

Things That Make Us Reminisce: Everyday Memory Cues as Opportunities for Interaction Design

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ABSTRACT

Interactive devices can support personal remembering to benefit well-being. These designs require insight into what brings the past to mind, and how people relate to such cues. Prior work focused on mementos in the home; instead, this paper presents a diary and interview study of involuntary memory cueing in everyday life. Data was collected from fifteen adult individuals, using sentence completion diaries, combined with debriefing interviews. Qualitative analysis of the data showed that these participants were relying on everyday physical objects like food items for cueing memories during everyday life, locations and (repeated) activities, while digital items and photos were shown to be less frequent stimulants. Meaningful relations to memory cues can be partially explained from a memory cueing perspective. We discuss how design for remembering can benefit from our insights, through careful trade-offs in timing, exposure to cues, and supporting a process of personal attachment with items invoking memories.

Author Keywords

Interaction Design, Memories, Memory cueing, Remembering, Diary study

ACM Classification Keywords

H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

INTRODUCTION

In everyday life we often remember our past: sometimes by deliberate effort, and sometimes because thoughts, people or elements in our environment remind us. Think of using social media to view and share family stories, or reminiscing while taking a walk in the park. Such reminiscing and reflecting on autobiographical memories has clear mental benefits, as remembering is vital to our self-image, personal identity, how we express ourselves, and relate to others [8]. These activities based on memories,

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and by extension the elements in the environment that trigger such memories, help us feel well and balance emotional needs [6, 30]. Stimulating beneficial remembering in daily life thus can be a worthwhile goal, as underlined by recent attention within the field of interaction design [e.g., 17, 30]. People have long used mementos for this purpose, and capture (for example) photographs to use as memory cues later on [30]. Interactive devices can support reminiscing using captured images and other data as memory cues, provided design efforts are based on a solid understanding of what makes people remember their past, how this colors their experience, and whether such interactivity is appropriate at a given time.

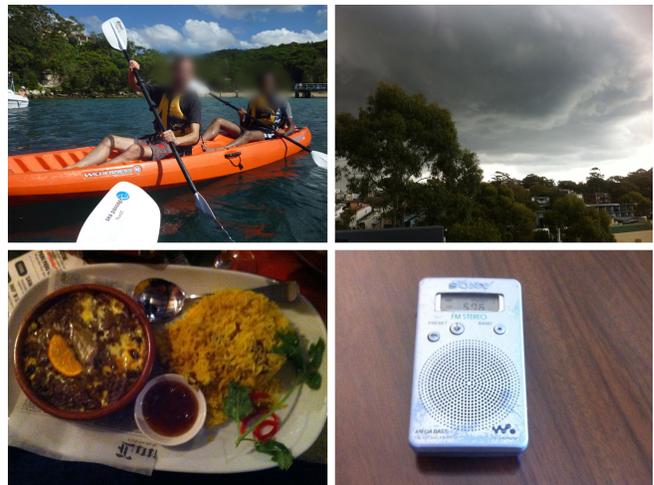


Figure 1. Examples invoking memories: Photo of a trip on Facebook; Thunderstorm; Boboti dish; Transistor radio.

Digital items stand a lesser chance of evoking memories and emotions compared to physical items due to lesser salience, often captured and stored but not reviewed [31]. People put meaningful items on display, and vice versa tend to attach meaning to items available in their environment. Personal mementos are increasingly stored digitally and are becoming more numerous due to lower perceived cost of capture, which also reduces chances of finding it again to help remembering [30]. When people were asked to indicate valuable items during home visits, digital mementos were often overlooked [20, 27]. Digitalization of personal media can reduce opportunities to evoke memories without effort [31], or as Schwarz argues do the opposite as we may frequently come across files when looking for

something else [29]. The latter would alter our relation to those memories to become more casual as memory-related items would involuntarily cue us more often (beyond direct control over such exposures, which may be undesired).

This raises the challenge of how to assist the revisiting of personal digital items. We believe that if such revisiting (involuntary or otherwise) can influence wellbeing (as shown for positive memories [6]), this challenges designers to do (or refrain from doing) so sensibly. Good design of supportive devices can make a difference, provided that people's experiential needs are met. Still, empirical understanding to inform design lacks in two ways [17, 32]. First, the relation between cueing medium (e.g., digital or physical) and resultant remembering experience is not clearly understood. It is not evident whether the representation of a memory cue (e.g., photo, audio, writing) influences cueing of a memory, and how we think about this memory [15]. Some forms may stimulate a more positive remembering experience than others, perhaps because certain ways of cueing allow more freedom to imagine the event and emotions as desired. If photographs of an event do not support someone to relate to their own experience at the time (e.g., a photo may depict a different feeling), would another representation be more suitable for a device to adopt for experiential reliving? Second, the way this knowledge can be applied to actual interactive designs needs refinement.

