-squared tests (Fisher's exact test for codes with few expected assignments) to detect

Categories / Needs	“entire life”	“last week”	Total	$\chi^2$	p	odds ratio
Travel	27	18	45	7.15	<.01**	2.62
Love & Relationship	24	20	44	3.12	.08	1.85
Friends	12	32	44	6.57	<.05*	0.38
Family	12	22	34	1.18	.28	0.65
Nature	11	15	26	0.02	.90	0.95
Individual Success	11	13	24	0.07	.80	1.12
Food & Drinks	2	18	20	10.47	<.01**	0.12
New Lifetime Period	15	2	17	15.65	<.01**	12.35
Good Weather	2	15	17	7.81	<.01**	0.15
Sport	6	9	15	0.08	.78	0.74
Animals	4	5	9		1.00 <sup>F</sup>	0.96
Music	2	5	7		.70 <sup>F</sup>	1.98
Relatedness	44	69	113	3.60	.06	0.49
Stimulation	19	24	43	0.01	.91	1.04
Security	17	9	26	6.16	<.05*	2.97
Competence	13	10	23	1.89	.17	1.86
Autonomy	14	8	22	4.28	<.05*	2.63
Popularity	2	6	8		.47 <sup>F</sup>	2.40

**Table 3.** Categories of the reported memories in Study 1 and their frequencies of assignment. The odds ratio refers to the “entire life” condition (numerator) relative to the “last week” condition (denominator). Probability (p) values marked with an F are calculated with Fisher’s Exact Test because at least one cell had an expected frequency lower than 5.

significant differences between the two memory types. All categories, needs, their frequencies of assignment, and test results are listed in Table 3.

Overall, most memories were related to travelling, love and relationship, friends, or family. An example experience from the “last week” group was: *“A trip to the Netherlands. It was spontaneous, together with my girlfriend. We don’t do that very often, which is why it was something special. Also, we like Holland”*. It was coded both with “Travel” and “Love & Relationship”.

The “entire life” group reported significantly less experiences relating to “Friends”, “Food & Drinks”, and “Good Weather”, but more experiences of the categories “Travel” and “New Lifetime Period”. The latter category was particularly interesting, because the transition between lifetime periods is typically considered as content for reflection as well (e.g., Mols et al., 2016a). However, a difference between the two groups is plausible because fewer life changing events happen in one week, compared to the entire life, and some can only be recognized as such after some time has passed. A closer analysis revealed that, among the 17 experiences with this code, 7 (41%) were related to graduation, 5 (29%) to moving to a different place, 2 (12%) to weddings, and 1 (6%) each to the start of a friendship, overcoming cancer, and the birth of a child. Thirteen of these were focused on specific, positive moments or festivities, and highlighted the presence of close others or a feeling of pride, for example: *“I was together with all my friends and we had a big party. Also, I received my certificate and was honored for it”*. Eight experiences also included a longer term perspective: *“Moving [to a new home] . Because this changed my life to the better”*. Among these eight experiences, most contained a certain degree of reflection as well: *“Exchange year to Finland in high school. Exciting, uncertain but everything went well. For a long time, this brought along other things. It made me grow”*. Nevertheless, given that the vignettes that followed explicitly asked participants to vividly relive the experience and pay attention to their feelings, rather than reflect on them, as well as the relatively small number of these experiences with a reflective notion, we considered this as unproblematic.

Regarding need fulfillment, the most frequently coded need was relatedness (113 of 152; 74%), followed by stimulation (43 of 152; 28%) and security (26 of 152; 17%). Security and autonomy were both more frequent in the “entire life” group than in the “last week” group. An example experiences that was coded with security was: “4 months skiing in Italy. Because it was the perfect mix of uncertainty and routine”, and an example autonomy experience was: “Riding my bike and listening to my favorite music after handing in a finished task at the university. [...] I felt free and happy”.

Taken together, most reported memories were relatedness experiences, with a (non-significant) tendency towards romantic experiences in the “entire life” group, and more friendship experiences in the “last week” group. Popularity was the least frequent need among our categories.

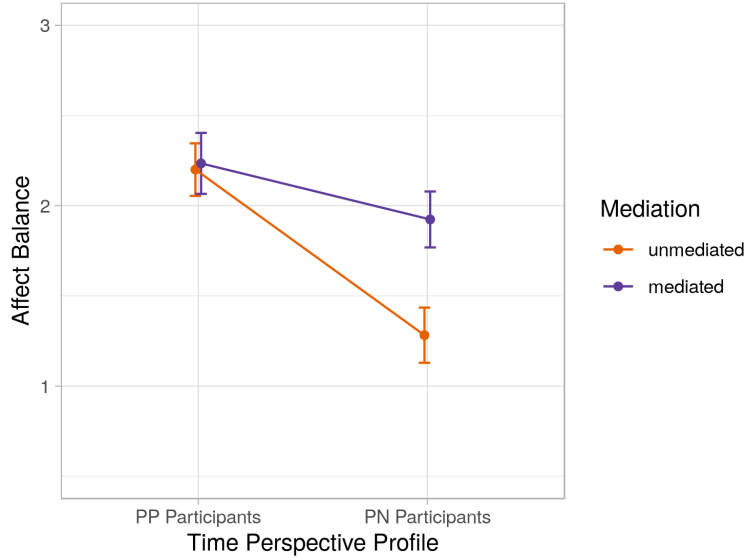
We analyzed differences between the “entire life” and “last week” memories in terms of emotional intensity and importance for one’s life using the two scales included. The “entire life” memories were significantly more emotionally intense than the “last week” memories ( $t(133.33) = 2.05, p < .05$ ). However, there was no difference in subjective importance ( $t(145.44) = 0.24, p = .81$ ). This was somewhat surprising, given that several memories in that group were about beginning a new lifetime period or related to the participants’ graduation, which could be considered as important events. Nevertheless, the difference in emotional intensity indicated a substantial difference in the type of memories reported.

## Affect

We ran a 2x2x2x2-ANOVA with the between-subjects factors time perspective (“past positive” vs. “past negative”), mediation (“technology-mediated” vs. “unmediated”), trigger (“external trigger” vs. “intentional”), and memory type (“entire life” vs. “last week”). The dependent variable was affect balance. The ANOVA revealed a significant main effect for mediation ( $F(1, 136) = 5.16, p < .05, \eta_p^2 = .04$ ), confirming that technology-mediated reminiscing ( $M = 2.07, SD = 0.97$ ) leads to more positive affect than unmediated reminiscing (H1;  $M = 1.76, SD = 1.05$ ). Against our expectation (H2), we found no main effect for the trigger factor ( $F(1, 136) = 1.51, p = .22$ ).

We also found no main effect for memory type ( $F(1, 136) = 0.00, p = .96$ ). However, memory types did play a more conditional role that was revealed in two related interaction effects (see Figures 1 and 2). First, the two-way interaction between mediation and time perspective was significant ( $F(1, 136) = 5.70, p < .05, \eta_p^2 = .04$ ). PP participants experienced high positive affect from both mediated and unmediated reminiscing. In contrast, PN participants had similarly high positive affect in the technology-mediated condition, but less positive affect in the unmediated condition. The difference between the two mediation factor levels for PN participants was marginally significant after Bonferroni correction ( $\alpha_{crit} = .008, t(75) = 2.69, p = .009, d = 0.62$ ). We also compared unmediated reminiscing between PP and PN participants and found a significant difference after Bonferroni correction ( $\alpha_{crit} = .008, t(63.93) = 4.29, p = .000, d = 0.99$ ). This two-way interaction suggests that, while technology-mediation had no beneficial effect overall on PP participants, it had a positive effect on PN participants. In the latter group, technology-mediated reminiscing led to more positive affect than unmediated reminiscing.

