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People infuse their passwords with autobiographical information

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ABSTRACT

Passwords might unlock more than our computer accounts. A New York Times Magazine described anecdotes of people who infused their passwords with autobiographical information [Urbina, I. (2014, November 20). The Secret Life of Passwords. *New York Times*. Retrieved from <https://www.nytimes.com/2014/11/19/magazine/the-secret-life-of-passwords.html>]. We suspected people infused their passwords with autobiographical information so they could privately remember that information. Across two studies we took a systematic approach to address the extent to which people infused passwords with autobiographical information and the functions that information served. We also examined the self-reported consequences of people infusing their passwords with autobiographical information. Across both studies, 41.6–71.1% of people infused their passwords with autobiographical memories; in Study 2, 9.3% of people infused their passwords with episodic future thoughts. People who infused their password with autobiographical information reported that information served identity, social, and directive functions, and they created their password to remember that information. These studies show that people do not simply use passwords to unlock their computer accounts. Some people might use passwords as mementos to cue autobiographical information.

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Technology eases the burden of remembering. Instead of remembering how to calculate a tip, we use an app; instead of remembering directions to our favourite restaurant, we use Google Maps, and instead of remembering our friends' phone numbers, we use an iPhone. Indeed, technology is often an extension of our mind: we remember where and how to access information, rather than the information itself—like the concept of a *transactive memory system* (Wegner, 1986; see also Clark & Chalmers, 1998). Several studies support this idea. For example, people are less likely to remember information if they know they can access that information using technology (Barr, Pennycook, Stolz, & Fugelsang, 2015; Sparrow, Liu, & Wegner, 2011; Storm & Stone, 2015). But technology often imposes a burden on remembering. To open the tip app, save that restaurant to Google Maps, or phone a friend, we first need to remember a password. Even phones that allow access by recognising our face or fingerprint require a password in certain situations. It stands to reason, then, that because technology demands we remember passwords, we seek to reduce the burden of remembering by creating passwords that are easy for us to remember (and hard for others to guess). But in two studies, we show that these passwords often serve functions beyond easy access to our devices: we use passwords to remind us of our identity, our relationships,

and to imagine our future behaviour. Passwords have a secret life.

In a popular New York Times Magazine article, “The Secret Life of Passwords”, journalist Ian Urbina (2014) described many instances of people who infused their passwords with personal facts, episodes, and imagined future events—which we collectively refer to as *autobiographical information*. Much of this autobiographical information was in the form of *autobiographical memories*, which are memories for events and facts related to the self (Brewer, 1986; Conway, 1987; Levine, Svoboda, Hay, Winocur, & Moscovitch, 2002). For example, one woman's password was “Odessa”, a reference to the Ukrainian city where her father was born, and where she had taken a trip with her father (Urbina, 2014). This woman told Urbina that Odessa was important because it was part of her lineage, and also because the trip she took with her father was transformative.

Why would this woman infuse her password with an autobiographical memory? Indeed, why would anyone infuse their passwords with autobiographical information? There are at least two possibilities. The first, and obvious, possibility is that people infuse their passwords with autobiographical information to make their passwords easy to remember. After all, information related to oneself is better remembered, presumably because it is more

elaborately encoded (see Symons & Johnson, 1997 for a review of the *self-reference effect*). Therefore, people are less likely to forget a password infused with autobiographical information than a password that was, say, randomly generated. Indeed, there are high costs to forgetting passwords, such as one man who reported losing \$30,000 because he forgot his randomly-generated Bitcoin PIN (Frauenfelder, 2017). The second, and not independent but less obvious, possibility is people might infuse their passwords with autobiographical memories because doing so covertly serves a purpose. It is this second possibility we addressed in the studies reported here.

Specificity of autobiographical memory

Before we address this possibility, we must first acknowledge the complexity of autobiographical memories. The example above about the woman with the password “Odessa” demonstrates that autobiographical memories can be recalled at different levels of specificity. For example, the woman’s trip to Odessa is more specific than the memories that connect Odessa to her identity. One model of autobiographical memory that defines the different levels of specificity is the *self-memory system* (Conway, 2005; Conway & Pleydell-Pearce, 2000). In this model, *episodic autobiographical memories* are events that happen on a single day and refer to a specific time and place. In contrast, *autobiographical knowledge* represents personal semantic knowledge, which includes extended memories and recurring memories.

Autobiographical memories that differ in specificity also differ in other ways. For example, younger people are more likely to recall episodic autobiographical memories than older people (Levine et al., 2002). In contrast, younger and older people recall autobiographical knowledge to a similar extent. Furthermore, numerous imaging studies have shown different brain regions are associated with recall of episodic autobiographical memories and autobiographical knowledge (Addis, McIntosh, Moscovitch, Crawley, & McAndrews, 2004; Levine et al., 2004; Maguire & Frith, 2003). More recently, one study showed that autobiographical memories at different levels of specificity also differ in the extent to which they serve important psychological functions (Waters, Bauer, & Fivush, 2014).

