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## Understanding Autobiographical Memory in the Digital Age: The AMEDIA-Model

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### ABSTRACT

Recent technological developments have led to an increased density of recorded life episodes. To understand how creating and sharing such immense amounts of data shapes the way individuals remember their past, we propose a model for autobiographical memory in the digital age (AMEDIA-Model) that systematizes the existing literature and sketches avenues for future research. The model views autobiographical remembering in the digital age as the result of the iterative process of combining information stored in the mind and information stored in the environment using high-tech applications. Moreover, the way autobiographical memories are (re-)constructed crucially depends on the way the information has been encoded and curated: Autobiographical remembering in the digital age is not a uniform process but is fundamentally shaped by the technology and the data that is being used. The AMEDIA-Model offers a framework for understanding technology-mediated human cognition in the twenty-first century.



### KEYWORDS

Autobiographical memory; digital age; external memory; internal memory; social media

As early as in 1945, Vannevar Bush imagined a desk-like device called “memex” that would enable individuals to store information ranging from books and newspapers to their personal communication and to retrieve this information whenever they want. Bush thought of the memex as a flexible and dynamic device that would work in an associative manner by connecting related content, similar to human memory (see also Jones, 1986). As it seems, our present-day societies are closer to a realization of this vision than any society before (cf. Bell & Gemmell, 2009): For an increasing number of individuals, living in the digital age means creating and sharing immense amounts of data. Recent estimates state that approximately five billion people worldwide are active on the Internet, and approximately 4.65 billion are social media users (Domo, 2022). In each minute of 2023, these users sent about 241 million emails, 41.6 million *WhatsApp* messages, and 360,000 tweets, shared about 694,000 reels via direct messages on *Instagram*, and liked 4 million posts on *Facebook* (Domo, 2023). From a more abstract point of view, these numbers point to several important characteristics of living in the digital age (see also Marsh & Rajaram, 2019). Maybe most importantly, the fact that great amounts of personal data can easily be stored and shared leads to an *increased density of recorded life episodes* (Heersmink & Carter, 2020; Kalnikaitė & Whittaker, 2012). That is, people living in the twenty-first century tend to preserve much more information about their private and professional lives than previous generations. In addition, the recorded content can often be accessed anywhere at any

time (Elsden, Kirk, et al., 2016; Heersmink, 2020) and can be searched and analyzed (cf. Clowes, 2013; Eliseev & Marsh, 2021). Moreover, the stored information typically represents a combination of different media sources, including but not limited to written text, photos, videos, and audio recordings (Konrad et al., 2016).

Arguably, the fact that the development and proliferation of mobile, digital technologies have simplified documenting one’s lived life to an astonishing extent could have far-reaching consequences for autobiographical remembering. From an optimist’s point of view, technology-mediated autobiographical remembering in the digital age could help to *compensate the weaknesses of human memory* by reducing biases and memory distortions (Bell & Gemmell, 2009; Burkell, 2016; Harvey et al., 2016). While human memory is highly reconstructive and therefore prone to errors, omissions, and confabulations, an externally stored life history could potentially provide a stable and accurate representation of past events that can be accessed to verify and—if needed—to correct our subjective perceptions. This also implies unprecedented possibilities for *memory augmentation* (Harvey et al., 2016; Heersmink, 2020; Loveday & Conway, 2011): Using the respective technology would allow us to create a rich and multimedia-based record of ordinary everyday events just as the personally important moments in our lives, ultimately enabling us to remember our past in greater detail. This should also *make it easier to narrate our lives* (Heersmink & Carter, 2020; see also Crete-Nishihata et al., 2012), as we could always turn to our digital memories in case we feel

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unsure about the order of events, our experiences and feelings at a certain point in time, or some other aspect of an episode from the past. Apart from that, having access to a virtually limitless storage space would enable *cognitive offloading* (Clark, 2015; Eliseev & Marsh, 2021; Heersmink & Carter, 2020; Lynch, 2016; Schönplflug & Esser, 1995; van den Hoven, 2014). In other words, it would be possible to store information that we consider important to remember but that we do not necessarily need to keep readily available in our own minds in a digital format and to retrieve this information whenever needed.

However, such an optimistic outlook is met with serious criticism by others who hold a more pessimist view. First, rather than increasing, the available technology could be *undermining our autonomy* (Burkell, 2016; Heersmink, 2017; Heersmink & Carter, 2020). This claim has two interrelated aspects. On the one hand, cognitive offloading could—as practical as it might seem at first sight—increase our dependency on the digital records of our lives: When the digital record is lost, everything is lost. On the other hand, narrating our lives requires at least some room for the creative interpretation of the events of our lives and their meaning (cf. McAdams, 2008). In this context, the weight of the seemingly objective facts could restrict the necessary narrative freedom in an unwelcome way. The latter aspect also points to the *adaptive function of forgetting* (Heersmink, 2017; Heersmink & Carter, 2020; Koops, 2011; Jacquemard et al., 2014; Mayer-Schönberger, 2009; Storm & Soares, *in press*; van House & Churchill, 2008). In the lives of many people, there are at least some episodes that they may prefer not to be reminded of because bringing them up again would potentially lead to negative emotions and social conflicts (e.g., remembering how angry and disappointed one was when hurt by a loved one). In a world of technology-mediated autobiographical remembering, avoiding such memories could become increasingly difficult—especially when the digital records are permanent and cannot be edited or deleted by the users. Apart from that, concerns regarding *privacy and surveillance* have also received considerable attention (Harvey et al., 2016; Jacquemard et al., 2014), as the collection of highly detailed and intimate data about all aspects of our lives could be used for ethically questionable purposes in case the wrong person, company, or government gains access to it. Last but not least, storage and file formats have undergone constant changes over the last years and decades, demonstrating that the *longevity of digital content is not guaranteed* (Blum & Beyer, 2019; Petrelli & Whittaker, 2010; van den Hoven et al., 2012; van House & Churchill, 2008). Quite the contrary, digital content typically becomes inaccessible when it is not updated on a regular basis while older, non-digital media for storing personal information such as books and paper diaries can survive centuries.

So should we rather be optimistic or pessimistic regarding the future of autobiographical remembering in the digital age? There is probably no easy answer to this question. Usually, new technologies tend to have complex and multi-layered effects on individuals and societies, which are not simply black or white; that is, the question whether digital technologies have desirable *or* problematic effects on

autobiographical remembering is likely to be too superficial to account for the complexity of reality (cf. Appel et al., 2020; Orben & Przybylski, 2019). Hence, what is needed and what we will provide in the next section is a nuanced model for Autobiographical Memory in the Digital Age (AMEDIA-Model). Through integrating the available empirical evidence on different sub-aspects of autobiographical remembering involving high-tech devices and applications as well as through connecting previously unrelated theory on non-technological autobiographical memory and technology-mediated remembering, our AMEDIA-Model provides the first systematic and comprehensive framework for understanding autobiographical memory in the digital age. Based on a strong foundation of established theoretical considerations and empirical findings, the AMEDIA-Model can help us to go beyond what is already known and to organize future research. Ultimately, the AMEDIA-Model will also enable us to get back to the question about the nature of the changes to autobiographical memory in the digital age and to the risks and benefits potentially associated with these changes.

### Thinking About the Future of Autobiographical Memory: The AMEDIA-Model

Let us begin with an example: Imagine that you are thinking about your summer vacation from two years ago. You try to remember what you did and when. While you can still recall spending three days in City A, you are not quite sure whether your stay in City B lasted for two or three days and whether you directly traveled from City A to City B or whether you spent one night elsewhere in-between. Hence, you decide to pick up your smartphone and to scroll through the pictures that you took during your vacation. As you quickly realize, you did indeed travel directly from City A to City B. However, you also stopped in a nice little town by the sea for a few hours. The photos you took verify this. Seeing these photos, you now also remember that a live band was playing in the café where you were having a cup of coffee and that you enjoyed the concert very much. Unfortunately, you have neither a photo nor a recording of the band's performance, but you are quite sure that you made a note of the band's name at the time. In fact, you find an entry in your smartphone's notes app that gives you the information that you were looking for. Therefore, you decide to play the band's latest album in the background while you continue scrolling through the photos of your vacation. As you listen to the music, various memories come to your mind. For example, you see yourself walking along the beach with your partner—and you remember how relaxed you felt during that vacation.

What exactly happens when you see the pictures of the nice little town by the sea that you visited two years ago? From a naïve point of view, one might argue that the pictures simply work as *cues* for your memory: Before seeing the pictures, you could not access your memories of spending a few hours in the nice little town by the sea, but once you have seen them, you can. This is, however, not the full story. As the example illustrates, seeing the pictures leads to a whole cascade of mental processes and actual behavior. It

results in an ongoing interaction with the recorded material, potentially leading remembering in directions that were not foreseen or intended when beginning the process. In our example, the process of remembering began with the question whether you directly traveled from City A to City B and ended with listening to music while continuing to reminisce about the good time that you had.