Second, a further significant three-way interaction included the factors mediation, time perspective, and memory type ( $F(1, 136) = 5.89, p < .05, \eta_p^2 = .04$ ). When reminiscing about memories from the past week, PP participants had more positive affect than PN participants both with mediated and unmediated reminiscing. Moreover, technology-mediated reminiscing led to more positive affect than unmediated reminiscing for both PP and PN participants. However, this was different for the “entire life” memories. PP participants had similarly high positive affect in the unmediated reminiscing group ( $M = 2.34, SD = 0.64$ ) and in the technology-mediated reminiscing group ( $M = 1.88, SD = 1.10, \alpha_{crit} = .008, t(15.32) = 1.36, p = .20$ ).



**FIGURE 1.** The interaction between mediation and time perspective on affect balance in Study 1. Error bars represent the standard error.

$d = 0.52$ ). In contrast, PN participants in the mediated reminiscing group ( $M = 2.31, SD = 0.78$ ) had more positive affect than in the unmediated reminiscing group ( $M = 1.22, SD = 1.19, \alpha_{crit} = .008, t(31) = 2.90, p = .007, d = 1.08$ ). We found no difference between PP and PN participants for technology-mediated reminiscing ( $\alpha_{crit} = .008, t(23) = 1.14, p = .27, d = 0.45$ ), but the difference in the unmediated reminiscing groups was significant ( $\alpha_{crit} = .008, t(28.67) = 3.74, p = .001, d = 1.18$ ).

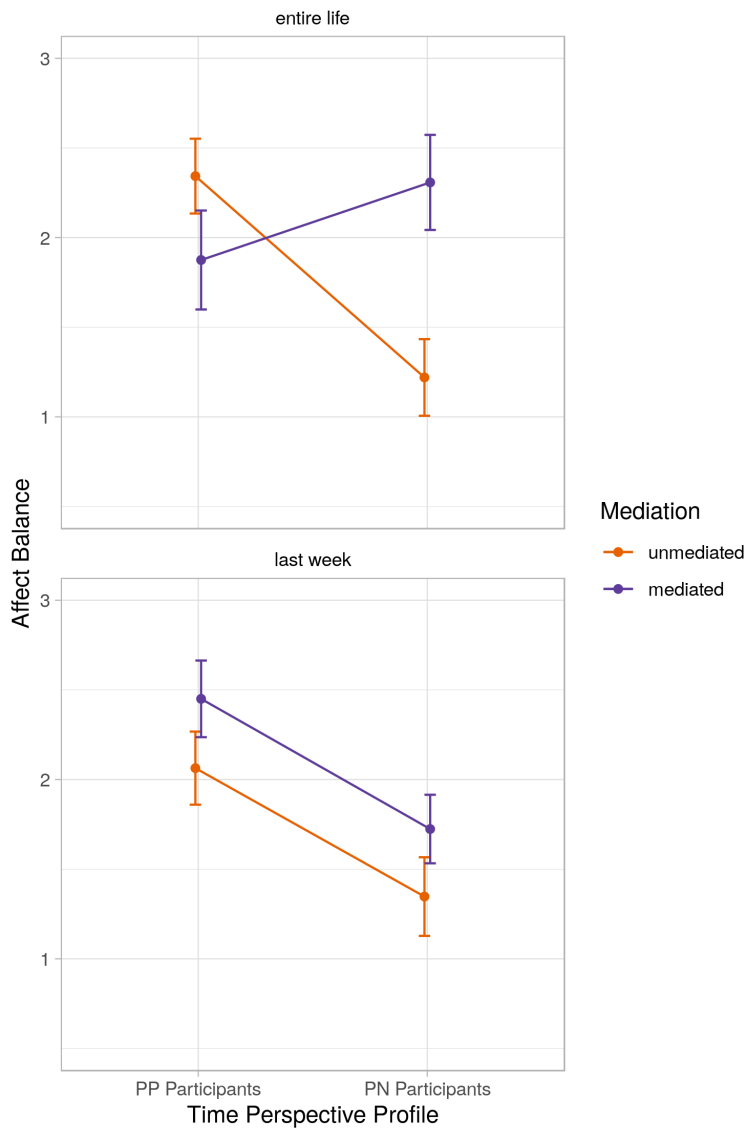
Taken together, our hypothesis H3a could not be confirmed as a general main effect, but we found a more subtle interaction. For everyday positive memories (from the last week, less intense), technology-mediation had a positive effect on all participants. However, with “entire life” memories, the positive effect was restricted to PN participants. PN participants in the technology-mediated reminiscing group had more positive affect than PN participants in the unmediated group and no effect of technology-mediation was found for PP participants.

Finally, we found the expected main effect for time perspective (H4,  $F(1, 136) = 11.74, p < .01, \eta_p^2 = .08$ ). PP participants ( $M = 2.21, SD = 0.84$ ) had more positive affect after reminiscing than PN participants ( $M = 1.60, SD = 1.09$ ).

### Psychological Need Fulfillment

Regarding need fulfillment, we ran a mixed 6x2x2x2x2-ANOVA with the repeated measure “need fulfillment”, measured by the six psychological need satisfaction scales. The other four factors were the same as above (time perspective, mediation, trigger, memory type). Against our expectation (H3b), we found no interaction effect between need fulfillment and memory type after Huynh-Feldt correction for sphericity ( $\epsilon = .92, F(4.60, 625.66) = 0.29, p = .91, \eta_p^2 = .00$ ). Thus, the intensity of need fulfillment during

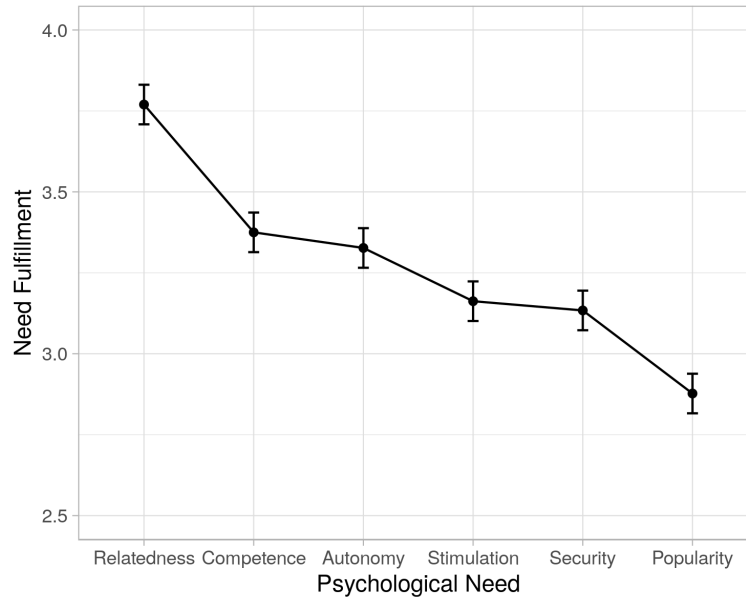




**FIGURE 2.** The interaction between mediation, memory type, and time perspective on affect balance in Study 1. Error bars represent the standard error.

reminiscing could not be explained by the emotional intensity of the past experience.

However, we found a significant main effect for need fulfillment  $F(4.60, 625.66) = 25.91, p < .01, \eta_p^2 = .16$ ). Post-hoc, Bonferroni corrected comparisons revealed several significant differences between different needs that are depicted in Figure 3. Relatedness fulfillment during reminiscing was significantly higher than fulfillment of all other needs. This was followed by competence, autonomy, and stimulation, all of which had significantly higher fulfillment than popularity, and the first two had higher fulfillment than security. Generally, this corresponds to our previous qualitative coding of need fulfillment in the memory descriptions, although a higher fulfillment of the security need could have been expected.



**FIGURE 3.** Need fulfillment after reminiscing in Study 1. Error bars represent the standard error.

We also found a main effect of time perspective ( $F(1, 136) = 6.04, p < .05, \eta_p^2 = .04$ ). PP participants reported higher overall need fulfillment during reminiscing ( $M = 3.48, SE = 0.10$ ) than PN participants ( $M = 3.12, SE = 0.10$ ).