In this work, we look into remembering experiences as cued by stimuli such as mementos, public images, and particular spaces (see Fig.1). We aim to relate memory cues with the memories and meaning within individuals' lives, and casted a wider net compared to earlier works focusing on a home context [20, e.g., 27]. Our focus is on external stimuli (in contrast to internal stimuli such as thoughts, which we cannot design or modify), as these external cues provide an opportunity for design to appropriate for everyday remembering. In addition, we discuss perceived differences between digital and physical items as cues. We argue this focus on digital, involuntary memory cues is warranted given the accumulation in people's archives and potential for appropriation by interactive devices. This work adds insight on involuntary memory cueing and related trade-offs to enable future design work to contextualize and explore this challenge.

RELATED WORK

Memory & cues in cognitive psychology

Remembered events of our life can differ in specificity: lifetime periods (e.g., being a teenager), general events lasting days to months, or event-specific knowledge for events lasting up to hours at most [8]. Memories come to our awareness based on intentional effort (e.g., seeing a vase and then trying to remember how you got it), or involuntarily (e.g., remembering your neighbor gave you a vase upon seeing that vase) [4]. Involuntary memories thus

need some way of invocation, whether taking a cue from (for example) thoughts, activities, or external items.

Based on diary studies, Berntsen finds involuntary cueing happens between one to five times per day. Cues are most often external (e.g., objects), some internal, with only a small amount of sensorial cues (e.g., sound, smell) or having no identifiable cues [4]. Despite limited understanding of the cueing process, some correlation between a memory and a potential cue is assumed [8]. Distinctiveness, recency, frequent rehearsal, or relation to a highly emotional event may improve a perceived item's ability to cue a memory [4]. However, other mental processes interact to modulate a cue's effects: one can see a photo frame many times without becoming aware of related memories. Such selective recall illustrates that motivations matter, as does recent activation of related memories [e.g., 4]. During mundane activities (e.g., cooking) some people are more likely to be involuntarily triggered, perhaps because they are open to stimulation [e.g., 4, 28].

Personal collections as memory cues

Items are able to stimulate vivid re-experience of the past [10]. Because interactive devices can stimulate similar functions via cues (e.g., display of photos, old messages, audio recordings), it is relevant what types of cues people relate to. People actively shape their environment to support and portray their identity through curation of items reminiscent of past memories, with the goal of keeping things around as symbols of the self [e.g., 10, 20]. This behavior, known as autotopography [27], shows the complex relations between objects and the self. The popularity of everyday objects as mementos is "by the virtue of what the owner has invested in them, be it time or emotion," and such meaning develops over time through cultivation, selection, and how items relate to others [27].

Such cultivation practices are harder to support with digital mementos not being present in the everyday environment. Not surprisingly those are mentioned infrequently in studies of personally relevant memory objects [20, 26, 27]. However, this belies that there is an ever-increasing use and reliance on digital capturing of memory cues (i.e., digital photos, social network communication, email). The ease or even automaticity of digital capturing has grown the collections people keep, as reflected in the life logging movement [30]. However, this 'cue hoarding' has led to too many cues with too little relevance as filtering gets less attention [30]. Work on digital legacy, inheritance and memorials highlights people may at times be confronted to deal with vast and often unstructured digital collections [e.g., 13, 22]. These issues raise questions on what kind of items would be considered beneficial as memory cues, and at which moments this cueing might be done (if at all). Such changed practices fundamentally alter the way we remember and support recollection [31], and the changing landscape begets answers on how design can best support this trend.

Memory cues in interaction design

We would like to highlight several works that have tapped into the opportunities provided by interaction design for involuntarily cued reminiscing. Smell is rare but noticeable as an involuntary cue, and offers a strong ability to bring back memories if a device would be aware of personally meaningful odors [24]. It is noticeable that several works employ a tactic of random selection for serendipitous effects. Pensieve explored the use of digital mementos by using earlier social media posts as emailed prompts for reminiscing [9]. 4Photos, a dinner table photo displaying device [23], aimed to start dinner conversation by presenting random photos from social network streams. A similar tactic was employed by Cueb to support parent-teenager communication through random display of digital photos on tangible objects [12]. Meerkat and Tuba also went for serendipitous presentation of digital media in the home, abdicating user control in favor of surprise [14]. Knowing what to present and when requires keen understanding of what is personally meaningful, questions of interest in this work.