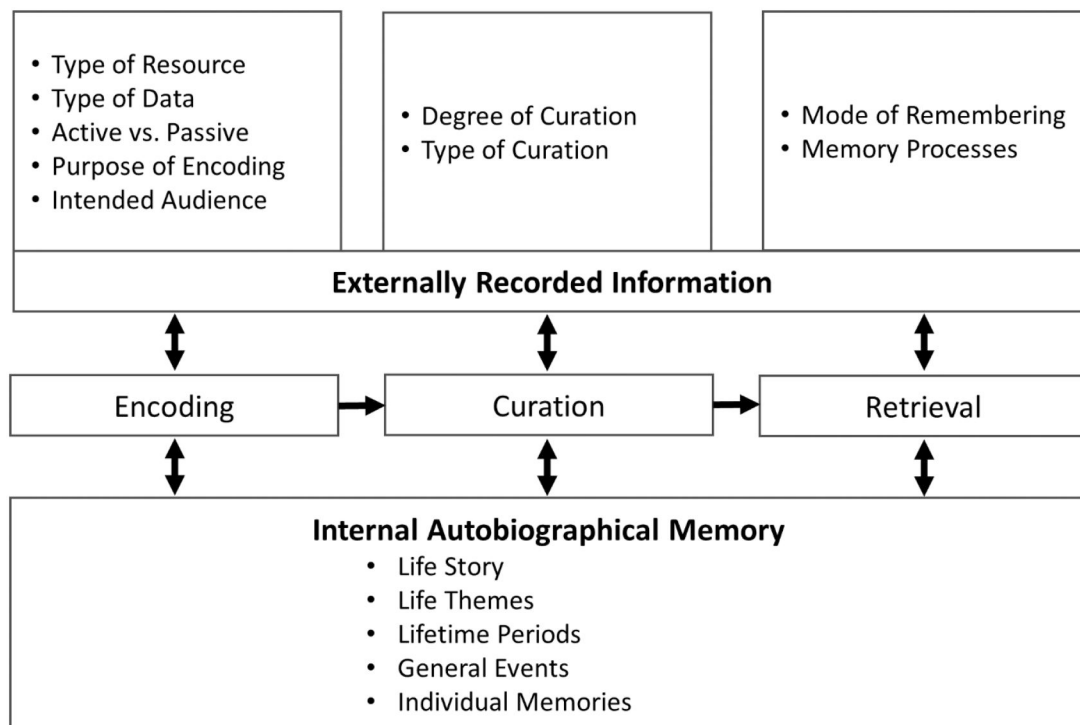
## Model Overview

This example can help to illustrate the main ideas of the AMEDIA-Model that we propose (see Figure 1). To begin with, we follow the basic distinction made by various authors over the last decades between *internal memories* that individuals keep in their minds and *externally recorded information* that is stored in their environment (e.g., Donald, 1991, 2001; Finley et al., 2018; Heersmink & Carter, 2020; Michaelian & Sutton, 2013; Nestojko et al., 2013; Schönplflug 1986a, 1986b; Sutton, 2015; see also Finley & Naaz, 2022). More specifically, an individual may have certain internal memories about their last summer vacation (e.g., whom the vacation was spent with, what happened at a particular day at the beach) but may also possess some externally recorded information (e.g., photos, videos, audio recording, notes). To be clear, not all of this internally or externally stored information is autobiographical in nature (see below for our definition of autobiographical memory). Therefore, our goal in the following will not be to capture the relation between internally and externally stored

information in general but only insofar as it concerns autobiographical memory and autobiographical remembering.

Crucially, we propose that internal autobiographical memories and external records *work in concert* to bring about autobiographical remembering; that is, autobiographical remembering in the digital age can be viewed as the result of the iterative process of combining information stored in the mind and information stored in the environment using high-tech devices and applications (for similar ideas, see, e.g., Schönplflug, 1986a, 1986b; Schönplflug & Esser, 1995; Esser, 1996; Finley et al., 2018; 2022). This does not, of course, mean that internally and externally stored information have the same characteristics or follow the same principles of organization. Obviously, the fact that internal autobiographical memories are stored in the mind, which is bound to the human cognitive, biological, and neural structure, while high-tech external resources rely on the data formats and processing characteristics of digital tools, goes hand in hand with certain strengths and weaknesses in each case (see Donald, 1991; Finley et al., 2018).

Fleshing out these ideas entails a twofold task: (1) to describe the *structure* of autobiographical memories as they are stored in our minds and to provide a precise description of the external resources that are used for autobiographical remembering, and (2) to analyze the interactions between autobiographical memories and externally stored information that lead to the (re-)construction of past events (i.e., the *process* of encoding, curating, and retrieving autobiographical memories).



**Figure 1.** Autobiographical memory in the digital age: model overview. The AMEDIA-Model views autobiographical remembering in the digital age as the result of the iterative process of combining information stored in the mind (*internal autobiographical memory*) and information stored in the environment (*externally recorded information*) using high-tech devices and applications. Internal autobiographical memory is organized in a hierarchical structure in which knowledge about general events and lifetime periods is built on individual memories that are integrated into life themes and a life story. The way autobiographical memories are constructed and reconstructed during retrieval crucially depends on the way the information has been encoded and curated. Autobiographical remembering in the digital age is namely not a uniform process but is fundamentally shaped by the kinds of technology and the kinds of data that are being used.



## Structural Components of the AMEDIA-Model: Internal Autobiographical Memory and Externally Recorded Information

### Internal Autobiographical Memory

In short, autobiographical memory can be defined as “self-referenced memory of personal experiences in the service of short-term and long-term goals that define identity and purpose” (Fivush, 2011, p. 561). This definition contains several important elements. To begin with, it allows distinguishing autobiographical from merely episodic memories. Episodic memories are memories of specific events that happened at a specific time at a specific place (Tulving, 1972, 2002). In addition to the information about the what, where, and when of an event, autobiographical memories also contain the awareness of the self having experienced the event in the past (i.e., *autonoetic consciousness*), that is, the notion that the person who is remembering the event now is the same as the person who experienced the event in the past (cf. Nelson & Fivush, 2004). Beside these autobiographical memories in a narrower sense, however, individuals may also refer to and make use of abstract knowledge about their lives (i.e., *personal semantics*; Renoult et al., 2012) including autobiographical facts (e.g., “My sister’s name is Maria”) and self-knowledge (e.g., “I am an open-minded person”) when engaging in autobiographical remembering. In any case, autobiographical memories perform several important functions in everyday life (Bluck et al., 2005): They can help us to learn from our past, that is, they can help to guide our future thinking and behavior and to avoid repeating the mistakes of the past (*directive function*). They support developing and maintaining social relations with others by providing material for conversations, giving us the opportunity to empathize with each other and to arrive at a better understanding of the other person (*social function*). Finally, they help us to maintain a sense of continuity of our self (*self function*).

Importantly, autobiographical memories do not exist in isolation but are integrated into larger and hierarchically structured units. More specifically, autobiographical memories can often be condensed into *general events*, which are related to certain *lifetime periods*, which are in turn related to personally important *themes* (Conway & Pleydell-Pearce, 2000; Conway, 2005). For instance, someone who is remembering their past relationships (i.e., a particular autobiographical theme) may think about the high school years (i.e., a particular lifetime period) and the things the person was typically doing when going on a date with their first great love (i.e., knowledge about a general event). On the highest level of abstraction, autobiographical memories can be woven into a *life story*. This life story, which typically begins to emerge in late adolescence (Habermas & Bluck, 2000; Habermas & Reese, 2015), helps us develop a narrative identity that connects our past to our present (McAdams & McLean, 2013; McAdams & Olson, 2010; Singer, 2004). In other words, creating a life story provides stability to our existence and therefore plays a central role in the development of the self

(McLean et al., 2007) as well as in achieving subjective well-being (Adler et al., 2016).

This also implies that the content and especially the interpretation of autobiographical memories is not fixed but may change, depending on our individual goals as well as the themes that are important at a particular point in our life (Conway, 2005): That is, the currently active goals crucially shape which new information is encoded, which old information can be retrieved from long-term memory, and how this retrieved information is interpreted and narrated. Arguably, this can create a tension between *coherence* and *correspondence* (cf. Conway, 2005). On the one hand, individuals are inclined to make their memories fit in with their current goals and needs (i.e., they strive for coherence between the different strands of their life story). On the other hand, they need to maintain an accurate record of the events of their lives in order not to run into conflicts with reality (i.e., there needs to be sufficient correspondence between the facts and the way individuals tell their lives). As these considerations make clear, autobiographical remembering is a highly constructive and reconstructive process.

### External Resources for Autobiographical Remembering

In the process of constructing and reconstructing memories, humans make use of external resources or external memory aids. This is not an invention of the digital age. Quite the contrary, humans have created external records to support remembering for thousands of years, ranging from oral traditions and cave paintings to archives, monuments, bodily practices, and printed books (cf. Donald, 1991, 2001; for a more recent overview, see Heersmink, *in press*). When such techniques are used by groups or societies, one commonly speaks of *cultural memory* (Assmann, 2012; Wertsch & Roediger, 2008). In the context of the AMEDIA-Model, however, we are mainly concerned with the ways *individuals* use external resources to store information and to (re-)construct autobiographical memories. In doing so, we follow the taxonomy proposed by Finley et al. (2018) who suggest to distinguish between social, low-tech and high-tech external resources (for a different taxonomy, see Sutton, 2015). *Social* resources for autobiographical remembering are other individuals who also have memories of a certain event or period of time. Sometimes, this is also referred to as *transactive memory* (Wegner et al., 1985; for a review, see, e.g., Huebner, 2016; Peltokorpi, 2008). When trying to remember the last summer vacation, for example, you may decide to talk to the people with whom you spent this vacation. As each individual remembers certain aspects or details that the other individuals do not remember, the combination of the individual memories in a joint communicative effort can help to create a more complete, more detailed, and more diverse memory of the things that happened during the vacation. In other words, the shared memory of the last summer vacation is the result of the memories of individuals working in concert. As a result of the social interaction, this shared memory may have properties that were not already contained in the individual memories. Importantly, transactive memory systems can also be

used intentionally by deciding who will try to remember what (e.g., based on the individuals' expertise). When preparing a vacation, for instance, one person may be responsible for memorizing information about certain sights, while another person takes care of more practical aspects (e.g., remembering how to get from the hotel to the train station).

In contrast to socially based memory aids, both low-tech and high-tech external resources refer to "information stored in the inanimate environment" (Finley et al., 2018, p. 5): While *low-tech* external resources do not require a power source to operate (e.g., paper, printed photos, material objects), *high-tech* external resources do (e.g., smartphone, computer). Sometimes, high-tech external resources are also described as *electronic memory* or *E-memory* (Clowes, 2013; see also Bell & Gemmell, 2009). Against the background of these theoretical distinctions, asking how autobiographical memory might change in the digital age means trying to understand how high-tech external resources shape (re-)constructing autobiographical memories. From our point of view, two aspects need emphasis here. First, "high-tech external resources" is a very broad umbrella term encompassing applications that are in fact not that different from their low-tech counterparts (e.g., an app for taking notes versus taking handwritten notes on a piece of paper) as well as applications that did not exist prior to the digital age and that clearly represent a new technological development (e.g., social media, automatic location tracking). Put differently, taking different types of technology into account when analyzing autobiographical memory in the digital age seems to be an important precondition for arriving at meaningful conclusions. This is also why we will organize our theoretical integration of findings along several dimensions that might play an important role in this context. Second, using the term "high-tech external resources", however, to designate what is new in the digital age seems justified, as most, if not all, of these resources share certain characteristics and affordances (cf. Gibson, 1979): First, they contribute to increasing the density of recorded life episodes (e.g., because they have overcome previous recording and storage limits and because they enable the automatic tracking of information); second, they lead to a searchable database (because the recorded data is available in a digital format); third, this digital database consists of a combination of different media sources (e.g., photos, videos, audio recordings, text, quantitative parameters); and fourth, this database can often be accessed anywhere at any time (e.g., because it is stored on one's smartphone or in a cloud system).