The functions of episodic autobiographical memory

What important psychological functions do autobiographical memories serve? Although there have been many proposed functions of autobiographical memory, most research in the literature describes episodic autobiographical memories serving three broad functions (Bluck, 2003; Bluck & Alea, 2011; Hyman & Faries, 1992). They can serve an *identity function*, helping to forge a sense of identity. They can serve a *social function*, helping to form and maintain social bonds. They can serve a *directive function*, helping to guide and direct future behaviour. Take, for

example, this episodic autobiographical memory from a graduate student in our lab—a memory which she infused into a password:

One day I bumped into an estranged friend I hadn’t spoken to in over a year. He was working at this new bar and invited me to a live music gig happening there. I’m not really very comfortable hanging out in bars, and even less comfortable with spontaneity, but it was a kind gesture on his part, so I went. The gig was kind of magical. The bar was lit up with fairy lights and the musician played this excellent cover of a song I already loved. But most of all, it was really great hanging out with my friend again, like we used to. I have a photo from that night, but I made a reference to that event in my password because it reminds me of a time when I was brave, and that good things happen that you don’t anticipate and you should embrace those opportunities.

This memory clearly serves all three functions of autobiographical memory. First, it serves an identity function by reminding her of a time when she was brave. Second, it serves a social function by reminding her of an old friend—and perhaps strengthening her friendship with this old friend. Third, it serves a directive function by encouraging her to embrace spontaneous opportunities in the future. This memory, therefore, demonstrates an important point about real life autobiographical memories: Memories can serve multiple functions (Bluck, 2003).

The functions of autobiographical knowledge

Our graduate student’s memory is of a specific event, and therefore is an episodic autobiographical memory. Does autobiographical knowledge serve the same functions as episodic autobiographical memories? In one study, people described extended and recurring events—both which are types of autobiographical knowledge (Waters et al., 2014). Indeed, extended and recurring events served identity, social, and directive functions. Moreover, episodic autobiographical memories served identity and directive functions to a greater extent than recurring events, and recurring events served social functions to a greater extent than episodic autobiographical memories. These findings suggest people who infuse their passwords with autobiographical memories should report these memories serve identity, social, and directive functions. Furthermore, people should report episodic autobiographical memories serve identity and directive functions to a greater extent than autobiographical knowledge, and autobiographical knowledge should serve social functions to a greater extent than episodic autobiographical memories.

Overview

Across two studies, we addressed three main questions. First, to what extent do people infuse passwords with autobiographical information? In Study 1 we asked subjects if they infused their passwords with autobiographical memories. In Study 2 we asked subjects if they infused their

passwords with autobiographical memories or episodic future thoughts. Second, what are the characteristics of these different types of autobiographical information? More specifically, what functions do they serve, and what are the events or facts on which those passwords are based? Finally, are passwords good cues for autobiographical information? That is, do people recall the autobiographical information when they type their password?

Study 1

Method

Subjects

We collected responses from 236 subjects using Amazon Mechanical Turk (www.mturk.com). A total of 201 (53.7% identified as women; 45.8% identified as men; and 0.5% identified as other) subjects completed the study. These subjects ranged in age from 19 to 67 ($M_{\text{age}} = 33.50$, $SD_{\text{age}} = 10.56$, $\text{Median}_{\text{age}} = 31.00$), and received 0.30 USD upon completion.

Procedure

We used Qualtrics survey software (Qualtrics (2016), Provo, UT) to present instructions and questions in subjects' web browsers. Subjects completed the survey online via Mechanical Turk.

We told people they would participate in a study about how people pick secure passwords. We asked subjects to complete the survey by themselves, without distraction, and to maximise their web browser. Subjects responded to five blocks of questions and statements about their current, or most frequently used password, which are all presented in Table 1 and the Supplemental Materials (Tables S1–S4). This study was exploratory, so we asked subjects a large number of questions about their

passwords, some of which are outside the scope of this paper. Here, we were primarily interested in the responses from Block 3 and Block 4. We did not ask subjects to tell us their passwords because it is likely that the passwords themselves would be short-hand cues for memories—and therefore only interpretable to the user.

In Block 1, subjects answered eight questions and statements about the security of their password (for example, "My friends would be able to guess my password") responding on a scale with anchors 1 (*strongly disagree*) to 7 (*strongly agree*). These questions and statements are presented on Table S1. In Block 2, subjects answered seven questions, to assess the composition of passwords. For example, "How many lower-case letters are in your password?" These questions are presented on Table S2.

In Block 3, subjects responded to four statements with "Yes" or "No" to determine if their password referred to an autobiographical memory, and if so, to further classify that autobiographical memory as an episodic autobiographical memory or instead as autobiographical knowledge. For example, one such followup "Yes/No" statement was, "My password contains information related to me, but not related to a specific event from my past". These statements are presented in Table 1.

If subjects' passwords referred to an episodic autobiographical memory or autobiographical knowledge, they were asked questions from Block 4, which were questions about the functions, the emotional valence, and emotional intensity of the memory. These questions were adapted from Rasmussen and Berntsen (2013). Each of the three functions were measured by presenting subjects with one statement—this single-item scale format has been previously validated by Rasmussen and Berntsen (2009). Then, subjects responded to two statements with 7-point scales: "As I type my password, I think about [*this event or the meaning of my password*]", from 1 (*Strongly disagree*) to 7 (*Strongly agree*) and "I created this password to reminisce about the past", from 1 (*Not at all*) to 7 (*To a very high degree*). Finally, subjects who indicated their passwords referred to episodic autobiographical memories completed the Autobiographical Memory Questionnaire, a 20-item instrument measuring, among other things, the sensory vividness, rehearsal, emotional response associated with these memories (Rubin, Schrauf, & Greenberg, 2003). A full list of items presented to those in Block 4 who indicated their passwords referred to autobiographical knowledge is presented in Table S3 and a full list of items presented to those who indicated their passwords referred to an episodic autobiographical memory is presented in Table S4.