All in all, and especially given the high level of relatedness experience, need fulfillment from the past memories could be relieved to an extent during reminiscing, but we found no difference between more and less emotionally intense memories.

### Happiness and Life Satisfaction

We had no hypotheses concerning happiness and life satisfaction, but measured both to provide comparability with earlier studies (e.g., Isaacs et al., 2013; Hollis et al., 2017). As depicted in Table 1, both scales correlated with positive affect, all psychological need scales, with each other, and with the time perspectives. Correlations with DBTP and the past negative scale were negative. This correlation pattern is consistent with earlier findings (e.g., Quoidbach et al., 2010; Zhang et al., 2012).

### 3.4. Discussion

Study 1 revealed several effects of different modes of interaction with reminiscence technologies on situated, immediate affect. Moreover, we found differential impacts on people with different time perspectives. H1 could be confirmed: Overall, technology-mediated reminiscing led to more positive affect than unmediated reminiscing, with one exception discussed further below. H2 assumed that externally triggered reminiscing leads to more positive affect, compared with intentional reminiscing. This effect could not be confirmed. Regarding earlier work on Pensieve (Peesapati et al., 2010), this suggests an alternative to their decision to trigger users in unexpected moments. When looking at single reminiscence sessions, intentional interaction has a similar effect on subjective well-being as incidental, externally triggered interaction, as long as positive memories are concerned. However, one advantage of externally triggered reminiscing in the case of Pensieve was that it led to more frequent reminiscing (Peesapati et al., 2010), which could have a positive long-term effect in natural settings (Lyubomirsky et al., 2005). With the present vignette paradigm, this could not be tested.

H3a assumed that reminiscing about more intense positive memories would lead to more positive affect, which could not be confirmed overall. Similarly, H3b stated that the the more intense positive memories would lead to higher need fulfillment during reminiscing, which could not be confirmed either. Nevertheless, participants experienced need fulfillment during reminiscing generally in proportion to need fulfillment in the memories, suggesting that need fulfillment transferred to the present situation, but not proportional to the emotional intensity of the past experience. In this first study, need fulfillment was highest for “relatedness”. To further explore the transfer of need fulfillment from the memory to the present, and to make this more usable for designers, one goal of the following Study 2 was to test whether we could elicit need-specific memories and whether this leads to higher need-specific fulfillment.

With H4 we assumed that participants with a more balanced past time perspective had more positive affect overall after reminiscing than participants with a less balanced past time perspective. This difference could be confirmed, although we cannot derive a causality from this quasi-experimental effect.

From our perspective, the most interesting finding from Study 1 was the selective mediation effect, that is, the interaction between mediation, memory type, and time perspectives. Technology-mediation had a positive effect, particularly in the group of PN participants. This is an encouraging finding for the development of reminiscence technologies, indicating that they could be especially helpful for people with a less balanced time perspective - arguably the group of people with the highest need for positive memories. The specific, positive effect for PN participants was most pronounced when reminiscing about the happiest memories of their entire life. We have three candidate explanations for this finding.

First, technology-mediation, in contrast to unmediated reminiscing, is typically based on digital media representations of an experience, rather than the (mental) memory itself. As argued in the introduction, PP participants tend to see their past experiences more positively, while PN participants tend to see them more negatively. Hence, the unmediated retrospection is selective (see also “rosy view”; Konrad, Isaacs, & Whittaker, 2016; Mitchell et al., 1997). Although we did not explicitly describe the type of images used in the smartphone app in our vignettes, the participants may have assumed them to be an external, more “objective” representation of their experience that may conflict with their mental representation. For PN participants, this could lead to a more positive view, correcting some of the overly negative evaluations of a past experience. In contrast, it could have a negative impact on the “too positive” memory of the PP participants, conflicting with a “rosy view”.

Second, PN participants may generally associate natural reminiscing (i.e., unmediated, mental) with negative experiences. Even though the scenario was based on an exceptionally happy memory, they may be concerned of their mind wandering towards less happy ones, for example from the same lifetime period.

A smartphone app that specifically focuses on one memory may help to fix the attention and prevent this mind wandering. This would be less of a problem for PP participants who generally see their past positively, explaining their high positive affect independent of mediation.

Third, PP participants may already have well-established practices of reminiscing in their everyday life, particularly for exceptionally happy memories. Introducing a smartphone into this practice may be seen as disturbing, which was a finding for reflection technology in an earlier study by Mols et al. (2016a). According to this explanation, technology-mediation would not necessarily have a positive effect on PN participants, but may instead have a negative effect on PP participants.

## 4. STUDY 2: SELECTIVE MEDIATION EFFECT

In Study 2, we further investigated the complex interaction as well as the relived need satisfaction found in Study 1. Our main intention was to test the three explanations for the selective mediation effect provided in the previous section. Moreover, we found most memories in Study 1 to be based on relatedness experiences and wanted to test whether memories relating to specific needs could be triggered selectively and whether that would lead to selective need fulfillment.

The first explanation assumed that subjective and objective memory representations have differential effects depending on the time perspective profile. Accordingly, our first factor was “realism” of the memory representation (objective vs. subjective). The second explanation assumed that involuntary mind wandering may be problematic for people with a negative past perspective but not for those with a positive past perspective. Thus, our second factor was “flexibility” of the memory (fixed vs. flexible). The third factor concerned different psychological “needs” of the memory (relatedness vs. popularity). The fourth factor was “time perspective” (past positive vs. past negative using median split of the DBTP).

Our hypotheses were as follows:

- H1:** PP participants experience more positive affect after reminiscing using “subjective” memory representations, while PN participants experience more positive affect after reminiscing using “objective” memory representations (explanation 1).
- H2:** PN participants experience more positive affect after reminiscing about a “fixed” positive past experience compared with “flexible” mind wandering (explanation 2).
- H3:** Reminiscence Technologies conflict with PP participants’ reminiscence practices more strongly than the practices of PN participants (explanation 3).
- H4:** Reminiscing about a specific need leads to higher need-specific fulfillment than reminiscing about another need.

### 4.1. Participants

We ran the second study on SurveyMonkey.com and 125 people completed it. As in Study 1, participants were invited to participate via student mailing lists and social media, and were provided with a link to the study. Ninety-eight (78%) identified as female, 25 (20%) as male, and 2 (2%) as “diverse/no reply”. The median age was 24 (*Min* = 18, *Max* = 68, 1 missing). Fifty-six (45%) participants had finished high school, 34 (27%) had finished undergraduate studies, and 17 (14%) had finished their Masters or Diploma. Seven

Measure	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Positive Affect	(.90)													
2. Negative Affect	-.13	(.80)												
3. Affect Balance	.89**	-.56**	(-)											
4. Autonomy	.52**	-.18	.51**	(.78)										
5. Competence	.53**	-.06	.47**	.67**	(.82)									
6. Relatedness	.40**	-.12	.39**	.40**	.30**	(.88)								
7. Stimulation	.41**	.04	.32**	.41**	.42**	.39**	(.75)							
8. Security	.39**	-.02	.34**	.67**	.56**	.36**	.39**	(.71)						
9. Popularity	.39**	-.02	.33**	.66**	.65**	.42**	.44**	.62**	(.82)					
10. SWLS	.05	-.09	-.08	-.09	.05	.22*	.06	.10	.19*	(.89)				
11. Integration	.57**	-.19*	.56**	.38**	.36**	.30**	.20*	.39**	.27**	-.03	(.76)			
12. Past Positive	.20*	-.09	.21*	.13	.17	.24**	.20*	.20*	.21*	.42**	.08	(.72)		
13. Past Negative	-.06	.34**	-.20*	-.11	-.08	-.22*	-.09	-.11	-.08	-.67**	.05	-.23**	(.86)	
14. DBTP	-.10	.29**	-.22*	-.09	-.12	-.27**	-.15	-.14	-.12	-.68**	.01	-.71**	.81**	(-)

**Table 4.** Intercorrelations of all measures used in Study 2. The diagonal line (in brackets) shows the internal consistencies measured with Cronbach’s alpha. SWLS = “Satisfaction With Life Scale”; DBTP = “Deviation from Balanced Time Perspective”

(6%) had finished a professional training, 1 (1%) a PhD, and 9 (7%) had a lower than high school degree, no degree, or a general certificate of secondary education (1 missing).