### Process Components of the AMEDIA-Model: Encoding, Curating, Retrieving

When speaking about the process of constructing and reconstructing autobiographical memories in the digital age, it is helpful to distinguish between three steps: *encoding*, *curating*, and *retrieving*. Although the example that we introduced to illustrate the main ideas of our AMEDIA-Model mainly focused on the way information is retrieved, neither the encoding stage nor the processes of organizing and curating

the encoded information can be neglected when trying to understand autobiographical memory in the digital age, especially because the way information is encoded and curated may have effects on the way this information is later retrieved and used. Moreover, it can be assumed that current life goals and themes not only influence to which aspects of our environment we direct our attention and which aspects we will try to preserve for later (encoding), but also which of the stored information we find important or worth exploring in detail (curating), as well as how and when we will try to remember what kind of aspect of our personal past (retrieval; cf. Conway, 2005). When analyzing and integrating the existing theoretical and empirical evidence in the following section, we consequently devote the first two subsections to encoding and curation before proceeding with the different processes of retrieving. Note that research regarding autobiographical memory in the digital age is still relatively limited, which is why we will sometimes provide informed speculations and sketch avenues for future research rather than offer empirically substantiated answers.

### Encoding

Encoding autobiographical information is always a matter of selection.<sup>1</sup> This applies to both internally and externally encoding. As far as internal autobiographical memory is concerned, it is well known, for instance, that emotional events are preferentially encoded compared to neutral events (Ochsner, 2000; Qasim et al., 2023) and that information on which we decide to focus our attention (e.g., because we find it important) will be remembered better (Aly & Turk-Browne, 2017; Driver, 2001). Although one might initially assume that the same applies to externally recorded information in the sense that individuals will encode more external information about important and emotional events, the situation is actually more complex: While internal autobiographical memories are inextricably bound to the cognitive architecture of our minds and brains, individuals have much more degrees of freedom regarding the way they encode information in external resources. In the following, we consider some crucial distinctions that might have an impact on autobiographical remembering in the digital age.

### Type of External Resource—Digital Substitutes Versus Innovative Tools

As already mentioned, we assume that all high-tech external resources share certain characteristics insofar as they tend to increase the density of recorded life episodes and contribute to creating a searchable database consisting of a combination of different media sources that can often be accessed anywhere at any time. Despite these commonalities, not all high-tech external resources are alike: We suggest sorting the

<sup>1</sup>This even applies in case individuals should decide to continuously record certain information about their lives (e.g., by using a video camera or by tracking their heart rate and location 24/7): Recording *absolutely everything* is virtually impossible as this would require recording the entire multidimensionality of our lives (including thoughts and feelings) in every single moment.

available high-tech external resources along a dimension that ranges from *digital substitutes* to *innovative tools*. In the case of a digital substitute, an already existing low-tech tool is simply replaced by its digital counterpart. In contrast, *innovative tools* did not exist prior to the digital age, offer a wide range of new possibilities, and come with new affordances (cf. Gibson, 1979). To get a better understanding of this continuum, let us consider three examples. First, taking notes in an app instead of taking notes on a piece of paper: This could be seen as the classic case of a digital substitute. However, even this digital substitute should not be considered a digital *equivalent* in the strictest sense of the word as the high-tech version of taking notes differs from the low-tech version with respect to the dimensions described above. Second, smartphone cameras—which could be considered to be located somewhere in the middle between digital substitutes and innovative tools—do not only surpass traditional cameras because they have overcome previous storage limits and are arguably more convenient to use, but also because digital photos can easily be modified (e.g., through applying filters), contain a wide range of metadata (e.g., information about when and where the photo was taken), and have transformed the photo-taking practices of individuals, most notably by leading to the wide-spread adoption of selfies (cf. Dinhopf & Gretzel, 2016). Third, social media and the internet allow sharing information about one's life with a broader audience, which sets them apart from some of the other high-tech resources (cf. Stone & Zwolinski, 2022). Notably, the consequences of using these tools for autobiographical remembering are likely to depend on the characteristics of the specific platform. For instance, people who write a blog on a personal web page (“macroblogging”) usually reflect upon specific aspects of their lives that they have chosen for self-presentation, often trying to tell a coherent story; in contrast, posting about one's whereabouts on social media (“microblogging”) relies much less on narrative integration but rather focuses instead on immediate sharing with others, nevertheless leaving a more or less permanent digital trace (Wang, 2013, 2021). These three examples already make it clear that the way an individual remembers autobiographical events in the digital age may crucially depend on the kind of external resource being used and the kind of data being recorded; that is, researchers investigating autobiographical remembering in the digital age will have to be explicit about the specific context and technology they are dealing with. Note also that what counts as an innovative tool may change over time as new technologies emerge. In the following subsections, we consider at least some of the potential dimensions that might be important for making further distinctions among the different high-tech external resources.

### **Type of Data—Qualitative Versus Quantitative**

Regarding the type of data that individuals record, we propose to distinguish between *quantitative* (e.g., location tracking, sleep patterns, mood ratings) and *qualitative* (e.g., text, photos, audio recordings) data. Strategies for collecting *quantitative* data about oneself are often referred to as lifelogging techniques and are sometimes associated with the quantified

self movement (Lupton, 2016; Selke, 2016). Quantitative data that can be recorded using smartphones and wearables (e.g., smartwatches, activity trackers, smartglasses) include health data (e.g., heart rate, sleep cycle, blood pressure) and various activity parameters (e.g., steps walked, calories burned; for a review, see Ribeiro et al., 2022). Although quantitative data can also be used to document one's life and to reflect upon long-term trends and developments as well as personal priorities and aspirations (Trace & Zhang, 2019), the primary goal of lifelogging usually seems to be the identification of behavioral patterns that are used for improving the quality of one's life (for a review, see Kersten-van Dijk et al., 2017). Obtaining meaningful quantitative data has proven difficult as individuals tend to track too many aspects of their lives while forgetting to record relevant contexts and triggers that could help analyzing the data later (Choe et al., 2014).

While quantitative data offer a rather formal and—at least seemingly—objective perspective on an individual's life, it should not be forgotten that even quantitative data never speak for themselves but need to be interpreted. When a wearable indicates a significant reduction in one's daily activities, for instance, this may have various reasons ranging from physical health issues (e.g., being sick, having had an accident) to psychological problems (e.g., depression) and problems with the software (e.g., having forgotten to enable the tracking). Despite the need to contextualize quantitative data, *qualitative* data give users even more room for interpretation and for reconstructing past events (Elsden, Kirk, et al., 2016), arguably because they provide richer and more diverse information about autobiographical events, including perceptual details (e.g., in the case of photos and videos) and insights into one's thoughts and motivations (e.g., in the case of text entries in a diary). Notably, the immersive potential of qualitative information may reach unprecedented levels using virtual reality environments that can simulate the multimodality and vividness of real-life experiences (Kisker et al., 2021; Schöne et al., 2019). Indeed, there is at least some preliminary evidence that recalling positive autobiographical events in a virtual reality setting that reinstates the environment of the original event can have positive effects on affect and emotion regulation (Fernandez-Alvarez et al., 2021).

Of course, individual users of digital technologies can combine quantitative and qualitative data (e.g., by adding text and photos to the tracked itinerary of one's last summer vacation) to acquire a more nuanced picture of their past. In previous research, there have been at least some attempts to combine qualitative and quantitative data: For example, location information and sudden changes in heart rate were connected to images that were taken using a wearable camera (Wang & Tanaka, 2019; see also Bermejo et al., 2020). Further investigating the effects of such combinations of qualitative and quantitative data seems particularly important, as different kinds of data may later support different kinds of memory processes. In this context, one study found that visual (i.e., qualitative) information is best suited for enabling detailed recollection, while locational (i.e., quantitative) information is more useful for reconstructing habits and behavioral patterns (Kalnikaitė et al., 2010).



### **The Individual's Role—Active Versus Passive**

Another important distinction in the context of encoding information in the digital age concerns the role of the individual: Individuals can either *actively* record certain bits of information (e.g., by taking a picture or writing text) or use *passive* recording (e.g., by allowing their phone to track their sleep cycle automatically). In this context, it has been argued that manually taken photos already have a meaning when being taken (because individuals usually have reasons for taking them); in contrast, automatically recorded photos taken with lifelogging cameras such as *SenseCam* or *Narrative Clip* appear more random and only acquire meaning insofar as they offer access to aspects of one's life that one would otherwise not think about (Lee & Ryu, 2020; see also Niforatos et al., 2017). In addition to the automatic tracking of information using technical devices, passive recording can also refer to information recorded by others (e.g., pictures a friend has taken at a birthday party and shared later). In this regard, it has been proposed that actively recorded information will feel more familiar to the individual than information recorded by another person, which also implies that this actively recorded information will be easier to retrieve and to interpret (Finley et al., 2018). However, this assumption still needs to be tested empirically.