Subjects then proceeded to Block 5. Subjects who, as a result of their responses to items in Block 3, indicated their password did not refer to an autobiographical memory, proceeded directly to Block 5 after completing Block 3. In Block 5, all subjects were asked seven questions to determine if they had complied with our instructions. For example, "Did you complete the experiment in a single

Table 1. A full list of items and descriptive statistics from Block 3 in Study 1.

Order	Item	Percentage	
		Yes	No
1	My password contains elements that are completely random (for example, "fdYq^v71d"). Answer "Yes" even if your password also contains elements that are not random. (Yes or No).	38.3	61.7
2	My password contains information related to me (for example, "Newy0rk1994"). Answer "Yes" even if your password also contains other information. (Yes or No).	60.7	39.3
3	My password contains information related to me, but not related to a specific event from my past (suppose the password "Bronx!91" refers to the area where you grew up). Answer "Yes" even if your password also contains other information. (Yes or No).	54.7	45.3
4	My password contains information related to a specific event from my past (suppose the password "Disneyland98" refers to a specific experience on a holiday). Answer "Yes" even if your password also contains other information. (Yes or No).	34.8	65.2

Note: The response options for each item are presented after each item in parentheses.

session, without stopping?" Finally, all subjects were debriefed.

Results and discussion

Our primary question was to what extent do people infuse passwords with autobiographical memories? Before addressing this question, we evaluated the dataset for subject compliance. We identified 31.3% of subjects who failed at least one of our compliance check questions. Including subjects who failed our compliance checks did not change the overall patterns of results, so we retained them in our analyses (see Table S5 for the percentage of subjects who failed each compliance question).

Recall the primary purpose of our study was to examine the extent to which people infused their passwords with autobiographical memories. It would be useful first to give the flavour of these passwords. Their median length was 9.00 characters ($M = 9.52$, $SD = 3.43$). Most of these characters were lower case letters ($M = 5.47$, $SD = 3.19$); fewer characters were numbers ($M = 3.02$, $SD = 1.92$) or capital letters ($M = 1.12$, $SD = 1.54$)¹. These findings are consistent with research examining databases of passwords (Yan, Blackwell, Anderson, & Grant, 2004). We now turn to our primary research question. To what extent did people infuse their passwords with autobiographical memories? In fact, 71.1% of people did: As Table 1 shows 34.8% of subjects told us their password contained information related to a specific event from their past. We categorised these subjects as reporting they infused their passwords with episodic autobiographical memories. 36.3% of subjects reported they infused their passwords with autobiographical knowledge. Only 28.9% of subjects reported neither infusing their passwords with episodic autobiographical memories nor autobiographical knowledge.² These data suggest that in constructing their passwords, people might be taking advantage of the self-reference effect by choosing information related to themselves, and at the very least constructing a password that should be easier to remember (Symons & Johnson, 1997).

Although these findings tell us about the types of memories people infuse in their passwords, they do not help us

address our second research question: What functions do these memories serve? To answer this question, we took subjects' ratings of the extent to which the memory served identity, social, and directive functions, and classified those ratings according to whether the memories were of episodic autobiographical memories or autobiographical knowledge. We plotted these mean ratings in Figure 1. As the figure shows, episodic autobiographical memories served directive and social functions to a greater extent than memories of autobiographical knowledge.

In null hypothesis significance testing (NHST) terms, a one-way MANOVA showed a significant difference in functions across the two types of autobiographical memories infused in passwords, $F(3, 139) = 44.13$, $p < .001$; Wilk's Lambda = 0.51, $\eta p^2 = 0.49$. In order to determine where, exactly, those differences were, we conducted three follow-up one-way ANOVAs. These tests support the pattern observed in Figure 1: Episodic autobiographical memories served social and directive functions to a greater extent than autobiographical knowledge. The difference between these two groups on the identity function was not statistically significant (admittedly with an ambiguous p -value): directive function $F(1, 141) = 11.51$, $p = .001$, $\eta p^2 = .08$; identity function $F(1, 141) = 3.72$, $p = .06$, $\eta p^2 = .03$; social function $F(1, 141) = 127.16$, $p < .001$, $\eta p^2 = .47$. These findings are inconsistent with past research that found episodic autobiographical memories served identity and directive functions to a greater extent than recurring autobiographical memories (a type of autobiographical knowledge) and recurring autobiographical memories served social functions to a greater extent than episodic autobiographical memories (Waters et al., 2014).