Petrelli *et al.* [27] argue the reflective value of a memento comes out of reencountering and re-evaluating our disposition towards an item and its related memories (although this evaluative process happens in the mind, and is not evident to interactive devices). Echo uses this principle to encourage reflection on cues captured earlier [18]. Data Souvenirs does similarly by placing ambiguous digitally augmented objects in the home environment that upon seeing may stimulate reflection [1].

Knowledge gap

Notwithstanding the above illustrations of how understanding memory, cueing, and interaction design can support remembering our past, questions remain. As some of the related work reveals, additional understanding of what is of value, and when people would (not) appreciate being cued is needed. Despite an increasing interest in memory cues, and effects on recollection [e.g., 15], the effect of cue attributes on remembering remains ambiguous and is often not directly addressed. Contradictory to the studies quoted above, van den Hoven *et al.* [16] found that a no-cue condition compared to several types of cues gave rise to richer recollection of a past event. This appears to suggest interactive devices might also miss out on intended effects using such cues (e.g., photos on phones). We argue this ambiguity impedes successful design of interventions to support everyday remembering.

This is why it is valuable to look into memory cues from a design perspective. What kind of items cue memories in everyday life, as opposed to lab studies or just the home environment? Memory retrieval may largely be an involuntary process, but cues could be in the surroundings for voluntary reasons (e.g., a photo frame deliberately put somewhere). To which cues do people attach value, and for

what reason? Is there a difference between digital and physical memory cues for the remembering experience?

This work qualitatively explores what elements in daily life cue a remembering experience, similar to the more quantitative approach in studies using diaries for data gathering [4, 28] and qualitative accounts of home visits [e.g., 10, 20, 27]. We were interested in items as memory cues and the related remembering experiences and meaning these items take on. Besides a general interest in the kind of memory cues encountered, we were especially interested in digital memory cues (if encountered). We believe our findings contribute towards successful designing for remembering support systems by further unpacking the relation between items and cued memories, and by outlining opportunities for future work through elucidating dimensions and trade-offs that designers may consider.

STUDY METHOD

This study explored the relation between memory cues and reminiscing in everyday life, in which diaries and debriefing interviews were used for data collection. We were interested in the type of cues and related memories, and how people relate to these cues. Involuntary memory cueing is a fleeting cognitive phenomenon quickly forgotten if not captured shortly after being cued. Akin to earlier work on involuntary memories [4, 28], participants were asked to record involuntary memories themselves in a diary as soon as they became aware of such a memory being cued. Self-reports provide a good account when initiated by a participant while the cued memory is still fresh, because reporting need not rely on retrospection (as might the case with other methods like experience sampling where delays between event and report are inevitable), at the cost of some subjectivity as interpretation may differ between participants [7]. Diary entries also provided input for debriefing interviews, which expanded on and added qualitative insight to themes found across diary entries.

Participants

Fifteen adults participated (another 5 started but did not complete). They were recruited via personal networks of the authors and university notices, via social network posts, emails, flyers, and in person. Participants were told the purpose of the study was to learn about the various ways people may be reminded of their past by encountering things in daily life. All respondents were included to maximize diversity, and no rewards were given for participation. Participants were aged 24 to 66 ($M=39$ years), 11 were female (73%), and most were affiliated to the university of the first author as postgraduate student or staff. Living situations varied from single, with flatmates, divorced (with children), to complete families. Half were born in Australia, others had been there for at least one year and had comparable to native language skills.

Diaries

Participants were handed a paper diary to record involuntary memories and related cues (see Fig. 2). They

were instructed to ‘write down things you encounter throughout the day that remind you of something about your own past, and perhaps made you go back to that moment for a while.’ This phrase was chosen to satisfy a focus on external memory cues, while trying to be open. It was explained to participants that ‘things’ could refer to all modalities. People logged their responses via sentence completion, with three questions to be completed per entry: ‘I remembered..’, ‘Because I noticed..’, and ‘This made me feel..’ This format garners free responses with a minimum of guidance necessary for the study interests. Participants kept the diary for a minimum of ten days, although it was allowed to keep the diary longer if the first ten days proved unfruitful (e.g., due to forgetting or not (realizing) being cued). Diary entries were transcribed prior to interviews, with unclear and interesting entries marked for further questioning. Diaries were contrasted with earlier entries to help grounding of early findings.