### **Purpose of Encoding—Intentional Versus Incidental**

Encoding of personal information can be *intentional* in the sense that a certain bit of information is encoded using an external resource in order to be remembered later (e.g., when using a smart journal). An early suggestion how to understand the intentional encoding of information in external resources comes from Esser (1996; see also Schönplüg & Esser, 1995), who suggests that the decision to record or not to record information in an external store depends on three factors. First, the *importance of recall*: The more important it seems to a person in the moment of experience to recall this experience at a later point in time, the more likely they will rely on an external resource. Although the importance of recall is assumed to be the most important criterion (see also Schönplüg, 1986b), considerations regarding the *effort of storing* (i.e., "How much effort does it cost me to store this information in an external store?") and the *probability of recall* (i.e., "How likely will I be able to retrieve the desired information when using the external store?") also play an important role. When encountering a new or unknown situation, individuals will use these three factors to determine the kind of information they want to store and the kind of external resource they want to use for doing so. However, individuals also establish habits regarding the kind of information they want to encode for reoccurring situations (e.g., documenting one's summer vacation) based on their previous experiences. Creating such *representational scripts* (cf. Esser, 1996) reduces cognitive load, as it frees the individual from the necessity to evaluate the appropriateness of a given external store for known situations. Moreover, it may also facilitate later recall, as individuals will know where to look for the stored information.

Taken together, this suggests that intentionally encoding information in external resources for later retrieval is an effortful process that requires attention (cf. Marsh & Rajaram, 2019). Recent studies suggest that individuals are willing to engage in this effortful process when they expect that the recorded information will serve one of the functions of autobiographical memory described above (Stone et al., 2022; see also Broekhuijsen et al., 2017; Choe et al., 2014; Elsdén, Durrant, et al., 2016; Finley et al., 2018; Soares & Storm, 2022). Individuals thus intentionally encode personal information in high-tech external resources because they assume that it will help them to express themselves and to account for their lives (*self function*), because it provides a basis for sharing their memories with others and for creating a legacy (*social function*), and because it potentially supports them in their goal to learn for the future (*directive function*).

Notably, however, much of the information that individuals store in high-tech external resources and that can be used for reconstructing one's past is recorded *incidentally*, that is, without the intention of creating a permanent archive that can be consulted later. For instance, the primary purpose of instant messaging services such as *WhatsApp* is to have conversations with other people. In a similar vein, posting on social media is often not so much driven by mnemonic goals but rather by social motivations (e.g., informing others about one's experiences; cf. Stone et al., 2022). However, the records of instant messaging conversations as well as one's posts on social media can also be used to reflect upon past events or to bring about memories. Note also that the distinction between intentionally and incidentally encoded information can be combined with the previously discussed dimension of active versus passive encoding. While writing a diary entry or recording a live concert to document one's experiences and to be able to review them later is both active and intentional, sharing photos or videos on social media hoping to get likes and followers is active but incidental in the sense that the information is not posted for memory purposes. In contrast, automatic location tracking is always passive. Depending on whether it is primarily enabled for later review (e.g., to remember one's whereabouts) or rather to get feedback regarding one's fitness level, however, it can either be intentional or incidental. To our knowledge, the differential impact of these different motivations for encoding autobiographical events on later retrieval has not been investigated so far.

### **Intended Audience—Public Versus Private**

The information stored using high-tech external resources can either be kept *private* (i.e., the information is encoded for oneself and not accessible to others) or made *publicly* available (e.g., by sharing them on social media). Arguably, publicly and privately stored information differ in several crucial respects. First, publicly shared information is often optimized for self-presentation and consequently more selective (Marsh & Rajaram, 2019). Second, the fact that the information shared online tends to be curated more



carefully, which also includes reflecting about an event's meaning as well as its key components, leads to a better internal memory for these events compared to information that is not shared (Johnson & Morley, 2021; Wang et al., 2017; see also Stone & Wang, 2019). Third, public and private encoding seem to accentuate different functions of autobiographical memory: In the case of publicly shared information, the social function is particularly prominent, while information that is kept private more strongly serves self-reflection and learning from past experiences (Stone et al., 2022; see also Hou et al., 2022). Interestingly, this can also lead to conflicts: When individuals aim at using a social networking site such as *Facebook*, which is optimized for public self-presentation, also for creating a personal archives of their lives, they may struggle to balance these different purposes (Zhao et al., 2013).

### Summary and Future Directions

In the above subsections, we have reviewed the existing evidence regarding several dimensions that play an important role for understanding the encoding of autobiographical information using high-tech external resources. As it seems, digital technologies indeed have the potential to shift the avenues available for encoding memories and to change the tone and texture of the encoded information. More specifically, it has become clear that a uniform process of autobiographical remembering in the digital age does not exist: The kind of high-tech external resource that individuals use and the kind of data that they record will shape how the encoded events will be reconstructed later on. To give but one example, qualitative information that has been actively encoded and publicly shared (e.g., *Instagram* stories) may contribute to autobiographical remembering in entirely different manner than quantitative information that has been passively encoded and kept private (e.g., running statistics, data collected by wearables). This has important implications for researchers: Given the lack of empirical studies regarding many of the aspects covered in this section, it seems desirable to design such empirical studies that allow for contrasting the different dimensions and their combinations as well as taking into account the different affordances of different platforms. Note also that the dimensions presented here do not provide an exhaustive list. For instance, the specific context of encoding (e.g., recording information in a private setting versus in a work environment) or the effects of encoding on the event that is being encoded could also be taken into account. Regarding the latter, it has been demonstrated that taking photos can increase the enjoyment of an event but less likely so when the photo-taking creates interference or the event is already highly enjoyable (Diehl et al., 2016; Nardini et al., 2019).

### Curation

When describing the process of (autobiographical) remembering, memory models usually distinguish between the three stages of encoding, storage, and retrieval. In our

AMEDIA-Model, we have replaced the term “storage” with the term “curation” to designate that externally recorded information is not necessarily simply kept in a (digital) storage space (such as one's hard drive, smartphone, or social media profile) until it is used for retrieval but that the material can be changed, rearranged, and reorganized. In fact, it has repeatedly been demonstrated that the captured data *need to be curated* in order to become meaningful (Banks, 2011; van den Hoven et al., 2012). In other words, while it is commonly accepted that the retrieval of autobiographical memories is a reconstructive process, we additionally emphasize that storing externally recorded information is not necessarily passive but can be deeply reconstructive as well. As we see it, acknowledging the dynamic nature of the curation process is essential for understanding autobiographical remembering in the digital age.

### Degree of Curation—From No Curation to Active Curation

Broadly speaking, there are two ways of dealing with information that has been encoded and stored in high-tech external resources: It can be kept as an unorganized accumulation of various kinds of data—or it can be curated (e.g., by rearranging, structuring, and integrating the recorded content). In previous research, it has been argued that active curation is preferable to no curation from the standpoint of autobiographical remembering because unorganized collections of an abundance of data make finding relevant information more complicated and because meaning-making requires prioritizing some aspects of one's life over others (Kalnikaitė et al., 2010; Sas & Whittaker, 2013; Whittaker et al., 2012). Interestingly, however, active curation seems to be used less frequently than one might intuitively assume given its importance for later remembering. This not only refers to incidentally encoded information (such as *WhatsApp* conversations) but also to information that is encoded actively and intentionally: Many of the photos that individuals take are never looked at again, slowly being forgotten on old smartphones and hard drives (Whittaker et al., 2010). Of course, sometimes some degree of curation is already achieved *through encoding*; that is, individuals purposefully decide which photos to take or what to post on social media, automatically limiting the kind of data that can be used later for reconstructing past memories (cf. Zhao et al., 2013). Nevertheless, the question of how to curate the vast amounts of data that each individual almost automatically produces in the digital age remains pressing (cf. Dang-Nguyen et al., 2018).

### Type of Curation—Human Versus Algorithmic Curation

There are many curatorial practices in which individuals might engage to organize their externally recorded information, such as changing the names of data files, putting related data files in a common folder, and adding tags or keywords so that the information can be retrieved more easily. Again, the available curatorial practices are likely to depend on the kind of tool and the kind of data individuals have stored. Here, we consider three exemplary curatorial

practices regarding which there is at least some preliminary evidence. First, individuals may decide to enhance and change recorded content, for instance by adding filters to photos. There may be various motivations for doing so, ranging from improving self-presentation and fostering social interactions to enjoyment and playful exploration (Javornik et al., 2022). Importantly, enhancing and changing recorded content is not restricted to photos but may also include rewriting diary entries (e.g., because one's evaluation of a past event changed in the light of new information) or making manual adjustments to one's running statistics (e.g., when assuming that the automatic tracking device made a mistake). Second, sharing information with others can also be considered a curatorial practice as it involves selecting the information that an individual wants to present and as it invites others to join the curatorial process by liking the shared content or by commenting on it (cf. Stone & Zwolinski, 2022). Again, the motivations behind sharing information with others may be manifold (Stone et al., 2022): While experiences may be shared for purposes related to the self and memory (*self function*; e.g., documenting autobiographical events, recording thoughts and feelings) or to achieve a certain directive goal (*directive function*; e.g., sharing useful information, influencing the way other people think), for instance, the most prominent motivation behind sharing autobiographical information online seems to be related to social goals (*social function*; e.g., staying in touch with friends, feeling close to others). Third, individuals may decide to delete recorded content, for instance, because a certain offloading goal has been completed (e.g., one has ordered the product of which one had taken a photo) or because one does not find the content esthetically pleasing enough (Soares, 2023). Interestingly, it has been shown that individuals can intentionally forget and suppress autobiographical memories (Barnier et al., 2007; Joslyn & Oakes, 2005; Noreen & MacLeod, 2013). Transferring this finding to externally recorded information, one might assume that individuals will also delete content that they do not want to be reminded of (e.g., photos or messages from an ex-partner). Indeed, deleting relationship-related photos seems to reduce the distress experienced after a breakup (McDaniel et al., 2021). Of course, more research is needed to systematize these and related curatorial practices and their effects on remembering.