Considered as a whole, our data provide evidence that people infuse passwords with autobiographical memories which serve identity, social, and directive functions. But thus far, we do not know the answer to our third research question: Are passwords good cues for autobiographical memories? To address this question, we asked people to rate the statements "I created my password to reminisce about the past" and "As I type my password, I think about this [event or the meaning of my password]". When we collapsed across both types of autobiographical memories, we found people often reported they intentionally created their passwords to reminisce. There was moderate agreement with the items "I created my password to reminisce about the past" ($M = 3.53$, $SD = 2.22$) and "As I type my password, I think about this [event or the meaning of my password]" ($M = 4.47$, $SD = 2.17$). As the left column of Table 2 shows, the more people thought their password memories served identity, social, and directive functions, the more they reported creating their password to reminisce. Moreover, the adjacent column shows that regardless of subjects' intentions when creating their passwords, the more subjects thought their password memories served identity, social, and directive functions,

Table 2. Pearson's correlations between the functions of memories infused in passwords and the extent to which people created their password to reminisce or think about that memory when typing their passwords, in Study 1.

Variables	1	2	3	4	5
1. I created this password to reminisce about the past	–				
2. As I type my password, I think about this [memory]	0.52	–			
3. Identity function	0.32	0.33	–		
4. Social function	0.38	0.44	0.38	–	
5. Directive function	0.35	0.47	0.37	0.48	–

Notes: We collapsed across people who reported autobiographical knowledge and people who reported episodic autobiographical memories ($n = 143$). Item 2 had different endings based on the two levels of specificity of autobiographical memories, see Table S3 and Table S4 for the exact wording. All correlations had associated p -values $< .001$.

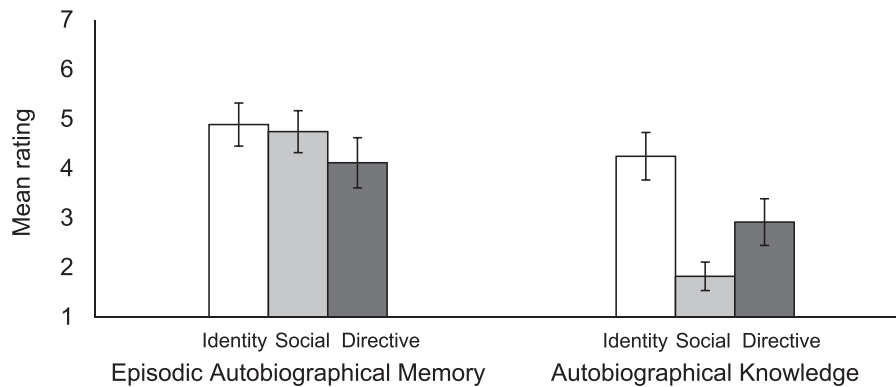


Figure 1. Mean identity, social, and directive function ratings subjects gave for the autobiographical memories infused in their passwords in Study 1. Error bars represent 95% confidence intervals of cell means.

the more they reported thinking about these memories when they typed their password. These findings suggest some people infuse memories that serve important functions in their passwords because those passwords then act as external cues, or mementos. Put another way, some of the 71.1% of people who infused their passwords with autobiographical memories, might have done so to privately rehearse those memories and reap the benefits of bringing those memories to mind.

Of course, we found that 28.9% of subjects did not infuse their passwords with autobiographical memories. Could these subjects have infused their passwords with other types of autobiographical information? The questions we asked subjects were not sensitive to one possibility: that at least some of those passwords might contain imagined future events, or *episodic future thoughts* (Szpunar, 2010). These episodic future thoughts are similar to autobiographical memories—they share similar underlying neural processes, and there is evidence that people use memories of the past to create simulations of the future (Schacter, Addis, & Buckner, 2007; Szpunar, 2010). Furthermore, episodic future thoughts have been shown to serve identity, social, and directive functions too (Rasmussen & Berntsen, 2013). In fact, Rasmussen and Berntsen found episodic future thoughts served directive functions to a greater extent than autobiographical memories. We would, therefore, expect to find the same difference in passwords infused with episodic future thoughts compared to episodic autobiographical memories. We might also expect other differences between these two types of autobiographical information. For example, a collection of several studies suggest episodic future thoughts are judged as more emotional, more frequently rehearsed, and more positive than autobiographical memories (Berntsen & Bohn, 2010; Berntsen & Jacobsen, 2008; Rasmussen & Berntsen, 2013; Sanson, Newman, & Garry, 2017; Van Boven & Ashworth, 2007). Urbina (2014) himself described a man whose password, “Quit@smoking4ever”, referenced his goal to quit smoking. Maybe his password cued him to simulate a future in which he did not smoke. Perhaps, too, some of our subjects

infused their passwords with episodic future thoughts. We can only speculate about this issue because we did not ask subjects if their passwords referenced episodic future thoughts.

Another issue we can only speculate on is the exact content of these autobiographical memories. We know the majority of subjects infused their passwords with autobiographical memories, but we do not know the events and facts on which these memories—and thus the passwords—were based. Were they common events and facts, cultural milestones, or were they more idiosyncratic events? Again, it is unlikely that asking subjects to tell us their passwords would answer this question because the passwords themselves would be uninterpretable shorthand cues for these memories. We know from the autobiographical memory literature the events people consider important are often predictable and follow a “script” based on the cultural expectations on what a typical person should experience in their lifetime (Berntsen & Rubin, 2004). For example, marriage, having children, and the first day of school, appear on many nations’ *cultural life scripts* (CLS). To the extent that the autobiographical memories people infuse in passwords are based on important events, we would predict these events would be CLS events. We know from previous research when people were asked to recall important events, 53–68% of those memories were from the CLS (Scherman, Salgado, Shao, & Berntsen, 2017). Therefore, if memories infused in passwords are important memories, then we would expect to see a similar percentage of subjects infusing their passwords with CLS events.