## 4.2. Material and Methods

Study 2 was conducted in January 2019. On the welcome page of the experimental online study, participants were informed that the data would be anonymized before analysis and that they could abort the study at any time. Moreover, they were informed about a raffle for a 30 € voucher in which they could participate and that the study would take around 15 minutes to complete. Additionally, for this study we informed them that we would donate 0.50 € for each complete participation to a small NGO that helps children in Yemen.

Next, participants filled out the past positive and past negative scales of the ZTPI, similar to Study 1. Internal consistency was again lower using the original calculation (past positive: *Cronbach's*  $\alpha = .52$ ; past negative: *Cronbach's*  $\alpha = .86$ ) and sufficiently high for the adapted German variant (see Table 4 for an overview of internal consistencies and interrelations of all measures used in Study 2). Thus, similar to Study 1, we proceeded with the adapted version. The ZTPI was followed by the SWLS, this time *before* the experimental manipulation. Item orders for all questionnaires were randomized between participants.

After the SWLS, we asked the participants to think about a specific memory from the time they were in elementary school. For one group of participants we highlighted relatedness, for the other popularity as the basis for the positive experience to be reminisced about:

*“Please think about an experience as positive as possible from the time you were in elementary school, in which you felt particularly close to people you felt connected with [“relatedness”] / in which you have savored a lot of recognition [“popularity”]. The experience can, but does not need to have anything to do with school. It is important that it is as positive as possible from the time you were in elementary school, and that you felt close to the people. For example, think about a particularly nice, common experience with friends or your family [“relatedness”] / felt the recognition. For example, think about a particularly nice experience during sport or music class, or also in school [“popularity”]. Please describe that memory briefly on the next page!”*

The bold parts are the manipulation on the “need” factor (emphasis added here for clarification). We chose relatedness as the need with highest fulfillment and popularity as the one with lowest fulfillment in Study 1 to maximize the contrast. Moreover, we tried to keep the experiences as relatable as possible for our sample, choosing elementary school as a common lifetime period most people in Germany have experienced, and which allows for different possible forms of relationships or moments of recognition. On the next page, participants were asked to briefly describe the experience and to give an explanation why it was so positive. We asked them how enjoyable the experience was on the same scale as in Study 1, but we left out the question about importance of the memory. This was followed by a reminiscence vignette:

*“After a long day you sit in your favorite place and you finally have some time for yourself. You take out your smartphone. A few weeks ago you have installed the ‘flashback’ app, that allows you to look at positive events from your life. This app presents the experiences **very realistically, just the way they have really been - even if that may differ from your memory** [“objective”] / **like they are in your memory, even if that is partially different from the ‘real’ event** [“subjective”]. You start the app and this time you pick the experience you just described earlier. You watch the situation just the way **it had happened** [“objective”] / **you remember it** [“subjective”]. The app is **not fixed on this one experience, you can easily divert to other memories. For example, those that have happened in the same lifetime period or at the same place. The app also shows you these other memories** [“flexible”] / **fixed exactly on this specific experience and you don’t digress with your thoughts. Instead, you concentrate fully on this experience** [“fixed”]. You use this app for a while before you put your smartphone aside.”*

Again, we provided a context as immersive as possible e.g., by mentioning an abstract “favorite place” and not describing what happened during the long day before. We manipulated the two factors “reality” and “flexibility” as indicated above. For one half of the participants, the app showed “objective” experiences that differed from their memories. For the other half, it showed a “subjective” version that may differ from the objective experience. Second, the app allowed flexible mind wandering for half of the participants, but was fixed on one specific memory for the other half.

The vignette was followed by the same question as in Study 1, asking how well participants could imagine the situation (immersiveness was good,  $M = 5.52$ ,  $SD = 1.29$ ). Then we included the PANAS as a measure for affect balance, and the need satisfaction scales for the six needs. Again, internal consistency for the “security” need was initially below the criterion (*Cronbach's*  $\alpha = .64$ ), and this time also for “stimulation” (*Cronbach's*  $\alpha = .69$ ). However, they could be increased by exclusion of the items “[I felt...] safe from threats and uncertainties” and “[I felt...] intense physical pleasure and enjoyment”, respectively. All internal consistencies and intercorrelations are depicted in Table 4.

Next, we included a self-developed scale to measure how well the practice would integrate into the participants’ everyday life. To that end, we instructed them as follows: “Imagine you would use this app for a longer period of time. How do you think it would influence your everyday life? This app would...”, followed by six items, for example, “...integrate naturally in my everyday life.” or “...disturb an existing habit. (inverted)” (see Appendix B1 for the full list). Participants could answer on a 7-point scale ranging from 1 (“I don’t agree at all”) to 7 (“I fully agree”). Internal consistency was good (*Cronbach's*  $\alpha = .76$ ).

Finally, we included demographic questions (age, gender, education) and a field to leave an email address to participate in the raffle.

DBTP and affect balance were calculated as in Study 1. After the median split, we tested the factor independence of the two DBTP levels using Chi-squared tests and independence of gender distribution using

Measure	Overall			“low DBTP”			“high DBTP”		
	M	SD	95% CI	M	SD	Range	M	SD	Range
Positive Affect	3.34	0.83	[3.19, 3.49]	3.36	0.81	[1.40, 4.80]	3.32	0.85	[1.10, 5.00]
Negative Affect	1.38	0.45	[1.30, 1.46]	1.27	0.40	[1.00, 2.90]	1.50	0.47	[1.00, 3.20]
Affect Balance	1.96	1.00	[1.79, 2.13]	2.09	0.96	[-0.30, 3.80]	1.83	1.02	[-1.20, 4.00]
Autonomy	3.23	1.00	[3.05, 3.41]	3.30	0.95	[1.00, 5.00]	3.15	1.05	[1.00, 5.00]
Competence	3.30	1.12	[3.10, 3.50]	3.35	1.08	[1.00, 5.00]	3.26	1.16	[1.00, 5.00]
Relatedness	3.63	1.11	[3.44, 3.82]	3.91	0.90	[1.33, 5.00]	3.35	1.23	[1.00, 5.00]
Stimulation	3.06	1.16	[2.86, 3.26]	3.14	1.10	[1.00, 5.00]	2.99	1.21	[1.00, 5.00]
Security	2.88	1.10	[2.69, 3.07]	2.93	1.13	[1.00, 5.00]	2.83	1.07	[1.00, 5.00]
Popularity	2.91	1.10	[2.72, 3.10]	2.98	1.16	[1.00, 5.00]	2.85	1.04	[1.00, 5.00]
SWLS	4.70	1.31	[4.47, 4.93]	5.45	0.87	[3.00, 7.00]	3.97	1.25	[1.00, 7.00]
Integration	4.02	1.24	[3.80, 4.24]	3.92	1.33	[1.00, 6.67]	4.12	1.15	[1.33, 6.33]
Past Positive	3.61	0.52	[3.52, 3.70]	3.86	0.33	[3.31, 4.69]	3.37	0.56	[2.08, 4.38]
Past Negative	2.80	0.80	[2.66, 2.94]	2.23	0.44	[1.36, 3.18]	3.36	0.67	[1.82, 4.45]
Immersiveness	5.52	1.29	[5.29, 5.75]	5.61	1.08	[3, 7]	5.43	1.47	[1, 7]
Happiness	8.48	1.74	[8.17, 8.79]	8.74	1.29	[3, 10]	8.22	2.08	[1, 10]
Age	26.08	8.29	[24.62, 27.54]	25.72	8.78	[18, 68]	26.43	7.83	[18, 55]

**Table 5.** Summary statistics of Study 2, overall and for the two levels of the median split. M = “Mean”; SD = “Standard Deviation”; CI = “Confidence Interval”; DBTP = “Deviation from Balanced Time Perspective”; SWLS = “Satisfaction With Life Scale”

Fisher’s exact test. All factors were independent and genders were equally distributed (see Appendix B2). Summary statistics for the overall sample and the two DBTP groups can be found in Table 5.