As actively curating the encoded information about one's life is an effortful process and as many individuals seem to avoid making this effort, it has been suggested that curation could be delegated to software (i.e., *algorithmic curation*) that would identify patterns within the data and reorganize them in a meaningful way (Dobbins et al., 2014; Teraoka, 2012). To a certain degree, such tools are already in use (cf. Jacobsen, 2020). For instance, many smartphones can automatically sort one's photos in folders based on location and date information—and social media platforms such as *Facebook*, *Instagram*, and *Snapchat* offer their users personalized year-end stories containing the supposed highlights of last year (Malik, 2021b; see also Holloway & Green, 2017). In a similar vein, *Spotify* presents users music and podcast

listening trends (such as their favorite songs; Perez, 2021) and *Reddit* summarizes the users' activities using statistics at the end of the year (Malik, 2021a). However, algorithmic curation is not without challenges. For instance, it has been observed that those criteria that individuals find most important when manually selecting photos (such as personal relevance or a high probability to evoke memories) are precisely the criteria that are difficult to evaluate and predict for an algorithm (Ceroni et al., 2015; see also Kuzovkin et al., 2019). In addition, one may wonder under which circumstances algorithmic curation supports and under which circumstances it undermines the meaning-making efforts of the individual. This mirrors the general observation that personalization in digital environments often comes as a double-edged sword: It can help us dealing with the abundance of available data but can potentially also threaten the freedom and autonomy of the individual (Hutmacher & Appel, 2023).

### Summary and Future Directions

Although there seems to be some consensus that curation is better than no curation when it comes to supporting autobiographical remembering, many open questions remain. For instance, one may ask which individual differences distinguish those individuals who decide to curate their data from those who do not or whether there are certain kinds of life events that serve as triggers for individuals to start curating the data. For instance, why are some individuals very selective about the content that they share with their personal environment while others share seemingly every mundane aspect of their lives—and what consequences does this have for the way they remember past events later? Moreover, it would be interesting to know what kind of curation strategies individuals use for what purposes—and whether the chosen strategies are as useful as anticipated when trying to remember the events later. In line with this, one could investigate whether the applied curation strategies change depending on the motivations, goals, and themes that are currently salient in the life of the individual. Similarly, understanding the impact of social factors (e.g., the way others in one's personal environment curate their data, norms about what is considered an appropriate degree of curation) on the curation strategies individuals use, is an important avenue for future research. Apart from this and as already discussed above, understanding the potential opportunities and risks associated with using algorithmic curation require thorough investigation.

### Retrieval

The dynamic interaction between the individual and the available external sources that lies at the heart of our AMEDIA-Model is arguably most pronounced at the retrieval stage. Here, internally and externally recorded information is finally combined to bring about autobiographical remembering. In theory and empirical research, retrieving autobiographical memories is often equated with

the amount of recalled information (i.e., How many autobiographical events do individuals remember in how much detail?). However, merely asking whether and, if so, how the amount of retrievable autobiographical information changes when using high-tech devices and applications seems inadequate: The transformations of autobiographical remembering in the digital age may also pertain to processes such as reflection (i.e., How do individuals think about their lives?), narration (i.e., How do individuals tell their life stories?), and rumination (i.e., To what degree do individuals tend to perseverative cognition circling around negative events and emotions?). In other words, using high-tech devices and applications may not only change *what* individuals remember about their past but also *how* they remember their past. Before reviewing some of the effects observed in studies from recent years that help to illuminate these different processes, we will briefly consider the circumstances under which autobiographical remembering might take place.

### **Mode of Remembering: Intentional, Incidental, and Triggered**

Briefly put, autobiographical remembering based on the information that has been stored in high-tech external resources can be *intentional*, *incidental*, or *triggered*. Autobiographical remembering is *intentional* or *voluntary* when individuals access the stored information in order to remember a certain event or period of life. As research has shown (Rasmussen & Berntsen, 2011; see also Bluck et al., 2005), intentionally remembering autobiographical events can be driven by a wide range of different goals and motivations, such as, regulating one's emotions (*self function*), wanting to solve a certain problem (*directive function*), or sharing information with others (*social function*). When remembering is intentional, this does not imply that the end of the entire process is already predetermined: As we hypothesize in our AMEDIA-Model, individuals may stumble upon information that they did not expect, leading the remembering process in unforeseen directions. However, remembering does not have to be planned but can also be *incidental* or *unvoluntary*: For example, individuals may browse the externally recorded information for purposes unrelated to autobiographical remembering (e.g., in order to find a document that a colleague sent some time ago) but stumble upon something that makes them engage in remembering. Such occasions are more frequent than one might intuitively think and can occur up to several times a day (Berntsen, 2021; see also Rasmussen & Berntsen, 2011). Moreover, people seem to enjoy rediscovering records of their past experiences; interestingly, this not only applies to special and extraordinary experiences but also to mundane everyday ones that may otherwise have been forgotten (Zhang et al., 2014). Crucially, algorithmic curation offers a third mode of autobiographical remembering, which we term *triggered* remembering. In this case, it is not the individual who initiates the remembering process but a software tool ("Look what you posted on our platform three years ago!"); at the same time, the trigger is not incidental as it was *designed to induce remembering*. Although algorithmically triggered autobiographical remembering can be a welcome opportunity for

reminiscing about one's recent past and is—as mentioned above—already used by several social media platforms in combination with algorithmic curation (Jacobsen, 2020; see also Brewer et al., 2017), it is also faced with several challenges. First, the algorithms not only help individuals to remember, but "narrate" themselves; that is, the way they remind individuals of past events potentially shapes the way these individuals remember them and ultimately also the way they construct their life narratives (Jacobsen, 2022a). Second, timing matters: If the reminders are not presented at the right moment (e.g., in a situation in which one is absolutely not willing to think about one's past; Jacobsen, 2022b; see also Bucher, 2020) or bring back memories that one would have preferred not to be reminded of (e.g., the death of a loved one; Lambert et al., 2018), triggered remembering can create confusion and lead to negative emotions. Third, it should however be noted that the effects of triggering memories are not fixed (Jacobsen, 2020): Ultimately, it is the individual who decides how to deal with algorithmic reminders and what to make of them. Even if one prefers to ignore a certain trigger because one finds it inappropriate, for example, one may still use the trigger as an inspiration to go through other recorded content. Once more, this illustrates that autobiographical remembering in the digital age can be viewed as the result of the iterative process of combining information stored in the mind and information stored in the environment using high-tech devices and applications as postulated in our AMEDIA-Model.

### **Memory Processes**

**Recollection.** *Recollection* denotes remembering past events in detail (cf. Sellen & Whittaker, 2010). Most studies that have investigated the effects of high-tech external resources on recollection focused on the impact of reviewing photos (see, e.g., Finley et al., 2011; Mair et al., 2017; Martin et al., 2022; for reviews, see Foley, 2020; Silva et al., 2018). Generally speaking, these studies indicate that having access to photos documenting one's life can help to reconstruct past experiences that are not accessible in unaided recall. Importantly, these findings are in line with the results obtained when looking at the effects of note-taking (Schryer & Ross, 2013) as well as the subjective perceptions of users of smart journaling apps (Hutmacher et al., 2023). In sum, this suggests that using high-tech external resources can augment human memory and can make it easier to avoid everyday memory failures (cf. Harvey et al., 2016).

**Reminiscing.** Engaging with externally recorded information does not necessarily have to be aimed at recollecting past experiences or life periods in the greatest possible detail. Sometimes one may want to think back to past events for sentimental and emotional reasons, that is, with the intention to delve into one's memories. This is called *reminiscing* (cf. Sellen & Whittaker, 2010). It has been observed that individuals engage in reminiscing when browsing through their social media profiles and the photos stored on their smartphones (Cosley et al., 2012; van Gennip et al., 2015). However, quantitative data can also serve as a starting point for reminiscing, especially when they have been visualized in

the form of maps or charts (Thudt et al., 2016). Interestingly, there is at least some preliminary evidence (from vignette studies) indicating that individuals prefer technology-mediated to unmediated reminiscing (Uhde & Hassenzahl, 2022). Nevertheless, the boundary conditions of such positive effects remain to be determined.

**Reflection and Narration.** Engaging with externally stored information can go beyond retrieving factual information: It can contribute to reflecting and narrating one's life in the sense that individuals use the recorded information as a vehicle to think about their desires, emotions, beliefs, or goals and to engage in autobiographical reasoning, that is, to place autobiographical events in a broader life story (cf. Grysman et al., 2024; Pasupathi & Wainryb, 2010). In other words, reviewing old social media posts, photos stored on the smartphone, entries in one's smart journal, or quantified lifelogging data may support individuals in understanding their personal past and in creating a unique perspective that integrates thoughts and feelings about positive as well as negative life events (Crete-Nishihata et al., 2012; Elsdén, Durrant, et al., 2016; Elsdén, Kirk, et al., 2016; Fawns, 2020; Isaacs et al., 2013; Lee & Ryu, 2020). Ultimately, this can lead individuals to change their views about themselves (DeVito et al., 2017) and maybe even to modify their behavior (Isaacs et al., 2013; Kersten-van Dijk et al., 2017). In line with our AMEDIA-Model, it has been pointed out that the recorded data do not present an authoritative version of one's past and that individuals are aware of this (Elsden, Kirk, et al., 2016): Individuals know that the recorded data need to be contextualized and interpreted and, consequently, negotiate the meaning of past events between their own internal accounts of what has happened and the externally stored information. Importantly, it has repeatedly been emphasized that the processes of narrating one's life and reasoning about autobiographical events are deeply social in nature and often take place in conversations (Grysman et al., 2024; Nelson & Fivush, 2004; Pasupathi & Wainryb, 2010). How such conversations may change in the digital age when high-tech devices and applications are used is largely uncharted territory. While there may be instances in which one would probably not expect marked differences between low-tech and high-tech devices (e.g., showing someone a photo stored on one's smartphone versus showing someone a printed photo), there are other contexts creating new affordances and interactional patterns. To give but one example, posting autobiographical information on social media means sharing this information with other individuals who can like the content and comment on it. To what degree this can prompt autobiographical reasoning in similar ways to how a face-to-face conversation with a friend can, seems an important question. In this context, it has been suggested that the content that individuals share on social media present brief slices of life that tend to be disconnected from other events (i.e., that are not necessarily integrated into a broader narrative), which could make the establishment of a coherent life story more difficult; at the same time, however, social media posts are usually

automatically listed in chronological order, which could provide at least a rudimentary framework for developing a life narrative (Habermas & Reese, 2015). Nevertheless, more research is needed to disentangle these potential advantages and disadvantages.