Therefore, in Study 2, we aimed to answer three questions. First, to what extent do people infuse their passwords with a third kind autobiographical information, episodic future thoughts? Second, if people do infuse passwords with episodic future thoughts, to what extent do those thoughts serve identity, social, and directive functions—and to what extent do the functions of episodic future thoughts differ from the functions of autobiographical memories? Third, to what extent does the autobiographical information infused in passwords reflect CLS events?

Study 2

Method

Subjects

We collected responses from 424 subjects using Amazon Mechanical Turk. A total of 399 (48.1% identified as women; 51.9% identified as men) subjects completed the study. These subjects ranged in age from 19 to 74 ($M_{\text{age}} = 35.92$, $SD_{\text{age}} = 11.06$, $\text{Median}_{\text{age}} = 33.00$). Workers received 1.00 USD.

Procedure

We followed a method similar to Study 1, with three main changes. First, we asked subjects if their password related to a future event. Second, we asked subjects if the memory infused in their password was a CLS event. Third, after examining subjects' written responses in Study 1, we thought some subjects had been erroneously categorised as infusing their passwords with episodic autobiographical memories, when, in reality, they were probably describing general events. So, in Study 2, we used remember/know judgments (see Hyman, Gilstrap, Decker, & Wilkinson, 1998; Rajaram, 1993) to categorise memories because we thought these judgments would be more accurate and clearer than the statements we used in Study 1. "Remember" judgments were categorised as episodic autobiographical memories and "know" judgments were categorised as autobiographical knowledge.

First, subjects completed Block 1, which were a series of questions to determine the type of password they used. Subjects indicated if their password contained autobiographical information. Unlike Study 1, only subjects who responded "Yes" to this statement were then asked if the autobiographical information they infused in their passwords related to an imagined event that will or might happen in the future. If subjects responded "No" to that statement, they were then asked if the autobiographical information they infused in their password was something they "remember" or something they "know". We explained how remembering and knowing were different, and provided subjects with examples adapted from Hyman et al. (1998) and Rajaram (1993). These statements are presented

on Table 3. Then, we asked all subjects to briefly describe their passwords in as much detail as possible without revealing their passwords. We also asked subjects why they chose that particular password.

Subjects who reported they infused their passwords with episodic autobiographical memories, autobiographical knowledge, or episodic future thoughts completed Block 2, in which they were asked about the functions and the extent to which they thought about the autobiographical information when they typed their password (these items and associated descriptive statistics are presented in Table S6 for autobiographical knowledge, Table S7 for episodic autobiographical memories, and Table S8 for episodic future events). In addition to these questions, people who reported they infused their password with an episodic autobiographical memory or an episodic future thought (but not those who reported infusing their password with autobiographical knowledge) completed Block 3—a 20-item scale to assess the phenomenological characteristics of that event. These items were taken from Rasmussen and Berntsen (2009) and adapted by Sanson et al. (2017). For example, "When I think about the event today, it appears vivid and clear". These items and associated descriptive statistics are presented on Table S9 for autobiographical events, and Table S10 for episodic future thoughts. These subjects also completed a 25-item US cultural life script checklist to report if any of the events on the CLS were the events infused in their passwords (Rubin, Berntsen, & Hutson, 2009).

Results and discussion

A total of 23.8% of subjects did not meet at least one of the seven compliance instructions. Responses from those subjects did not change the overall patterns in subsequent analyses, so we retained them in our analyses. See Table S5 for a list of these compliance questions and the percentage of subjects who failed each question.

We now turn to our primary research question: What types of autobiographical information did people infuse in their passwords? A total of 14.8% of subjects reported

Table 3. A full list of items and descriptive statistics from Block 1, in Study 2.

Order	Item	Mean	Median	SD	Lower 95% CI	Upper 95% CI
1	How long have you used this password for? (in years) (type answer).	4.59	2.00	5.27	4.07	5.11
2	My password contains elements that are completely random (for example, "fpYq^v71d"). Answer "Yes" even if your password also contains elements that are not random. (Yes or No).	Yes =	55.9%		No =	44.1%
3	My password contains information related to me (For example, your password could be your nickname, your old address, or a specific event that happened to you). Answer "Yes" if your password includes any personal information. (Yes or No).	Yes =	50.9%		No =	49.1%
4	Is this personal information in your password related to an imagined event that will, or might, happen in the future? (Yes or No).	Yes =	18.2%		No =	81.8%
5	Is this personal information in your password something you remember or something you know? (Remember or Know).	R =	35.5%		K =	64.5%

Notes: The response options or response formats for each item are presented in parentheses. We excluded those subjects who indicated in Item 1 that they had been using their password for 50 years or longer. In Item 5, "R" = percentage of "Remember", and "K" = percentage of "Know" responses. Percentages are based on the number of people who were asked each statement, not percentages based on the entire sample.