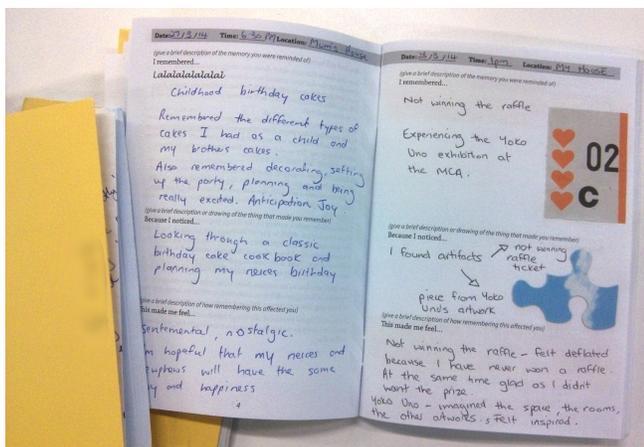


Figure 2. Example of a completed and filled in diary.

Interviews

Three to seven days after handing in the diary an interview was held to aid interpretation of the diary, and discussed reminiscing practices and perspectives. The semi-structured interview elaborated on diary entries and how significant these listed memory cues were to the participant, how important reminiscing and reflection is in their life and in what way items play a role, and how they perceive differences (if any) between physical and digital mementos. The interviews were held in a quiet space on campus and lasted up to one hour.

Analysis

Data from 15 participants have been used (see Fig.3), including interview data for one participant who withheld her diary because she thought that its content was too personal for her to share, and another person handed in a diary but was not available for an interview. In total, 208 diary entries were used. Seven diary entries did not relate to a past memory and were excluded (e.g., observations about in-the-moment events). Entries based on involuntary internal cueing (i.e., thoughts), although infrequent and not the focus here, were left in. Qualitative thematic analysis

aimed for data reduction through quantitative summaries of diary entries and identified recurring themes through inductive coding of the data, using a single coder [cf. 5]. Entries were coded twice: first in a directive approach on summative measures as in earlier work to enable comparison (i.e., categorizing as objects, or smells, or people, etc.) [4], and second, entries were clustered based on emergent affinity which allowed finer grained categorization and contrasts (i.e., not just objects as category, but split into tools, souvenirs, clothing, etc.). Further measures per entry included memory valence (positive/ambivalent/negative), memory specificity (lifetime periods/general events/event-specific knowledge [8]), and whether the participant controlled the exposure to a memory cue (as interpreted by the coder via entry text).

Interviews were transcribed and all relevant statements (i.e., excluding elaborations on tangential matters) were printed and cut into separate paper strips. These strips from all participants were clustered by similarity into a hierarchical structure to support examination. Recurring themes emerging across interviews, and diverse views on these themes were used as the basis for organization and analysis. Together with the diary clusters this provides the structure for our insights into what role memory cues play in people’s lives, how people relate to their past, and what potential role HCI can play.

FINDINGS

We give an overview of the data, and discuss several themes that emerged during analysis, and relate the findings to our research questions. When relevant, findings will be contrasted with earlier work. Quotes from diaries are marked (P2-d), interview quotes show (P2-i).

What cues memories?

Quantitative overview of diary entries

We would like to give a brief quantitative impression (although our qualitative findings do not depend on these). The median number of reported cued memories was 11 (range: 2-37). This study limited itself to externally cued memories, while other studies included internal cues (e.g., thoughts) and those reported a slightly higher average of recorded memories [4]. Following a categorization similar to Berntsen, most cues relate to physical objects (52%), locations (14%), activities (9%), people (9%), digital items (e.g., photos or social media; 10%), and 7% other (e.g., sensory, feeling, wording). Objects were mentioned more often compared to ~17% in earlier work on involuntary memories using diaries [e.g., 4, 28]. This bias towards objects may result from our request for external cueing.

Valence showed strong dominance of positive (51%) compared to negative (21%) and ambivalent feelings (27%). In prior diary studies a higher percentage of negative memories surfaced (positives were similar), perhaps due to inclusion of internal memory cueing [4]. The cued memories related to event-specific knowledge in 45%

of entries, with 40% cueing general events, and 15% related to lifetime periods. Both measures showed variance between participants, which may either be genuine, due to style and specificity of writing, or due to a low number of entries for some. Our data is inconclusive on this aspect. For half of the cues reported on participants had some control over the exposure to a cue by means of ownership and/or deliberately seeking out these stimuli. This was clearly the case for categories such as tools, souvenirs, (digital) photos and websites visited. Other categories related to locations, music, social events, and social media did not give much control over exposure to cues.