**Rumination and Forgetting.** Despite the positive effects that possessing a detailed digital record of one's life might have, there are also potential downsides (cf. Hutmacher et al., 2023). For instance, thinking about one's past does not necessarily have to be an enriching experience—as described in the previous section—but can also lead to rumination, that is, to perseverative cognition circling around negative events and emotions (Eikey et al., 2021). Just as likes and positive comments from others might spark important meaning-making processes, a lack of likes as well as receiving negative feedback might undermine efforts of narrative self-exploration. One additional concern that is also discussed in the literature is the idea that the increased density of recorded life events could undermine the adaptive function of forgetting (Heersmink, 2017; Heersmink & Carter, 2020; Koops, 2011; Jacquemard et al., 2014; Mayer-Schönberger, 2009; Storm & Soares, in press; van House & Churchill, 2008). For this problem to occur, the information stored in high-tech external resources needs to be permanent and non-editable. Otherwise, individuals could just delete the content that they no longer want to be confronted with. Although the decision which information to encode and which information to keep at least partially lies in the hands of the users, there certainly is externally recorded information that is permanent (“The Internet never forgets”), such as information that others have shared about oneself on social media (cf. Eichhorn, 2019). Moreover, there is evidence indicating that the mere presence of a digital record does not disrupt memory processes that help individuals to uphold a positive self-image (Konrad et al., 2016).

**Summary and Future Directions.** The existing literature provides compelling evidence that high-tech external resources can be used and are already used for autobiographical remembering. In line with the predictions made in our AMEDIA-Model, the available data support the idea that the externally recorded digital information does not merely serve as a cue but is used in an iterative process to stimulate reflection and narration. Nevertheless, more research is required to capture and analyze the interplay between internal memory and externally recorded information in more detail. In particular, this will also require conducting more studies that go beyond investigating how using high-tech external resources changes the amount of retrievable information. This may include describing changes to the process of engaging in autobiographical remembering, the tone of the retrieved memories, or the contexts in which autobiographical remembering takes place. In this regard, one may ask, for instance, what kind of recorded data is useful for what kind of memory processes, that is, whether different kinds of data have different affordances, which



may ultimately also influence how individuals reconstruct and narrate their lives. To disentangle the effects of different technologies (e.g., quantitative data collected by wearables versus photos shared on social media versus entries in a smart journal that is kept private), it will be essential to refer back to the dimensions described in the section on encoding.

The way different digital technologies shape the social and conversational nature of autobiographical remembering and autobiographical meaning-making also deserves particular attention. As much of technology-mediated autobiographical remembering is likely to be either involuntary or triggered, considering how these retrieval contexts serve the self, social, and directive functions of autobiographical remembering is worth exploring. In addition, it would be important to know whether the observed effects go beyond the effects achieved by other, non-digital external resources (e.g., written paper diaries). Given that the available technology allows for recording information about one's life with increased density (cf. Heersmink & Carter, 2020; Kalnikaitė & Whittaker, 2012) as well as using an unprecedented number of different media sources and data formats (cf. Hutmacher et al., 2023; Konrad et al., 2016), the digital age could lead to a fundamental transformation of autobiographical remembering. At the same time, the fact that much of the recorded information is never looked at again and that the sheer amount of data may prevent individuals from a meaningful interaction with the stored content (cf. Dang-Nguyen et al., 2018; Whittaker et al., 2010) could also limit the transformative power of modern technologies. As these modern technologies are relatively new, it will be particularly interesting to see how they shape autobiographical remembering in the long-term, that is, over years and decades.

## Discussion

Based on the insight that understanding the impact of the current technological changes on autobiographical remembering requires a nuanced analysis, we have proposed our AMEDIA-Model, which provides the first systematic and comprehensive framework for understanding autobiographical memory in the digital age. The AMEDIA-Model not only integrates a wide range of existing evidence but also provides a theoretical basis for investigating the interplay between individuals and the technology that they use in the context of encoding, curating, and retrieving autobiographical memories. Most importantly, we view autobiographical remembering in the digital age as the result of the iterative process of combining information stored in the mind and information stored in the environment using high-tech devices and applications. Moreover, the way autobiographical memories are constructed and reconstructed crucially also depends on the way the information has been encoded and curated, meaning that autobiographical remembering in the digital age is not a uniform process but is fundamentally shaped by the kinds of technology and the kinds of data that are being used. Taken together, our AMEDIA-Model has important consequences for understanding technology-

mediated human cognition, for conducting research in different areas of application, for making normative claims about the recent developments, and for anticipating the impact that future technological innovations might have on autobiographical remembering.

## Varying Degrees of Autobiographical Dependency

As summarized above, the AMEDIA-Model is based on the assumption that internal autobiographical memories and external records *work in concert* to bring about autobiographical remembering. Importantly, however, the degree to which autobiographical remembering depends on external records may vary across situations. Indeed, the vacation example that we used to introduce our AMEDIA-Model included different levels of *autobiographical dependency* (Heersmink, 2020). For some aspects of the vacation, the autobiographical dependency was low or moderate, in other words, you were able to remember these aspects in detail or at least partially without the support of an external resource. In the case of the few hours that you spent in the nice little town by the sea, however, your autobiographical dependency was high. You needed therefore to interact with the pictures stored on your smartphone in order to remember the event. Taking this logic one step further, one could also imagine instances in which interacting with an external record does not result in the *internal feeling of remembering*. In our example, this would be the case if you scrolled through your vacation pictures and realized that you must have spent some hours in a nice little town by the sea without actually remembering you having been there (e.g., you do not remember the live band or taking a walk on the beach).

Would it be justified in this case to say that you have an *autobiographical memory* of spending a few hours in the nice little town by the sea, an external albeit not an internal one? While some authors seem to believe so (Heersmink, 2020; see also Sutton & Windhorst, 2009), others dispute this (cf. Nestojko et al., 2013). Building on the definitions provided within our AMEDIA-Model, we hold that external records of one's life that are not accompanied by auto-noetic consciousness should not be counted as autobiographical memories in the narrower sense because auto-noetic consciousness is an essential part of what is commonly considered to constitute autobiographical memories. Nevertheless, they might still be counted as autobiographical facts or personal semantics that also play a role in constructing our life narratives; that is, although subscribing to the idea that human cognition is often embodied, embedded, extended, and enacted (so-called "4E cognition"; Clark & Chalmers, 1998; Gallagher, 2017; Malafouris, 2020; Varela et al., 1991; for an overview, see, Newen et al., 2018; for applications in the context of human memory, see Heersmink, 2020; Heersmink & Carter, 2020; Michaelian & Sutton, 2013; Sutton, 2010), we find it important to emphasize that autobiographical remembering is something that a *person* does and that, *in principle*, cannot be delegated completely to the environment.

## Consequences for Theory and Empirical Research

### Toward a Memory Ecology

If internal memories and externally recorded information are indeed used *in concert* to bring about autobiographical remembering, “focusing on unaided human cognition [...] rather than integrated human-cognitive tool systems, [...] miss[es] precisely what is unique about human cognition” (Yamashiro & Roediger, 2019, p. 16; see also Stone & Zwolinski, 2022). Taking this line of reasoning seriously would imply a clear divergence from the way many researchers still approach human memory and remembering. For instance, there are several studies demonstrating impaired internal memory for information that is saved in an external resource (Sparrow et al., 2011) at least when the saving process is perceived as reliable (Schooler & Storm, 2021) as well as studies showing that taking photos of objects can impair memory for these objects (Henkel, 2014; for a potential explanation, see Barasch et al., 2017).<sup>2</sup> Asking how using external resources for storing information changes internal memory representations is certainly a relevant question. However, internal memory representations should not be confused with the *ability to remember*, because remembering is—as outlined in our AMEDIA-Model—what happens when internal memories and externally recorded information are *combined in an iterative process*. Individuals who have access to certain external resources for recording information certainly behave differently than individuals who do not. Comparing the performance of individuals who usually rely on a certain external resource in a situation in which they have access to this resource to a situation in which they do not seems to miss the actual point of how remembering works in real-world settings and may ultimately obfuscate scientific progress.

In other words, the proliferation of digital technologies has the potential to transform autobiographical remembering. If people decide to use and to rely on these technologies, however, testing how they perform when these technologies are taken away again will not result in meaningful insights; that is, when investigating autobiographical memory in the digital age, researchers should focus on understanding the characteristics of the interplay between internal memories and externally recorded information as well as the affordances that come into play with new platforms and technologies. In short, the new digital technologies should probably not be viewed as tools for cognitive offloading but rather as tools for memory augmentation and memory diversification (cf. Eliseev & Marsh, 2021; Storm & Soares, in press), which can of course be used in more or less useful ways (see also Nestojko et al., 2013).

On a more general level, such an approach would mean embracing the idea that individuals are embedded in a

*memory ecology* (Hoskins, 2016; see also Stone & Zwolinski, 2022), in which they are never really separated from their social and inanimate environment (cf. Hirst & Stone, 2015). Although memory research seems to be slowly moving away from studying individuals in isolation (cf. Burnell et al., 2023; Heux et al., 2023), the host of empirical studies on autobiographical memory published in recent years arguably still views externally available information as nothing but a cue that individuals respond to, misrepresenting the dynamic and iterative nature of human remembering. Against this background, thinking about autobiographical memory in the digital age could serve as another, long-needed wake-up call for memory research.

### Conducting Empirical Research

Embracing the dynamic and iterative nature of human remembering also has important consequences for conducting empirical research: While experimental and laboratory studies have the clear advantage of allowing a well-controlled manipulation of the variables of interest, they also come with a reduced ecological validity as they tend to create settings in which the individual is removed from the usual environment, in which the above-mentioned processes of encoding, curating, and retrieving usually take place. Importantly, it has repeatedly been observed that findings on human memory obtained in experimental and laboratory settings do not always generalize to more ecologically valid real-life settings (e.g., Haas et al., 2022; Wank et al., 2020). Together with the more general claim that psychology as an academic discipline should put greater emphasis on methodological pluralism (cf. Hutmacher, 2023; Hutmacher & Franz, 2024; Mayrhofer & Hutmacher, 2020), this observation lends credibility to the idea that researchers interested in autobiographical memory in the digital age should strive to capture everyday practices and contrast them with experimental and laboratory studies to create an evolving dialectic of “thinner” (i.e., more controlled but less ecologically valid) and “thicker” (i.e., less controlled but more ecologically valid) descriptions of the phenomena under investigation (cf. Fivush, 2013).