they infused their passwords with information related to specific episodic autobiographical memories; 26.8% of subjects reported they infused their passwords with information related to autobiographical knowledge. Finally, 9.3% of subjects reported they infused their passwords with information related to episodic future thoughts. That is, and as Table 3 shows, 50.9% of subjects infused their passwords with one of the three types of autobiographical information.³

The percentage of subjects who infused their passwords with autobiographical information was lower than in Study 1. It is possible this difference supports our concern that some subjects in Study 1 had a password based on a general event, but were categorised as having a password based on an autobiographical memory. This discrepancy might also be attributable to the different response formats. In Study 1, all subjects responded to all of the statements about the type of autobiographical information in their passwords. By contrast, in Study 2, only subjects who responded “Yes” to the statement “My password contains information related to me” were asked if that autobiographical information was related to a future event. Only subjects who indicated their password was not related to a future event were then asked the remember/know question. Perhaps more subjects in Study 2 would have responded “Yes” to the statements about autobiographical information, but because they said “No” in response to the first statement, they were not given the opportunity to do so.

Table 4. Percentage of subjects who indicated the event infused in their password was from the US CLS, in Study 2.

Event	Episodic future thought (%)	Episodic autobiographical memory (%)	Overall (%)
Marriage	27.0	5.2	13.7
College	5.4	15.5	11.6
Having children	8.1	10.3	9.5
Fall in love	8.1	6.9	7.4
High school	8.1	5.2	6.3
First job	5.4	5.2	5.3
Begin school	5.4	3.4	4.2
Go to school	2.7	5.2	4.2
Own birth	5.4	3.4	4.2
Settle on career	5.4	3.4	4.2
Leave home	5.4	1.7	3.2
First kiss	5.4	1.7	3.2
Own death	5.4	0.0	2.1
Other's death	2.7	1.7	2.1
Retirement	5.4	0.0	2.1
Puberty	0.0	3.4	2.1
First sex	0.0	3.4	2.1
Begin talking	2.7	0.0	1.1
Begin walking	2.7	0.0	1.1
Begin driving	0.0	1.7	1.1
Grandchildren	0.0	1.7	1.1
Begin daycare	2.7	0.0	1.1
Empty nest	0.0	1.7	1.1
Parent's death	0.0	0.0	0.0

Note: Events are ordered from the overall most common event, to the least common event.

To address our second research question, we compared between the three different types of autobiographical information with respect to their identity, social, and directive functions. We plotted mean function ratings in Figure 2. As the figure shows, there were at least three interesting findings. First, inconsistent with Study 1, people who infused their passwords with autobiographical events reported these memories served identity, social, and directive functions to a similar extent as people who infused their passwords with autobiographical knowledge. This inconsistency between Study 1 and Study 2 could be attributed to the different methods we used to categorise episodic autobiographical memories and autobiographical knowledge. The second interesting finding was people who infused their passwords with episodic future thoughts reported those thoughts served directive functions to a greater extent than people who infused their passwords with episodic autobiographical memories and autobiographical knowledge. This finding is consistent with Rasmussen and Berntsen (2013) who found that positive future experiences were rated as more directive than autobiographical memories. Third, episodic future thoughts served social functions to a greater extent than autobiographical facts.⁴

In NHST terms, a one-way MANOVA showed a significant difference in functions across the three types of autobiographical information people infused in their passwords: $F(6, 396) = 7.38, p < .001$; Wilk's Lambda = 0.81, $\eta p^2 = 0.10$. In order to determine where, exactly, those differences were, we conducted three follow-up one-way ANOVAs and Tukey HSD post-hoc tests. These tests supported the pattern in Figure 2: The three groups differed on directive functions $F(2, 200) = 14.00, p < .001, \eta p^2 = .12$ and social functions $F(2, 200) = 9.83, p < .001, \eta p^2 = .09$, but there was no significant difference in identity functions $F(2, 200) = 0.42, p = .66, \eta p^2 = .00$. Tukey HSD post-hoc tests showed episodic future thoughts were statistically higher in directive functions than autobiographical knowledge ($M_{diff} = 1.81, p < .001$) and episodic autobiographical memories ($M_{diff} = 2.00, p < .001$). Episodic future thoughts were also higher in social functions than autobiographical knowledge ($M_{diff} = 1.63, p < .001$). Episodic autobiographical memories were also higher in social functions than autobiographical knowledge ($M_{diff} = .80, p = .039$).

We now turn to our third research question: To what extent do these autobiographical memories and episodic future thoughts reflect CLS events? Of those 96 subjects who reported they infused their password with an episodic autobiographical memory or an episodic future thought, a total of 66.7% ($n = 64$) reported the event was a CLS event. A larger percentage (81.1%) of people in the episodic future thoughts group ($n = 30$) reported their password was a CLS event compared to 57.6% of those in the episodic autobiographical memory group ($n = 34$). This difference was statistically significant ($z = 2.37, p = .02$). The exact percentages of CLS events are presented in Table 4.