### 4.3. Results

#### Memories

Similar to Study 1, all experiences were coded by two independent coders. Again, one coder inductively created categories of the content which were used by the second coder. Inter-rater reliability was good (Krippendorff’s  $\alpha = .70$ ). Additionally, all experiences were assigned to the needs, similar to Study 1, with an inter-rater reliability of Krippendorff’s  $\alpha = .62$ . Multiple assignments were allowed in both cases and disagreements were sorted out in a follow-up discussion. The assignments to the categories and needs can be found in Table 6.

Taken all memories across conditions together, the most frequent content category was “Successes & Awards” (57 of 125; 46%), followed by “Friends” (48 of 125; 38%) and “Family” (38 of 125; 30%). We found several differences between the two need conditions (“relatedness” and “popularity”) using Chi-squared tests and Fisher’s exact tests when appropriate. Successes were more frequent in the “popularity” condition, as were “public performances”. In contrast, relatedness memories were more often associated with the categories “friends”, “family”, “nature”, and “carefree”. Generally, this is compatible with our experimental variation. The events with a “nature” code (20 of 125; 16%) contained descriptions of places outdoors, mostly playing with friends (9 of 20; 45%), during school events (5 of 20; 25%), or on vacation with the family (3 of 20; 15%). “Carefree” memories included a feeling of security, often based on someone else being there. For example, one participant reported a memory with the mother, where she took the time in the morning for breakfast and pressed orange juice: *“It was nice to be so gently taken care of. That was a silent situation between me and my mother. She didn’t have to do that, but it showed me that I was loved”*. Similar to Study 1, relatedness memories often came along with a feeling of security.

Categories / Needs	“relatedness”	“popularity”	Total	$\chi^2$	p	odds ratio
Successes & Awards	8	49	57	44.13	<.01**	0.06
Friends	35	13	48	22.03	<.01**	6.32
Family	23	15	38	4.38	<.05*	2.28
Exceptional Events	15	20	35	0.25	.62	0.82
Nature	16	4	20	10.81	<.01**	6.00
Carefree	16	2	18	15.26	<.01**	12.38
Public Performances	2	15	17	9.49	<.01**	0.12
Trips	8	4	12	2.19	.14	2.52
Childhood Love	3	1	4		.34 <sup>F</sup>	3.60
Popularity	12	45	57	27.07	<.01**	0.13
Relatedness	47	9	56	57.45	<.01**	27.54
Competence	8	40	48	27.70	<.01**	0.11
Stimulation	11	4	15	4.97	<.05*	3.69
Security	8	2	10		<.05* <sup>F</sup>	5.20
Autonomy	4	4	8		1.00 <sup>F</sup>	1.17

**Table 6.** Categories of the reported memories in Study 2 and their frequencies of assignment. The odds ratio refers to the “relatedness” condition (numerator) relative to the “popularity” condition (denominator). Probability (p) values marked with an F are calculated with Fisher’s Exact Test because at least one cell had an expected frequency lower than 5.

This also showed in the need fulfillment assignments. While the “popularity” condition had more assignments of popularity and competence, relatedness memories had more assignments of relatedness, stimulation, and security. In this study, autonomy had the least frequent codes, which may be caused by the setting in the participants’ childhood, a lifetime period of depending on others.

Finally, we compared emotional intensity between relatedness and popularity-based memories and found no difference ( $t(123) = 1.15, p = .25$ ).

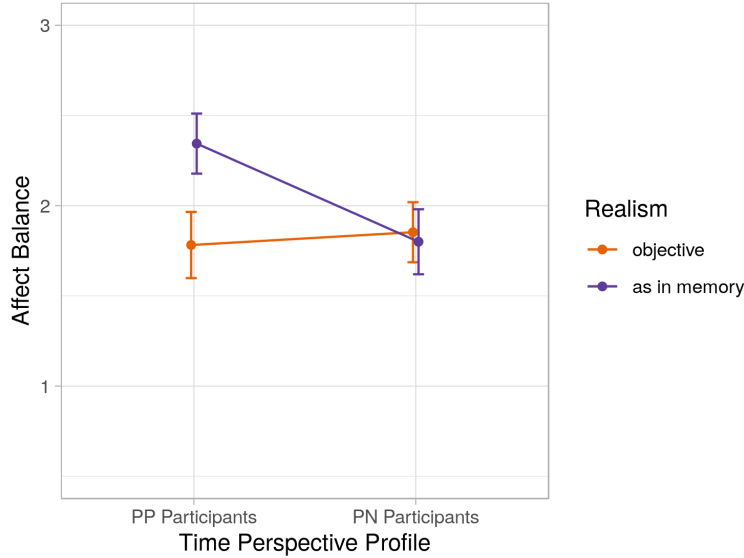
## Affect

We ran a 2x2x2x2-ANOVA with the between-subjects factors time perspective (“past positive” vs. “past negative”), realism (“objective” vs. “subjective”), flexibility (“flexible” vs. “fixed”), and need (“relatedness” vs. “popularity”) and the measure affect balance. We found an unexpected main effect for “flexibility” ( $F(1, 109) = 4.02, p < .05, \eta_p^2 = .04$ ). Post-hoc analysis revealed that overall fixed reminiscing ( $M = 2.18, SD = 0.90$ ) led to a more positive affect balance than flexible reminiscing (allowing for mind wandering across memories) ( $M = 1.73, SD = 1.04, t(123) = 2.55, p < .05, d = 0.46$ ).

The expected (H1) interaction between time perspective and realism was significant ( $F(1, 109) = 4.11, p < .05, \eta_p^2 = .04$ , see Figure 4). Pairwise comparisons revealed a significant difference for PP participants: Reminiscing using the subjective version led to more positive affect ( $M = 2.34, SD = 0.87$ ) than reminiscing using the objective version ( $M = 1.78, SD = 1.00, t(60) = 2.37, p < .05, d = 0.60$ ). This difference was not significant for PN participants ( $t(61) = 0.20, p = .84, d = 0.05$ ). We then compared PP and PN participants on each level of “realism”. Reminiscing using the subjective version led to more positive affect for PP participants ( $M = 2.34, SD = 0.87$ ) than for PN participants ( $M = 1.80, SD = 0.96, t(61) = 2.35, p < .05, d = 0.59$ ), but there was no difference between PP and PN participants with the objective version ( $M_{PN} = 1.85, SD_{PN} = 1.08, t(60) = 0.27, p = .79, d = 0.07$ ).

H2 assumed an interaction between time perspective and flexibility which was not significant ( $F(1, 109) = 0.46, p = .50, \eta_p^2 = .00$ ). However, we found an additional interaction effect between flexibility and real-





**FIGURE 4.** The interaction effect between realism and time perspective on affect balance in Study 2. Error bars represent the standard error.