More specifically, we suggest three methodological paths to complement experimental and laboratory studies. First, research on autobiographical memory in the digital age would greatly benefit from a more systematic inclusion of *qualitative and mixed methods* (cf. Fawns, 2020), which could help to elucidate the interplay between internal memories and externally recorded information. Such methods could include naturalistic observations and interviews as well as content analyses of digital archives and collections, but also more unconventional qualitative methods, which have been applied in the context of autobiographical remembering, such as letting participants engage in role-playing (e.g., Armstrong et al., 2023) or using (auto-)ethnographic writing (e.g., Hutmacher, 2024).

Second, *ambulatory and ecological momentary assessment* can be used to sample individuals’ current behaviors and experiences over a longer period of time in a naturalistic

<sup>2</sup>Note that these studies were not concerned with remembering autobiographical but with remembering factual information and that things may look different in the case of autobiographical memory (cf. Stone & Wang, 2019; Wang et al., 2017). However, the studies can still be used to illustrate our concerns regarding focusing on unaided human cognition. Note also that these studies have been criticized on both theoretical and empirical grounds elsewhere (Eliseev & Marsh, 2021; Heersmink, 2016; Storm & Soares, in press).

environment, providing important insights into within- and between-person variability (for a recent study in the context of autobiographical memory, see, e.g., Colombo et al., 2024). Third, *mobile sensing*, that is, using quantitative data from smartphones or wearables as tracked by onboard sensors could provide an important add-on to currently applied methods (for an overview, see Harari & Gosling, 2023). In contrast to ecological momentary assessment, which usually requires participants to respond to questions, mobile sensing allows the automatic, continuous, and unobtrusive tracking of real-world behavior. While this may be inadequate for gaining deeper insights in meaning-making processes that usually play a great role in the context of autobiographical remembering, it can provide a relatively objective basis for understanding the way individuals use modern-day technologies.

Ultimately, applying a host of different—quantitative and qualitative, experimental and observational, laboratory-based and ecologically valid—methods would allow testing the key assumptions of our AMEDIA-Model, such as the idea that internal autobiographical memories and external records *work in concert* to bring about autobiographical remembering. Although we believe that testing the entire model in a single study would be too ambitious, empirical investigations can focus on specific sub-aspects and thereby also contribute to refining our model. For instance, one could ask participants to review their own data and the way they have organized them to evaluate the usefulness of different curatorial practices (qualitative and mixed methods); one could ask participants to use an app programmed for the purpose of the investigation in their daily lives and manipulate how participants encode autobiographical events in order to see how this influences their memories of these events (ambulatory and ecological momentary assessment); or one could relate quantitative parameters about and individual's usage patterns of modern-day technology to the subjective reconstructions of their past (mobile sensing).

### Areas of Application

Our AMEDIA-Model offers a theory-based and empirically founded perspective that can be used as a tool for analyzing the ways in which the available technologies may change and transform autobiographical remembering. While it seems plausible that the increased density of recorded life episodes has the potential to lead to a richer and more detailed record of one's life, it is still an open question how exactly this will affect the way individuals construct and reconstruct their memories and life narratives (for discussions, see, e.g., Eliseev & Marsh, 2021; Storm & Soares, in press). Crucially, answering this question would also entail investigating whether the key findings from seminal studies on autobiographical memory, which have often been conducted in the pre-digital age, are still valid in our present-day societies or whether there are signs of technology-mediated cross-temporal variability that need to be taken into account (cf. Hutmacher & Mayrhofer, 2023; for some preliminary evidence, see Stone et al., 2022; Talarico, 2022). More generally speaking, the

AMEDIA-Model can also be extended and applied to different areas of research. In the following, we briefly sketch how the model might be used for organizing research in the field of developmental, social, and clinical psychology.

### *Developmental Psychology: Narrative Identity in Adolescence and Beyond*

To begin with, the way individuals encode, curate, and retrieve external information might change across the life-span, possibly in line with processes of identity formation and identity development (cf. Davis & Weinstein, 2017; Manago, 2015; Soh et al., 2024). As identity exploration and identity formation as well as the creation of a coherent life story play a particularly prominent role in adolescence and emerging adulthood (cf. Habermas & Bluck, 2000), these phases of life have been studied most extensively in this respect. On the one hand, it has been observed that young individuals will typically change the content that they store and share when their identity changes as they grow older (e.g., Davis, 2010; Weinstein et al., 2015). This may also include deleting old information that does no longer fit with one's current identity or that is deemed irrelevant given that the focus of one's life has changed. In other words, changes in identity may not only change the nature of the information that is newly being encoded but also lead to a host of curatorial practices. This is also illustrates that the externally recorded information that individuals possess about their lives are not static and passive data reservoirs but actively shaped by individuals, which may ultimately also shape the way these individuals remember their personal past. On the other hand, using digital media gets individuals in touch with different possible ways of narrating their lives (Granic et al., 2020), which can include both culturally dominant master narratives as well as alternative narratives that might be particularly important for marginalized groups or groups of individuals with non-mainstream interests (cf. Bates et al., 2020).

Despite these potential positive effects, one might still ask to what extent social media and digital technologies do in fact contribute to a positive identity development, given that most platforms incentivize quick responses in the form of likes and shares rather than reflection and narrative integration (cf. Granic et al., 2020). Moreover, processes of autobiographical remembering and meaning-making are often associated with social interactions (Gryzman et al., 2024; Nelson & Fivush, 2004; Pasupathi & Wainryb, 2010): When talking about autobiographical events, individual adopt factual details from their conversational partners, adapt interpretive details, and experiment with forming links between the different elements of their lives. If autobiographical remembering in the digital age is shaped more by online posts and less by face-to-face conversations, then the individual's identity work is happening less in protected and trusted environments and more in the public sphere. This could impact identity development in profound ways: As it can be hard for individuals to predict how the public will react to their postings, they may decide to limit the aspects



of their lives they are willing to share, thereby unintentionally also limiting the aspects of their lives regarding which they engage in profound identity work. Although exploring these and related questions may be particularly pressing in the case of adolescents and emerging adults, the AMEDIA-Model provides a rationale for extending the research beyond these phases of life: Assuming that the digital traces about our lives will eventually span decades, exploring the way this information affects narrative identity and the construction of the life story at later stages of life is likely to become an important area of research as well.

### ***Social Psychology: From Social Identity and Family Narratives to Collective Memory***

As the considerations about the development of a life story in times of social media have already made clear, understanding autobiographical memory in the digital age may begin but should not end with the individual. Three observations seem particularly important in this context. First, digital data that is being encoded and curated does not only document and express a personal but also a *social* identity (cf. Barker & Rodriguez, 2019). Take selfies as a case in point: Selfies indeed convey aspects of personality and lifestyle and give hints to people's values (cf. Dollinger, 2017); however, they can also be used as a means to negotiate social roles and societal expectations (e.g., in the case of motherhood; see Gawrońska & Sikorska, 2023; Holmes & Atkins, 2023). Importantly, this is not a one-directional process: By taking a selfie, one does not merely express one's social identity or one's relationship with the personal environment; in contrast, the way these photos have been taken can also shape and transform these identities and relationships (Stiglbauer & Weber, 2018).

Again, these findings fit well with the assumptions made in our AMEDIA-Model, namely that the way data is being encoded, curated, and retrieved has important consequences for the way the past is being reconstructed, that the process of combining internal memories and externally stored information is iterative and interactive, and that this process is fundamentally shaped by the kinds of technology and the kinds of data that are being used. This also applies to the second observation: the importance of digital data for constructing family narratives. Although it is well known that externally recorded information plays a key role for establishing, representing, and rearranging family narratives (e.g., Petrelli et al., 2014), research from recent years has confirmed that this also applies to digital data such as the photos that individuals share on social media. More specifically, it has been shown that such photos are used to present moments and events that families spend together as well as to depict intergenerational relationships, possibly spanning grandparents, children, and grandchildren (Barnwell et al., 2023).

Third, and moving beyond the level of one's immediate social environment, one might also examine how digital media contribute to constituting and reproducing collective memories of groups and societies. It seems almost self-

evident that there is a close connection between mediated memory practices and collective memory: "On the one hand, for a memory to be collective, it needs to be manifested and socially shared, and thus ought to be mediated; on the other hand, many media products and mediatization processes incorporate shared recollections" (Neiger, 2020, p. 1). For instance, there is a clear nexus between the death of people of public interest and memory work regarding these individuals: When people of public interest die, this usually leads to a sharp rise in media attention and social media activity that decays in a matter of days (West et al., 2021) and rises again at anniversaries and special dates related to the deceased individual (cf. Ferron & Massa, 2014; Keegan & Brubaker, 2015). Fascinatingly, collective memories seem to serve similar functions as individual autobiographical memories (Burnell et al., 2023; Heux et al., 2023): They shape the identity of collectives, can provide a basis for future decision-making, and may create bonds between different collectives (e.g., when two nations commemorate an event that was important to both). This also suggests that the AMEDIA-Model can also be applied to the way larger groups and collectives encode, curate, and retrieve memories in an attempt to craft an overarching narrative.

### ***Clinical Psychology: Digital Memory as Curse and Blessing***

As far as investigating autobiographical memory in the digital age from a clinical perspective is concerned, one worry that might immediately come to mind is that the information that is shared on social networking sites gives rise to upward social comparisons, which can have negative effects on well-being and mental health (Verduyn et al., 2020; for meta-analyses, see Yang et al., 2019; Yoon et al., 2019). That is, as the information that individuals publicly share online is often optimized for self-presentation, seeing the digital traces of the lives of others may give rise to the feeling that one's own life is comparably shallow and boring. The detrimental effects of upward social comparisons notwithstanding, there is also consistent evidence that the overall effects of digital media on well-being and mental health are rather small and depend on a wide range of contextual factors (for an overview, see Orben & Przybylski, 2019; Valkenburg, 2022). This suggests, however, that using digital media in general and externally recording information about one's life in particular must also have positive effects for individuals that somewhat counterbalance the negative effects. For instance, research has shown that individuals sometimes share memories online for therapeutic reasons (e.g., to ease their distress, to get advice and feedback from others, or to gain insight into their problems; Stone et al., 2022).