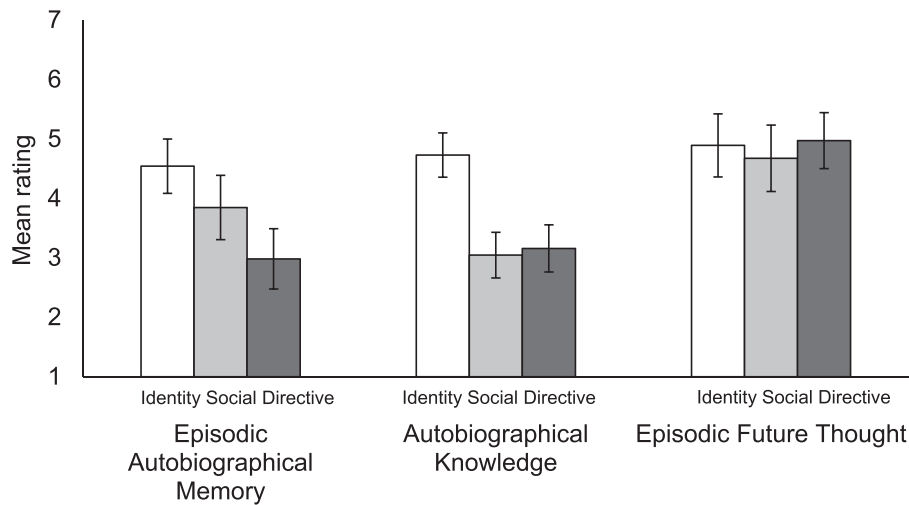


Figure 2. Mean function ratings of autobiographical information infused in passwords by the type of autobiographical information in Study 2. Error bars represent 95% confidence intervals of the cell means.

Finally, we compared the phenomenological characteristics of memories for episodic autobiographical memories and episodic future thoughts. We adopted the approach taken by Sanson et al. (2017), to avoid making a large number of comparisons by combining 10 of the 20 items into three sum variables: *emotional response* (which consisted of “When I think of this event today it triggers a physical reaction”, “When I think of this event today it affects my mood”, and “When I think of this event today the feelings I experience are intense”) *rehearsal frequency* (which consisted of “Before today I have deliberately thought about the event”, and “Before today I have had the event pop up in my mind by itself—that is, without me trying to think of it”), and *sensory vividness* (which consisted of “When I think of this event today it appears vivid and clear”, “When I think of this event today I can see it in my mind”, “When I think of this event today I can hear it in my mind”, “When I think of this event today I can smell or taste it in my mind”, “When I think of this event today I can recall the physical surroundings”). These sum variables showed good internal reliability in our data: Cronbach’s $\alpha = 0.87, 0.82, 0.76$, for emotional response, rehearsal frequency, and sensory vividness, respectively.

The individual variables that made up the sum variables, along with descriptive statistics are displayed on Tables S9 and S10. In line with the episodic future thought literature, people who infused their passwords with future events judged those events as eliciting more of an emotional response, and were rehearsed more frequently than people who infused their passwords with episodic autobiographical memories (Berntsen & Bohn, 2010; Sanson et al., 2017; Van Boven & Ashworth, 2007). We also found a trivial difference between past and future events in sensory vividness. We used a one-way MANOVA to test these differences: $F(3, 92) = 4.83, p = .004$; Wilk’s Lambda = 0.86, $\eta p^2 = 0.14$. In order to determine where, exactly, those differences were, we conducted follow-up univariate ANOVAs.

Future events were statistically higher in emotional response $F(1, 94) = 11.64, p = .001, \eta p^2 = .11$ and rehearsal frequency $F(1, 94) = 8.94, p = .004, \eta p^2 = .09$ compared to episodic autobiographical memories. But there was no significant difference in sensory vividness $F(1, 94) = 1.04, p = .31, \eta p^2 = .01$. Finally, we wanted to test for differences in the valence of past and future events. Previous research found that future events were more positive than past events (Berntsen & Jacobsen, 2008; Finnbogadóttir & Berntsen, 2013; Rasmussen & Berntsen, 2013). But inconsistent with this research, we found trivial differences in valence between episodic future thoughts and autobiographical events $F(1, 94) = .04, p = .84, \eta p^2 = .00$.

General discussion

Across two studies we aimed to determine the extent to which people infused their passwords with autobiographical information. We found that many people did just that. More specifically, 71.1% of people in Study 1 and 41.6% of people in Study 2 infused their passwords with autobiographical memories—a disparity likely due to the different survey formats between Study 1 and Study 2. In Study 1, subjects were presented all items in Table 1. In Study 2, subjects were only presented Item 4 in Table 3 if they responded “yes” to Item 3, and subjects were only presented Item 5 if they responded “no” to Item 4. That is, fewer people in Study 2 had the opportunity to indicate they infused their passwords with autobiographical events and episodic future thoughts than in Study 1. We also found 9.3% of people in Study 2 infused their passwords with episodic future thoughts. We then aimed to determine the functions these types of autobiographical information served. We found, in Study 1, episodic autobiographical memories served identity, social and directive functions to a greater extent than did memories of autobiographical knowledge. But in Study 2 we found episodic

autobiographical memories and autobiographical knowledge served these functions to a similar extent. Episodic future thoughts served social and directive functions to a greater extent than did both episodic autobiographical memories and autobiographical knowledge. Finally, we aimed to determine the extent to which passwords were good cues for autobiographical information. Subjects reported they thought of the autobiographical information when they typed their passwords—and some subjects reported they deliberately infused autobiographical information in their passwords to reminisce. Furthermore, we found in both studies the more this autobiographical information served identity, social, and directive functions, the more people reported they created their passwords to think of that information.