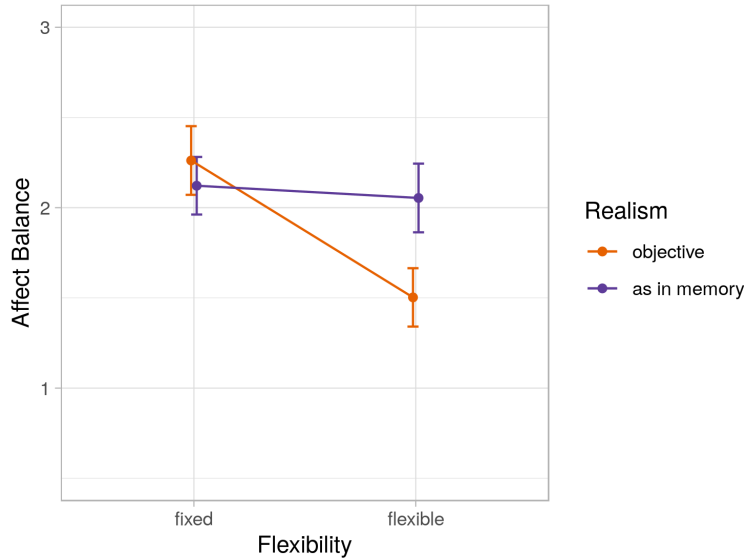
ism ( $F(1, 109) = 4.61, p < .05, \eta_p^2 = .04$ , see Figure 5). With the objective version, fixed reminiscing ( $M = 2.26, SD = 0.78$ ) led to a significantly more positive affect balance than flexible reminiscing ( $M = 1.50, SD = 1.08$ ) after Bonferroni correction ( $\alpha_{crit} = .008, t(60.00) = 3.20, p = .002, d = 0.80$ ). On the “flexible” level, the difference between the objective ( $M = 1.50, SD = 1.08$ ) and the subjective version missed significance after Bonferroni correction ( $M = 2.05, SD = 0.91, \alpha_{crit} = .008, t(60) = 2.18, p = .04, d = 0.55$ ). Taken together, we found that affect was influenced by an interaction between flexibility and realism, but independent of time perspectives.

### Integration

H3 assumed a difference between participants with different time perspectives regarding how well they expected the reminiscence technology to integrate in their everyday life. Using the integration scale as measure in an independent samples t-test, and “time perspectives” as independent variable, we found no significant difference ( $t(123) = 0.90, p = .18, d = 0.16$ ). Thus, H3 could not be confirmed.

### Psychological Need Fulfillment

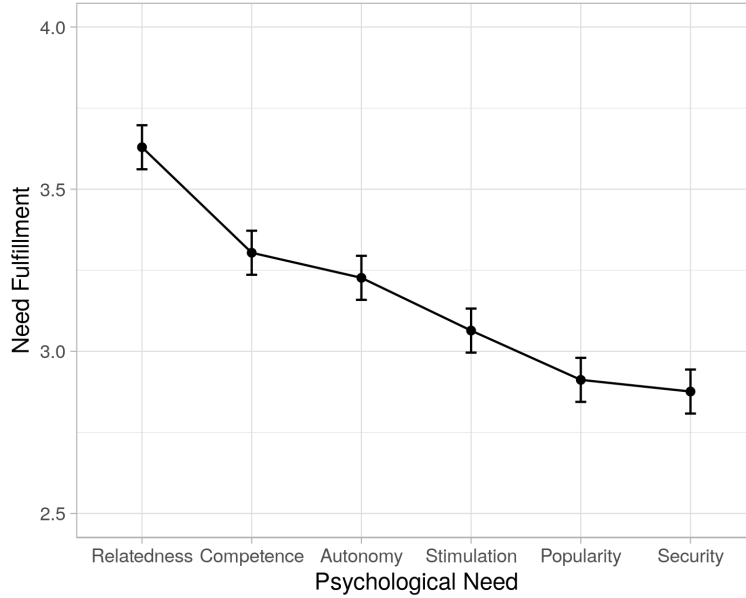
Concerning need fulfillment, we ran a  $6 \times 2 \times 2 \times 2$ -ANOVA with the repeated measure “need fulfillment” using the need satisfaction scales and the four between subjects factors time perspective, realism, flexibility, and need (the relatedness vs. popularity conditions). This revealed a main effect for need fulfillment ( $F(5, 545) = 15.34, p < .01, \eta_p^2 = .12$ ). Post-hoc, pairwise comparisons with Bonferroni correction revealed several differences (see Figure 6). Similar to Study 1, relatedness had the highest overall need fulfillment,



**FIGURE 5.** The interaction effect between realism and flexibility on affect balance in Study 2. Error bars represent the standard error.

significantly higher than all other needs. This was followed by competence, autonomy, and stimulation. Finally, popularity was lower than competence and autonomy, and security was lower than competence, autonomy, and stimulation. The low score of popularity is interesting in so far that popularity was one of the needs we had specifically targeted with our intervention. The rank order generally resembled the one from Study 1, although security and popularity switched positions. No other main effect was significant.

We had expected (H4) an interaction between need fulfillment and the need factor which became significant ( $F(5, 545) = 8.39, p < .01, \eta_p^2 = .07$ ). Pairwise comparisons revealed a significantly higher need fulfillment for relatedness in the “relatedness” condition of the need factor ( $M = 3.87, SD = 0.97$ ), compared with the “popularity” condition ( $M = 3.42, SD = 1.19, t(122.62) = 2.36, p < .05, d = 0.42$ ). However, the difference in popularity need fulfillment missed significance between the “popularity” condition ( $M = 3.06, SD = 0.99$ ) and the “relatedness” condition ( $M = 2.74, SD = 1.20, t(123) = 1.63, p = .053, d = 0.29$ ). Given that we had found additional significant differences in codes of “security” and “competence” between the two need conditions, we also tested them for differences in need fulfillment. No significant difference was found for security between the relatedness condition ( $M = 2.84, SD = 1.03$ ) and the popularity condition ( $M = 2.91, SD = 1.15, t(123) = -0.38, p = .71$ ). However, we did find a difference for competence: Competence was higher in the popularity condition ( $M = 3.63, SD = 1.04$ ) than in the relatedness condition ( $M = 2.93, SD = 1.09, t(123) = 3.70, p < .01, d = 0.66$ ). This finding, in combination with the difference in coding, indicates that the condition that was intended to elicit experiences of popularity seems to have elicited experiences of competence more strongly.



**FIGURE 6.** Need fulfillment after reminiscing in Study 2. Error bars represent the standard error.

#### 4.4. Discussion

Study 2 provided further insights into the interrelation between time perspectives, life satisfaction, and different modes of technology-mediated reminiscing on affect. Regarding the different explanations of the interaction effects between memory type, mediation, and time perspective in Study 1, we found the strongest support for the first one. According to explanation 1, PP participants profit from subjective memory representations in line with their “rosy view”, while PN participants profit from objective memory representations able to shape their overly negative view on their past. Accordingly, PP participants in Study 2 had more positive affect with the subjective memory version compared with the objective version of the reminiscence app. However, the difference between subjective and objective representations for PN participants was not significant.

The second explanation stated that PN participants might profit from technology-mediated reminiscing because it keeps them from mind wandering towards more negative memories. We did not find support for this explanation, although fixed reminiscing generally led to more positive affect than flexible reminiscing.

Concerning the third explanation supposing that PP participants would perceive technology-mediation as disturbing for their established reminiscence practices, we found no support either.

Finally, patterns of need fulfillment generally resembled those of Study 1, but we found that specific needs could be targeted with memories that cater for them. However, although we targeted popularity experiences, participants experienced competence more strongly. Although this highlights an opportunity for designers to selectively target specific needs, it also indicates that this targeted elicitation needs to be designed with caution and tested if possible.

## 5. GENERAL DISCUSSION

In this article we presented the first two studies analyzing individual time perspectives in the context of reminiscence technologies. We compared basic design decisions for reminiscence technologies and different types of memories in terms of their impact on individuals with a balanced time perspective (i.e., a generally positive attitude to their personal past) and those with an unbalanced time perspective (i.e., a generally negative attitude to their past). Study 1 demonstrated that technology-mediated reminiscing is generally experienced as more positive than unmediated reminiscing, especially by participants with an unbalanced time perspective when reminiscing about intense, positive memories. Moreover, we found that participants with a balanced past time perspective had a more positive experience overall than those with an unbalanced past time perspective.