<p>[I remembered] <i>breakfast in my childhood - my father made breakfast every day, and we always had a porridge as part of our breakfast, which he was very particular about cooking</i></p>	<p>[I remembered] <i>sitting with my dad while he talked about 'how' to do things</i></p>
<p>[Because I noticed] <i>I still love to cook & eat porridge for breakfast – but my porridge is from the supermarket. My dad bought a special mix from the health food shop</i></p>	<p>[Because I noticed] <i>I was sitting explaining what the plumber was doing with my friend's son</i></p>
<p>[This made me feel] <i>connected back to my childhood, which was very happy and the routines + care of my father, which always gave me lots of safety + love.</i></p>	<p>[This made me feel] <i>very happy, teary</i></p>

Figure 3. Two examples of typical diary entries.

Objects as cues

Physical things proved the most common memory cues. While incidence of objects was higher compared to other diary studies, this was not the case for all participants. Some participants perceived less sensitivity to objects: *“The nature of the diary led me to believe that physical objects were the cause of my memories, but what I found was that it was actions that made me remember things,”* (P8-i) according to a participant who noted not keeping a lot of things around in his home.

The kind of objects varied widely, with tools, clothing, souvenirs, gifts, books, decorative pieces, images, and food being the main subcategories. Not every object may bring back memories, but for those that do there is usually a story in which the object played a (minor) role and has since become a signifier for this story: *“[I noticed] My transistor radio! I listen to the ABC through the day - sport, news, and classical music! [I remembered] my father listening to his transistor radio all day as he carried it about with him around the house & garden (...) [This made me feel] fond + proud of my dad, and happy for everything that he taught me”* (P3-d). This entry illustrates that an object often cues memories not because of itself, but rather because it, or the

cued memory, relates to other people. A part of the memories reported relate only to the participant, but the majority involved a social relation. This can range from rather mundane (e.g., acquaintances having the same cutlery set) to teddy bears that played a role in significant periods of someone’s intimate relationships.

Photos as cues

With few exceptions people display photographs around the house, as told during interviews, but entries were infrequent for photos as cues. Most participants were active users of the camera function on their mobile phones. An interesting aspect of this use is the occasional glancing at taken photos people engage in whenever they have some time to kill. Recent and not so recent photos are flicked through ever so often for relaxation purposes.

Practices and values on personal photographs differ widely between people, as some take less and attach less value to images, whereas others appreciate photography as a hobby and enjoy having aesthetically pleasing examples around. Therefore, photos (and other items) in the home can take on a position beyond memory cue as a medium of expression of (family) identity, a conclusion similar to Kirk *et al.* [20]. Photographs may be a familiar sight and did not capture attention with related memories. When prompted, people could report on related events, but in daily life such items appear to be no constant source of involuntary memories: *“we do have lots of photographs around, but those in the living room weren't the ones stimulating memories. (...) It's nice to have some pictures around the house. I would be sorry if I'd lost them”* (P11-i).

Digital versus physical cues

Digital cues account for a small amount of entries, with social media posts most prevalent (e.g., photos posted by others). These photos were not deliberately sought by participants but rather appeared in the digital environment people frequent. All participants mentioned digital photos although only one diary entry listed a digital photo as cue. Perhaps people realize memory cueing more with physical than with digital items, including photographs. An example of such different perceptions is this quote by a male participant on family photos: *“I don't really pay much attention to the computer-stored ones. For me family pictures in frames around the house are important.”* This seems in contrast with a later quote on digital photos: *“When the laptops are on there is a rotation of family pictures on them. And I do enjoy the process of seeing 'm come up.”* (P11-i). Family pictures in frames take on extra meaning given their placement in the home. Digital media, when merely stored and not put to use as a background image or otherwise, as a result could be valued less. This finding, while not original [19, 25], appears robust across participants.

A majority expressed preference for physical compared to digital items as mementos. The following quote summarizes the opinions well: *“Things... you can feel and touch*

something. (...) Whereas with the digital (...) there is something removed about that, in a sense.” (P3-i). One participant explicitly mentioned his preference for digital media given that voluntarily bringing back memories feels equal to him, but physical things can be a practical burden (he kept hardly any himself).

Participants felt that digital media, such as photos taken on a phone, were lower in perceived value and usefulness, almost ephemeral. Such qualities have merit: digital snapshots are considered well suited to share with others as a means of keeping in touch. Preservation is not a big topic for some of the interviewees, with one participant mentioning she lost digital images by giving away an old phone to a friend and not feeling too bothered about the fact. A somewhat paradoxical case of preservation is seen in another participant’s efforts to complete his life’s timeline on Facebook by scanning and uploading old pictures. Despite considerable effort to make sure “his story is told” (P15-i), he mentioned not feeling much attachment to this result. In case of losing it (e.g., due to demise of Facebook), he would still have the memories, as well as the original photos. The tendency to ascribe lower value to digital mementos is generalizable [25, 27]. It appears positive values derived from digital media are less evident.