Our results are largely consistent with the autobiographical memory literature. For example, in one study, positive future events served identity, social, and directive functions to a greater extent than positive or negative past events (Rasmussen & Berntsen, 2013). Our findings in Study 2 are also consistent with the finding that episodic future thoughts are more emotional, rehearsed, and are more likely to be from the CLS than autobiographical memories (Berntsen & Bohn, 2010; Berntsen & Jacobsen, 2008; Sanson et al., 2017; Van Boven & Ashworth, 2007). But, inconsistent with the studies suggesting past events are higher in sensory vividness than future events, we found a trivial difference between past and future events in vividness (Berntsen & Bohn, 2010; D'Argembeau & Van der Linden, 2004). It could be that both past and future events were similar in vividness because by typing these passwords, subjects were recalling these events to a similar extent.

Our findings make at least two important contributions to the autobiographical memory literature. First, the findings show how the functions of autobiographical knowledge compare to the functions of episodic autobiographical memories. We expected, in line with other research, that episodic autobiographical memories should serve identity and directive functions to a greater extent than autobiographical knowledge, and that autobiographical knowledge should serve social functions to a greater extent than episodic autobiographical memories (Waters et al., 2014). But our results did not support this prediction: In Study 1, episodic autobiographical memories served social and directive functions to greater extent than autobiographical knowledge. In Study 2, using a remember/know question to classify the type of autobiographical information, there were only trivial differences in functions between episodic autobiographical memory and autobiographical knowledge. It could be that the differences observed between functions in the previous study are specific to recurring events, and not autobiographical knowledge generally. We know that memories of events become semantic knowledge over time (Conway, Gardiner, Perfect, Anderson, & Cohen, 1997). Therefore, our results suggest the functions episodic autobiographical memories

serve might remain stable, even after they become semantic knowledge. But, of course, because of the inconsistent findings between Study 1 and Study 2, this conclusion is tentative.

Our second contribution is to provide scientifically-grounded evidence in line with the idea that some people infuse their passwords with autobiographical information—and our data further suggest that at least part of the reason why people do so is to privately rehearse that information. Unlike in a transitive memory system (Wegner, 1986), people need to remember their passwords. Therefore, people are likely to pick passwords that are easy to remember. But we have shown that ease of remembering is not the only reason why people pick their passwords: people use passwords as mementos or cues to privately recall autobiographical information. Future research could compare the ease of remembering and private rehearsal explanations in order determine which one best explains why people infuse their passwords with autobiographical information.

An interesting question worthy of future research is to ask to what extent people use mementos to simulate future events. Although we now know some people use certain passwords to simulate the future, it might be that other mementos help accomplish the same goal. Alternatively, it could be that passwords are not like other mementos. Indeed, we suspect at least two differences might exist between passwords and other mementos. First, unlike other mementos, passwords are often secretive—we don't proudly display them in our living rooms or post them on the internet. Second, unlike other mementos, for example, a person's 21st birthday shot glass, or magnet from their last vacation, passwords are unique in that we are forced to think about them frequently. Future research could compare these secretive and frequently used password mementos with other, more public and less used, mementos. We would expect passwords would serve fewer social functions than a person's 21st birthday shot glass, or a magnet from a person's last vacation—or other mementos proudly displayed around the home. But we can only speculate on this matter because we did not ask subjects about other mementos.

Taken together, people infuse their passwords with autobiographical information. A large portion of this autobiographical information refers to common life events, such as marriage and attending college—a finding that could be used by people to help guess or crack other peoples' passwords. Indeed, Urbina (2014) himself reported an anecdote about a financial company located in the World Trade Center. After the 9/11 attacks, the company—desperate to keep its business afloat—needed to access the trading records of some of their dead employees. The most success they had was from contacting family members for nuggets of autobiographical information. This autobiographical information helped experts crack the dead employees' passwords and saved the company valuable records. Perhaps, then, there is

sometimes danger in letting people create their own passwords: Instead of creating strong passwords, people sacrifice secrecy for the opportunity to reminisce and simulate their future.

Notes

1. We excluded responses from these analyses that were 30 or greater.
2. We coded those subjects who responded “yes” to their password relating to a specific event from their past as an episodic autobiographical memory. We coded those subjects who responded “no” to their password relating to a specific event from their past, and “yes” to either their password containing information related to themselves, their password containing non-specific information related to themselves, or both, as autobiographical knowledge.
3. Note, the percentages of people infusing their passwords with autobiographical information are the percentages of the entire sample. The percentages presented on Table 2 are the percentages of the people who were presented each item. Recall, only subjects who responded “yes” to Item 3 in Table 1 were presented items 4 and 5.
4. We also conducted the correlations we conducted in Study 1 between the functions of the autobiographical information and the extent to which people created their passwords to reminisce, and the extent to which they think of that information when they type their password. These correlations show the same pattern as Table 2. These analyses are presented in Table S11.

Disclosure statement

No potential conflict of interest was reported by the authors.

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