Study 2 was designed to further analyze how the selective advantage of technology-mediation on participants with an unbalanced time perspective can be interpreted. We tested three explanations and found best support for the notion that the type of memory representation matters. Participants with a balanced past time perspective profit from “subjective” material (e.g., similar to their memory), allowing them to keep their “rosy view” (Mitchell et al., 1997) of the past. In contrast, participants with an unbalanced time perspective experienced “subjective” and “objective” representations as similarly positive. This finding indicates that the “rosy view” that was found in the literature before (Isaacs et al., 2013; Konrad, Isaacs, & Whittaker, 2016; Mitchell et al., 1997) may be restricted to people with a balanced past time perspective, which makes sense given the reasoning behind time perspective theory (Zimbardo & Boyd, 1999). Thus, we explain the three-way interaction between time perspectives, mediation, and memory type from Study 1 by a) a generally more positive experience of mediated reminiscing over unmediated reminiscing across all participants, and b) an overlapping, additional “rosy view” for the balanced participants that is negatively affected by technology-mediation (depending on the representation) and less pronounced for recent memories. The other two explanations were 1) a generalized negative affect associated with reminiscing of people with an unbalanced past time perspective and 2) a disturbing effect of technology on existing, positive practices of people with a balanced time perspective. Both could not be confirmed.

Finally, regarding need fulfillment we found that targeted reminiscing about memories that address a specific need can lead to specific need fulfillment of that need, although our intended “popularity” condition turned out to cater for “competence” more strongly, which is plausible given the content of the memories. Besides this specific effect, relatedness was the most central need affected by the memories in both studies.

Taken together, our studies showed that participants with different time perspectives experience the (imagined) interaction with a reminiscence technology in different ways. This is an important finding for the development of new reminiscence technologies, which calls for systematically including time perspectives and more carefully designing for them and it contributes to the field of reminiscence technologies specifically as well as technology-mediated remembering more generally. Different individuals need different types of technology and the positive potential of reminiscence technologies can be assessed and compared with well-being measures (affect and life satisfaction). Specific suggestions are discussed below.

Beyond our findings about time perspective theory, the present article is also the first to include measures of subjective well-being in the context of technology-mediated reminiscing. We found an overall positive impact on immediate, situational affect. In addition, we also showed that basic design decisions can influence this positive impact of a technology even in a single imagined reminiscing session. Earlier studies involved elaborate, interactive prototypes with longer usage intervals (e.g., Odom et al., 2020; Peesapati et al., 2010; Petrelli et al., 2010, 2017). Future studies which simply include measures of affect and/or life satisfaction before and after using the prototypes could move the field forward in terms of assessing the impact of

reminiscence technologies on subjective well-being, with limited additional effort. Similar measures have been used in studies about reflection technologies before (Isaacs et al., 2013; Konrad, Isaacs, & Whittaker, 2016; Konrad, Tucker, et al., 2016; Hollis et al., 2017).

## 5.1. Limitations

Some criticism can be made with regards to the method used in the two studies. First of all, it is important to stress that all results presented here are based on *imagined* interaction with a reminiscence technology. This allowed to test multiple variations of reminiscing technologies efficiently, but it remains open how these results ultimately transfer to real interaction. Nevertheless, field studies often lack control and don't allow to single out important factors that can make a reminiscing technology successful or not. In this respect, EVM provides a complementary approach and a starting point for further research on time perspectives, subjective well-being, and reminiscence technologies. For example, our results and further EVM studies can help to integrate the different findings from the field in a systematic way, to point out important decisions to address in concrete designs, and to explore more speculative designs or test more hypothetical ideas. The distinction between “objective” and “subjective” memory content in Study 2 is an example of that.

We varied all factors in both studies between participants. For time perspectives, there was no alternative because it cannot be varied randomly. For all other factors, we decided to include one reminiscence session only, in order to keep the studies short. The alternatives would have been to include repeated reminiscing sessions using the same past experience or with varied past experiences, both of which bring new variations that can complicate interpretation. In future work, pre- and post-testing of the central measures could further increase certainty about the results.

In addition, our sample was not representative for the general population, given our sampling method. Most of our participants were female and the recruitment method using student mailing lists led to a sample consisting of mainly students. With regards to differences in balanced time perspective, gender effects have not been found in all but one study so far (Stolarski et al., 2020) and genders were randomly distributed across groups. However, the sample consisted mainly of young adults with a higher educational background from a German cultural context. Thus, further validation with different samples of different age groups and backgrounds would be desirable.

## 5.2. Further Research

There are several opportunities for future research based on our findings. First, in contrast to previous studies on reflection technology (e.g., Isaacs et al., 2013; Konrad, Isaacs, & Whittaker, 2016), we have no insights into long-term effects of reminiscing yet. Although an effect on long-term life satisfaction seems less likely (Westerhof et al., 2010), frequent, short-term positive affect can indirectly result in positive long-term outcomes, such as higher sociability and “liking of self and others” (Lyubomirsky et al., 2005). An important area for future work is the study of potential long-term effects of technology-mediated reminiscing.

Second, our studies used positive memories only. While we do not expect positive affective experiences from reminiscing about negative past experiences, we have insufficient information about possible negative effects. It is likely that prompting people to reminisce about a negative past experience may cause harm. In an earlier work on digital memorabilia after romantic break ups, Herron et al. (2016) identified several ways how digital memorabilia can make it difficult to leave a negative experience behind. Similarly, unintentional reminders, for example through personalized advertisements on web platforms can lead to intensely negative experiences (Brockel, 2018). This is consistent with negative effects of unmediated, negative remi-

niscence (Lyubomirsky et al., 2006). A better understanding of these negative effects is needed, but it should be studied in safer settings than an online study can provide.

Third, time perspective profiles and their interaction with reflection technologies have not been studied yet. Future longitudinal studies (such as Isaacs et al., 2013) should include time perspectives and test whether technology-mediated reflection can help balance time perspective profiles.

Fourth, the current measure of time perspectives is based on a questionnaire which makes it easily usable for pre- and post-testing, but difficult to include in continuous usage scenarios. Two previous studies have presented first results for different ways of measuring time perspectives more continuously, based on language analysis (Park et al., 2017) and a combination of Bluetooth proximity sensors to characterize social situations with short follow-up questionnaires (Hernandez et al., 2019). The latter study found that people focus more on past events when interacting with intimate friends, but they focus more on the future when interacting with strangers. More research is needed to develop efficient and theoretically grounded measurements.

### **5.3. Design Implications**

Our studies imply a number of important aspects for the design of reminiscence technologies. First of all, we found reassuring evidence that most of the time technology-mediated reminiscing about positive experiences has an overall positive impact on subjective well-being. Broadly speaking, as long as the material is positive, technology-support seems to be unproblematic. For subjectively negative content we cannot make any recommendations, yet.

Second, and more specifically, we think that future reminiscence technologies should consider the differential impact on user groups with respect to their different time perspective profiles more explicitly. While pre-screening of each user may be too time consuming for technology to be used in everyday life, we believe that some technologies are typically used by people with a certain time perspective profile. For instance, physical photo albums invite positive reminiscence and the typical user group may have a relatively positive past perspective already. This can lead to a mismatch between technology and user group. For example, previous research in time perspective coaching (Boniwell et al., 2014) has suggested the use of “positive portfolios”, which are essentially collections of treasured material that evoke positive emotions. However, they require intentional interaction, which might reduce the frequency of use if people have no such habit yet. For people with a less balanced time perspective, more lightweight forms of interaction could increase the frequency of reminiscing. Thus, a combination of the idea behind the positive portfolio (having a subjectively and carefully curated collection of material), with the idea behind Pensieve (Peesapati et al., 2010) to trigger memories at random times seems to be a promising way to support people with less balanced time perspectives.