Locations as memory cues

Locations, and actions in specific locations, were reported on frequently. Most entries related to earlier experiences in the same environment, but just similarity was enough in some cases to invoke memories. For example, a sandy beach and high temperatures were distinct enough to cue memories of another beach far away in time and space. In other cases it was not so much the location as the opportunities afforded, such as the ability to go somewhere at a ferry terminal. The latter example could be described as reflective, similar to motivations to go to a park that later sparks many related memories.

This study provides no clear perspective on whether a location as a whole is the cue, or rather something specific within this environment. For example, in an entry noted at a beach a low moon reflected in the ocean, triggering a participant’s memory of “going in the ocean at night for the first time a couple of weeks ago. [This made me feel] excited: keen on going swimming at night soon again” (P17-d). Being in the same place may evoke a similar state of mind and makes it likely some aspect pulls past events to the surface, making it difficult to retrospectively tell if it really was just that element as cue. Another entry underlines this by pointing to the column portico of a university building upon returning there. The act of going back, and taking that familiar walk, contributed to the sense of nostalgia before seeing the distinctive portico.

Activities as memory cues

Activity was often named as a cue for events in which a similar action had been performed. A few participants realized that for them it often wasn’t specific items that

brought back memories but rather it was doing something similar as in the past. For one person, aware of his proclivity to remember by doing, it became part of his practice (and tendency not to take many photos): “When doing things, you get a déjà vu: what you were seeing, smelling, and feeling as well. [...] An image... I’d think ‘oh, yeah, that was really, really good,’ but doing something engages that whole process of remembering.” (P8-i).

Why do activities cue memories? When trying to fit groceries in a bicycle bag, a participant was reminded of previous times she faced the challenge. Without an immediate challenge present, it is less straightforward: “When I swim in the morning, I always remember my boyfriend. [Sporting] became part of something we did together (...) and then you think about a person and it becomes a habit” (P4-i). We argue it may be repetition, and through this the accumulation of meaning that aids remembering of events in which the activity took place. Although mundane activities like cleaning and cooking were mentioned as well, it appears sports provide a unique opportunity through the repetition and relation to values in life. This diary entry captures it well: “[I noticed] how good I felt after going for a jog, and arguably during the jog. [I remembered] how good I felt when I was more active. (Used to run frequently). [This made me feel] good, proud that I have restarted the regime.” (P1-d).

Food related cues

Eating and food-related materials came up often, and included ingredients, making food, related tools, and sharing a meal (see Fig.2). Although not mentioned often within HCI [23], food is one category where items, activities, social gatherings and accumulated meaning combine. Food-related cues prompted memories on social gatherings, past events, people’s preferences, and the relationship with family members: “[I remembered] cooking with my mother – as a child living at home, [Because I noticed] her handwriting on a recipe I was about to use that evening. [This made me feel] a little sad – that I can no longer call her & chat about day-to-day things. That she is no longer with us.” (P9-d). Like activities, food and its social practices appear to accumulate meaning over time and as such the repetition makes for a stronger memory. The cooking example indicates dishes can be specific to an event or a period and take on a role as signifier for those moments, presumably cementing its ability to cue memories later.

Which memory cues are valuable?

While our focus was on involuntary cueing, discussions on valuable items as cues centered on practices in the home as the place for storage and display of items for their related memories and/or aesthetics. We found a relationship between the perceived need of access to related memories and item placement. For some, items were deliberately put on display to serve as signifiers of positive moments and self-attributes. These items thus served to display and cue

positive attributes of identity: *“it's like each of those things paint a stroke in your own painting”* (P4-i). This desire to have the home reflect identity is found with nearly all participants, and echoes prior work [e.g., 10, 20, 27]. This highlights that the need for reminiscing ties into perspectives on the past, and how it relates to the present.

An item's relation to the present may morph over time as it may take on new meaning after influential events, and remain valuable partly because of this. For example, a hand-knitted scarf once received as a gift from a friend since lost has come to signify personal growth: *“it's ultimately a symbol of rejection [in the past]; it's also a symbol of love. (...) And when you keep things of your own failures around, it keeps you humble. (...) It encourages you to keep growing”* (P4-i). Such tokens of important life events relate to complex emotions. Other work on digital remains and heirlooms corroborate these findings [20].