In addition, it has been demonstrated that automatically capturing snapshots of everyday life as well as recording short videos can help people to remember aspects of their recent past that may otherwise become inaccessible (Hodges et al., 2011; Loveday & Conway, 2011; Martin et al., 2022; for a review, see Silva et al., 2018). This might be



particularly helpful in situations in which an individual's internal autobiographical memory lacks detail or is particularly prone to errors. From a clinical perspective, there seem to be at least two use cases. On the one hand, autobiographical memories become less specific and generally harder to recall in the case of people with dementia (Irish, 2023; see also Hutmacher, 2021). On the other hand, it has been observed that individuals with psychiatric diagnoses remember fewer specific and more general memories compared to individuals without a psychiatric diagnosis (overgeneral memory; for a meta-analysis, see Barry et al., 2021). Although it remains to be determined what exactly drives these differences between people with and without psychiatric diagnoses, and although effectively supporting the autobiographical memory of people with dementia remains challenging, digital technologies could potentially offer a way for addressing the lack of detail and specificity in autobiographical memories. Most importantly, the different components of the AMEDIA-Model offer a framework for organizing research in this respect and for keeping the different facets in mind that might be relevant for designing tools for intervention.

### Ethical Considerations: From the Empirical to the Normative

The AMEDIA-Model is a *psychological* model. That is, it provides a framework for understanding the interplay between internal memory and externally recorded information that is rather descriptive than prescriptive. Nevertheless, the AMEDIA-Model can be used to inform societal debates with normative implications. To begin with, we have emphasized that autobiographical remembering in the digital age is not a uniform process but is fundamentally shaped by the kinds of technology and the kinds of data that are being used. From a normative perspective, this implies that articulating hopes and concerns regarding technology-mediated memory in the twenty-first century should always take these nuances into account. To give but one example, being skeptical about the benefits of quantifying humans' lives (cf. Mau, 2019) does not imply that one needs to be skeptical about all aspects that come with the increased density of recorded life episodes in the digital age. In addition, our elaborations also suggest that externally recorded information is not meaningful in and of itself but that it needs to be curated and interpreted (Banks, 2011; van den Hoven et al., 2012). In close connection with this, individuals usually neither want their internal memories to be replaced by external recordings (Eliseev & Marsh, 2021; Harvey et al., 2016) nor do they strive for capturing as many moments of their lives as possible: Instead, they are more interested in having a more detailed record of the moments that are dear and important to them (i.e., situation-specific capture; Sellen & Whittaker, 2010; see also Heersmink, 2018). Against this background, the AMEDIA-Model can be used as a basis for critically evaluating the promises associated with recent technologies, as it enables us to determine whether the features of these technologies rather support or undermine the

functioning and well-being of individuals. As most platforms and services that individuals use for storing and sharing information about their lives are provided by companies with commercial interests, which do not necessarily align with the users' needs and preferences, this seems to be a particularly important point. For instance, the business model of many tech companies involves collecting as much information about individual users as possible. In turn, the concerns regarding data privacy resulting from this might keep users from fully exhausting the options that the available technology offers (cf. Hutmacher et al., 2023). It has repeatedly been pointed out that such ethical concerns should be taken much more seriously during the development of digital technologies so that these technologies can be a force for good instead of merely increasing company revenues (Calvo & Peters, 2014; Floridi, 2013).

In addition to these points, we want to address two broader ethical dilemmas: data permanence and the digital divide. As far as data permanence is concerned, there is the idea that autobiographical remembering in the digital age could lead to problems because of both too much and too little data permanence. *Too much data permanence* might be a problem insofar as it reduces the individuals' control about the way they narrate their lives and as it prevents forgetting that is necessary for distinguishing important from more ephemeral life events (cf. Mayer-Schönberger, 2009; Tirosch, 2017). Arguably, publicly sharing information about one's life (e.g., on social media) might be particularly problematic in this respect, because this information is far more difficult to delete than information that individuals keep for themselves (e.g., in a smart journal). Somewhat paradoxically, *too little data permanence* could be a problem as well: As already briefly mentioned in the introduction, storage and file formats have undergone constant changes over the last years and decades (e.g., Blum & Beyer, 2019). In addition, the popularity and availability of different platforms and applications also changes relatively rapidly, making it unclear whether information that is posted on *Instagram* or stored in the software environment of one's activity tracker today will really be available for remembering one's life in thirty or more years in a similar way as photo albums and paper diaries were for previous generations. Although it may be too early to tell which of the two problems related to data permanence turns out to be more pressing in the long run, it seems clear that both phenomena could have important policy implications: As the externally recorded information that individuals store using high-tech devices and applications does not merely serve as a cue for autobiographical remembering but forms an important part of the individual's memory ecology, both the unintended availability and unintended unavailability of information about one's life could be experienced as deeply troublesome. Last but not least, the relevance of our AMEDIA-Model rests on the assumption that living in the digital age means creating and sharing immense amounts of data for individuals. Although this is true for the majority of people on our planet (cf. Domo, 2022, 2023), there is still a significant digital divide within and across societies (van Dijk, 2020; Warschauer,

2003). That is, it should not be forgotten that not everyone has equal access to the currently available technology or possesses the skills for using it. For example, elderly individuals who would arguably form one of the groups that could profit the most from using digital technologies to counterbalance weaknesses of internal memory (e.g., Martin et al., 2022) are generally less likely to benefit from the digital revolution (e.g., Mubarak & Suomi, 2022). In a similar vein, individuals who cannot afford the available technology will not be able to integrate it in their memory ecology and may ultimately feel excluded and disconnected from the recent developments.

### Anticipated Future Developments

Recent years have seen impressive technological developments that have brought us closer to the realization of Bush's (1945) memex vision than ever before. Even more so, the existing high-tech tools such as smartphones may already possess capabilities that Bush did not even dream about. However, there is no reason to believe that the technological developments will come to an end any time soon. Importantly, we believe that our AMEDIA-Model will provide a valid framework for understanding and investigating the impact of such future developments. That is, although the AMEDIA-Model was created based on the available empirical evidence and through extending and connecting existing theoretical strands, the basic structures and processes that we have identified can be transferred to new technological innovations. As far as such technological innovations are concerned, we have three potential changes in mind that might already be waiting around the corner. First, given the rapid progress of language-based artificial intelligence applications, new forms of algorithmic curation and algorithmic narration seem to be within reach; that is, newly designed algorithms could help us engaging with externally recorded information in an unprecedented manner. Already as of now, it does not seem far-fetched to feed an application such as *ChatGPT* with information about one's life and to ask the application to create a coherent story out of this information. In fact, a first empirical demonstration has shown that AI-driven models can create helpful and accurate summaries of diary entries (Siriwardhana et al., 2023). Although this is to date not much more than a proof of concept, that is, although it remains to be seen to what degree individuals will be willing to integrate such tools into their memory ecology, their potential seems obvious.

Second, the technology that might become available over the course of the next years may offer unforeseen possibilities for *designing* memories that serve the self-enhancing function of autobiographical remembering. Again, preliminary versions of such technologies are already available today: For instance, applying beauty filters enables individuals to optimize their physical appearance without much effort or expertise (e.g., Appel et al., 2023). Crucially, these beautifying practices go beyond superficial changes (such as adjusting color saturation) and may include significant modifications (such as adjusting the shape of the nose or

the contour of the jawline). Against this background, the possibility to design memories in the sense that one can create photos or videos in which one does things that one has in fact never done or in which other individuals are added to or removed from the available footage almost seems like a logical next step. Given that several decades of empirical research have impressively demonstrated that individuals can be relatively easily tricked into believing that fictitious events have actually taken place (cf. Loftus, 2005), the possibility to willingly fake our personal past using digital technologies offers a worrying outlook into the future. The same applies to the possibility that third parties might try to manipulate and change an individual's memory of past events through changing the externally recorded information related to this event, for instance using *deepfakes* (Appel & Prielzel, 2022; Murphy & Flynn, 2022). Although it remains to be determined how powerful such manipulations can be, that is, to what degree they can alter the content of internal autobiographical memories, the potential dangers of such developments for both individuals and societies should not be brushed aside easily.

Third, the availability of an incredible amount of data about the life of each individual in combination with the progress in the context of virtual reality environments could present new ways for creating immersive scenarios for re-experiencing past events or for experimenting with alternative outcomes and realities ("What would have happened if I had done X instead of Y in this situation?"; see also Fernandez-Alvarez et al., 2021; Kisker et al., 2021). Taking things even one step further, virtual reality environments could offer opportunities for—at least seemingly—interacting with deceased individuals (Stein, 2021): For instance, it could become possible to create virtual avatars that not only mimic the physique but also the personality of loved ones that have passed away. While this might be helpful for continuing bonds with the deceased or during therapeutic interventions (e.g., when addressing difficult or traumatic experiences), it also raises important ethical concerns (e.g., Bassett, 2022; Öhman & Floridi, 2017): Would it be morally justifiable, for instance, to create a virtual reality scenario in which two estranged siblings are reunited although this runs counter to what the deceased sibling would have wanted? Importantly, virtual reality could not only be used for private or entertainment purposes but also in the context of education, for example, when it comes to providing future generations access to witnesses of past events (e.g., in the case of the Holocaust; Marcus et al., 2022). In this case, virtual reality could help to connect individual and collective memories.

### Conclusion

The digital age is associated with profound and far-reaching changes for individuals and societies. Autobiographical remembering is a core aspect of being human that might undergo significant transformations in the face of the current technological innovations. In the AMEDIA-Model that we have proposed in the present paper, autobiographical

remembering in the digital age is seen as the result of the iterative process of combining information stored in the mind and information stored in the environment using high-tech devices and applications. The AMEDIA-Model offers a valuable and nuanced basis for understanding and investigating how individuals construct and reconstruct their personal past in the digital world of the twenty-first century.

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