In contrast, we found that participants with a more balanced past time perspective experienced the subjective material more positively than the objective material (Study 2). The more explicit consideration of the degree of subjectivity in itself opens up an interesting dimension along which we can think about reminiscence technologies. Existing material on the “subjective” end include expressive writing (Burton & King, 2004) or drawings, or image manipulation (e.g., in Mols et al., 2017, 2020), while unaltered photos and videos are more objective representations. Our findings suggest that new forms of assistance in expressing the subjective perspective of a memory may be especially appropriate for participants with a balanced time perspective.

Third, and in relation with the above, time perspective coaching (Boniwell et al., 2014) aims to change time perspectives to make them more balanced. While this is generally good, once we build technologies

for a specific target group the requirements for technological support may change, if the person changes. More subtle and reliable measures based on for example, automatic language analysis (Park et al., 2017) may help to build adaptive systems that could reflect that change through memory selection or by providing different representations. However, while we found differences in affect based on different categories of material (objective/subjective), we believe that this problem actually touches on an even broader topic. Across the life span, the same person remembers different details about the same experience from the past, depending on their current understanding of themselves in the present (Conway, 2005). Thus, if we set out to build adaptive reminiscence technologies, we need to bridge the two complementary processes of reminiscence and reflection. Reminiscence represents a source for positive emotions, but reinterpreting the past experiences and adapting them to the current situation is a core concern of reflection technologies (e.g., Isaacs et al., 2013; Konrad, Isaacs, & Whittaker, 2016; Konrad, Tucker, et al., 2016; Mols et al., 2016b). In order to ensure the long-term usefulness of reminiscence technologies, insights from both fields need to be combined.

## **6. CONCLUSION**

We began this article with a subjective view on life as a story based on personal experiences and our interpretation of them. Reminiscing about positive experiences can contribute to a more positive relationship with our past by highlighting personal moments of happiness. An evaluative view on life is always based on a subjective selection of details and people who believe their life so far was good, overall, may simply be better at choosing more positive experiences to savor. Depending on individual time perspectives, reminiscence technologies can support people in identifying personal highlights, can help them to interpret past experiences more positively in general, and prompt them to revel in them as often as possible. Our paper is a start to systematically explore different elements of successful reminiscing technologies beyond single case studies. Hopefully, this lays the foundation for a more comprehensive theory of technology-mediated reminiscing to support well-being.

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## APPENDIX A. STUDY 1

### A1. Item Exclusion

Round	Excluded Items	Cronbach's alpha
0	none (baseline)	.62
1	“Ich ertappe mich selbst dabei, wie ich mich ausklinke, wenn sich andere Familienmitglieder über vergangene Zeiten unterhalten.” “I find myself tuning out when family members talk about the way things used to be.”	.67
2	“Ich ertappe mich häufig selbst dabei, wie ich von der Aufregung des Augenblicks mitgerissen werde.” “I find myself getting swept up in the excitement of the moment.”	.69
3	“Wenn ich könnte, würde ich jeden Tag so leben, als wäre er mein letzter.” “Ideally, I would live each day as if it were my last.” “Meine Entscheidungen sind meistens von den Menschen und Dingen um mich herum beeinflusst.” “My decisions are mostly influenced by people and things around me.”	.72

Item exclusion process for the past positive scale in Study 1. The two items in the third step both led to an expected Cronbach's alpha of .70, thus we opted to exclude both.

## A2. Experimental Vignettes

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Factor levels	Text
mediated, ext. trigger	You are sitting at your work place around noon and do a lot of paper work. Probably this work will last for the rest of the day. You take your smartphone out briefly and you see a reminder of your new “memory trace” app, suggesting you take a short break. With this app you can look at nice events from your life. You click “start” and it shows you some images from the experience you have just described. While you browse through the images, you feel vividly put back into the situation, with all its facets. After you have stayed in this memory for long enough, you put your smartphone aside and continue your work.
mediated, intentional	You are sitting at your work place around noon and do a lot of paper work. Probably this work will last for the rest of the day. But first you take a break. So you take your smartphone out and open your new “memory trace” app. With this app you can look at nice events from your life. You click “start” and it shows you some images from the experience you have just described. While you browse through the images, you feel vividly put back into the situation, with all its facets. After you have stayed in this memory for long enough, you put your smartphone aside and continue your work.
unmediated, ext. trigger	You are sitting at your work place around noon and do a lot of paper work. Probably this work will last for the rest of the day. You look around the room and somehow you have think about the event you have described earlier. Because you could use a break now anyway, you close your eyes. You think back to this situation and the images already come back to your mind. You feel vividly put back into the situation, with all its facets. After you have stayed in this memory for long enough, you open your eyes and continue your work.
unmediated, intentional	You are sitting at your work place around noon and do a lot of paper work. Probably this work will last for the rest of the day. But first you take a break. So you close your eyes. You think back to the situation you have described earlier and the images already come back to your mind. You feel vividly put back into the situation, with all its facets. After you have stayed in this memory for long enough, you open your eyes and continue your work.

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The experimental vignettes used in Study 1.



### A3. Factor Independence

Factor	Level	“low DBTP”	“high DBTP”	Total	$\chi^2$	p	odds ratio
Mediation	Unmediated	43	39	82	0.68	.41	1.10
	Mediated	32	38	70			0.84
Trigger	Intentional	37	45	82	1.27	.26	0.82
	External Trigger	38	32	70			1.19
Memory Type	Everyday Memory	42	44	86	0.02	.89	0.95
	Entire Life Memory	33	33	66			1.00
Gender	Female	64	61	125		.53 <sup>F</sup>	1.05
	Male	11	14	25			0.79
	Other/no reply	0	2	2			0.00

Test results of factor and gender independence in Study 1, using Pearson’s Chi Square test (top three factors) and Fisher’s exact test (Gender, because of an expected frequency lower than 5 in the “Other/Diverse” group). DBTP = “Deviation from Balanced Time Perspective”. The odds ratio refers to the “low DBTP” participants (numerator) relative to the “high DBTP” participants (denominator).

## APPENDIX B. STUDY 2

### B1. Integration Questionnaire

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Nr.	Text
1.	...eine existierende Gewohnheit stören. (inverted) ...disturb an existing habit. (inverted)
2.	...mein Verhältnis zu meiner Vergangenheit verbessern. ...improve my relation with my past.
3.	...meine Erinnerungen schöner machen. ...make my memories more beautiful.
4.	...mir gut tun. ...be good for me.
5.	...sich ganz natürlich in meinen Alltag einbetten. ...integrate naturally in my everyday life.
6.	...eher Probleme verursachen. (inverted) ...rather cause problems. (inverted)

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The six items of the integration questionnaire with an English translation.

## B2. Factor Independence

Factor	Level	“low DBTP”	“high DBTP”	Total	$\chi^2$	p	odds ratio
Realism	Objective	28	34	62	.97	.33	0.82
	Subjective	34	29	63			1.17
Flexibility	Flexible	30	32	62	.07	.79	0.94
	Fixed	32	31	63			1.03
Need	Relatedness	29	29	58	.01	.93	1.00
	Popularity	33	34	67			0.97
Gender	Female	51	47	98		.68 <sup>F</sup>	1.09
	Male	10	15	25			0.67
	Diverse/no reply	1	1	2			1.00

Test results of factor and gender independence in Study 2, using Pearson’s Chi Square test (top three factors) and Fisher’s exact test (Gender, because of an expected frequency lower than 5 in the “Other/Diverse” group). DBTP = “Deviation from Balanced Time Perspective”. The odds ratio refers to the “low DBTP” participants (numerator) relative to the “high DBTP” participants (denominator).