Meaning develops over time for many personal items, as these things get put on display, get used, scarred, or fall out of use and are reencountered after a while. A good example is a story on a bike that a participant uses to go to work daily, which was bought years ago and has since accompanied him around the world: *“... I need to replace a few things. So I think 'do I get a new bike? Or do I replace the components?' And I replaced the components, because of the memories I think, and probably as a keepsake.”* (P8-i). Other people illustrated similar stories that showed a gradual attachment over time as an item played a small part in their life. This complements other work on personal belongings that emphasize the beneficial role of a repeatedly observed (or used) factor for investment of meaning [20, 27].

DISCUSSION

In the reported study, we investigated involuntary memory cueing to inform design for remembering. Our findings show that a broad range of external stimuli can trigger remembering experiences. We found physical items took precedence as involuntary memory cues; environments such as parks and beaches got frequent mention, as did activities. The latter is not often discussed, perhaps because activities are not typically thought of as a cue for earlier events. Yet, psychology studies on involuntary memory cues back up our findings for these kinds of cues [e.g., 4, 28].

The use of self-reports throughout the day brought in reports beyond the personal and curated. However, for personal items people were able to relate stories and histories in which these items played a role. Meaningful items are often put on display (e.g., photos to display family bonds) or, like inherited dinner plates, are “honoring through use” [20]. Indeed, when discussing personal memory-related practices in the home, our findings dovetail with earlier ethnographic accounts [10, 20, 27], although these works oriented towards voluntary memories, and employ a broader sociological perspective [cf. 20].

In earlier involuntary cueing work there was no attention to the media representation of a cue, so no comments were possible on digital cues [e.g., 4, 28]. We did categorize these, and found digital items were not common as involuntary cues. Most participants who use digital social media were able to remember instances of reminiscing invoked this way. Browsing photos on a phone gave no diary entries, but was mentioned by several participants as a pleasant activity. It may be that participants regarded this as a voluntary act, while the focus here was on involuntary cues. Alternatively, if digital media are encountered involuntarily as on social media, these are able to foster reminiscing, but for self-managed material this value may be overlooked due to accessibility (e.g., participants mentioned storage and management burden). Photos on phones may lower the bar, being within easy reach.

Despite intent to focus on digital cues, this study does not make clear whether there is a difference in remembering experience for cues that could be both digitally and physically presented. Our findings suggest ability to cue extends to a wide variety of items, but availability to be observed is key (which may explain the prevalence of physical items in the responses). This question of representation is in need of future attention, because if remembering experiences differ depending on the way a memory cue is presented this has implications for future devices that support remembering using cues.

Some methodological limitations apply. Using diaries enabled self-reports directly after being cued. However, some people wrote in the diary a while after because they felt burdened carrying it around. Such practices may introduce retrospection on memories invoked earlier or leave ephemeral and quickly forgotten memories unreported. Diaries were then filled out upon coming home, perhaps around dinnertime, which may have primed food-related entries. Future studies could employ a staged capturing of data (e.g., noting keywords, with full descriptions added later) to ease reporting.

Observed differences between participants might be attributed to different task interpretations. In particular, some felt restricted to physical observations and, for example, excluded music as cue. This may partly explain the higher count of objects in our data compared to other work [4], and could have reduced the number of digital cues. However, comparing is difficult, as those did not specify involuntary memory cues as digital. Furthermore, we suspect some filtering took place on what was recorded. While unexpected when relying on someone's awareness of being involuntarily cued, some participants might have discarded cued memories that did not feel very personally relevant, which may bias our findings.

Although we stressed people to not look for things that reminded them of personal memories, and rather rely on involuntarily cueing, we could not control for this other than retrospectively asking about their motivations to note

certain entries. While responses suggest entries were indeed based on unintentional invocation of memories, in many instances in the home items were deliberately put on display to serve as occasional reminders and evidently did so, blurring the line on intentionality.

It needs acknowledgement that memory cueing is not a straightforward process and a cue can via cascading thoughts lead to a memory that may no longer be recognized as brought about by the original cue. The act of writing in the diary (or remembering to do so later) may equally modify one's perspective on the original cueing event and related memories. This modifying aspect is relevant to consider for interactive devices, but here it can be seen as a potential influence outside our control.

The remainder of this section relates implications and opportunities for interaction design to support reminiscing, which are described as dimensions of trade-offs to consider. These dimensions are timing, exposure, and the process of becoming a meaningful memory cue.

Timing: moments for presenting cues

Reminiscing and reflection are not activities people set out to do for a while, according to participants. A reflective mood will certainly increase the odds, but it is rather something that comes up while doing another task (e.g., doing laundry, cooking, riding a bike). Depending on cognitive demands, a task may allow the main activity to move to the periphery of attention [2]. Opportunities for reminiscing can be facilitated by augmenting existing interactions that are prone to mind wandering. Making food was indicated as an example of such a low-key activity, and a device could capitalize on the opportunity to inspire positive reminiscing. Facilitation is certainly challenging because it may be hard to steer the wandering mind, but such suggestive devices embedded into everyday activities have potential to tap into moments when people say they enjoy thinking about their lives.

To engage people in reminiscing via designed cueing requires sensitivity to opportune moments. By definition involuntary cueing is unsolicited, but devices that aim to do so would benefit from a way to sense (un) desirability, or alternatively, provide the means for people to indicate in retrospect whether they appreciated the experience of being cued. Over time, a system may be able to learn from such feedback. Other technical means may be available to sensing appreciation (e.g., facial expressions, time spent looking at an item). Similarly, user activity could be classified as relaxed and open to interruption, or in a state of flow. The opposite end on this spectrum would entail no cueing is commenced without prior voluntary action.

Exposing a cue: what and how

A key element for any system is to find out which available items relate to a valued memory for someone, and in which way these items are best presented. Finding out about perceived value (whether of an item-as-cue or a related

memory) could be done in advance through explicit inquiry, or retrospectively through feedback. One issue for automated gathering of such knowledge is that meaning of an item is idiosyncratic and perhaps ambivalent, as our findings indicate. While (for example) number of interactions may be a telling signifier (e.g., how often a song was played), a system may not know why. Previous work has sidestepped this issue by considering random viewing as a way of achieving serendipity [e.g., 9, 14].

Next comes the question of which form this exposure should take. While our data suggests a related memory is a stronger indicator of appreciation than the cueing itself, our findings leave room for exploration of this cueing manifestation. Remembering through action is worthwhile for further investigation. We imagine interactions can be leveraged not just as means to access content, but also be conducive to reminiscing. If a device is aware of reminiscence-prone activities, there may be opportunities to reminisce on earlier events through stimulation of activities. Relating to positive memories could stimulate similar experiences, as seen with the jogging example.

People expressed no need to consider the past all the time. Potential overexposure is important to consider for interactive devices as digital devices enable us to frequently encounter many mementos: we can quickly retrieve any old item, whenever we want, which may change how we develop relations with these mementos [29]. It is a contrast with the normally hidden shoeboxes of old, and explorations building on this theme [e.g., 11]. Frequent interaction with the past can have adverse effects, both for painful memories and the inability to move on with one's life, as pointed out by two participants familiar with depression. There is equal value in forgetting as part of a healthy memory system, and indiscriminate invocation of unpleasant memories can adversely affect people's wellbeing [3]. Still, we believe that when done right, designs can engage with the process of reflecting on meaningful events of the past [e.g., 21].

Process of becoming meaningful as a cue

Can meaning be designed for or cultivated through design? This is a design challenge we seek to contribute to. The study presented in this paper was concerned with existing items that had the ability to bring back memories without being designed explicitly for that goal. Based on our findings we note that memories and meaning do not form a straightforward relationship with an item. This sometimes tangential relationship can be idiosyncratic [27]. For example, the scarf discussed earlier symbolizes a lost friendship, but this symbol could have been another item. We speculate everything might be able to become a memory cue depending on how people relate to it, but some designs may be better suited to bring back memories. The scarf's handmade materiality may be such a design element that signifies emotional investment, a quality harder to replicate in digital media. Therefore, especially for digital

devices that could cue memories, we believe a very relevant question is how it can be designed to become meaningful.

The notion that meaning develops over time is interesting to investigate in future designs, and echoes similar findings by Petrelli *et al.* [27]. Repeated exposure and engagement with potential memory cues seems important, and such investment of time hampers digital cues to pick up meaning. Compared to physical cues, digital ones get comparatively less exposure in everyday life, if going by our results (although Schwarz points at a different trend [29]). If repetition is key to accrue meaning, designs could explore ways in which meaning develops and grows over time (e.g., through repeated exposure). If indeed how people come to relate to something is more relevant than what the thing is, we should consider how we could foster a relationship between a personal memory and a cue. Designing for this process and facilitation of reminiscing and reflective thought appears a veritable direction of inquiry. This is different from designing an item to be able to cue an autobiographical memory, and rather may use items to facilitate the process.

Whether such accrual of meaning is deliberately sought via interactions with someone (e.g., by repeated exposure) or, as per the opposite, that increasing meaning is derived from usage data (e.g., how often an item is revisited), is a design decision to be made. It relates to the other dimensions by focusing on what could become valuable if given time. As an example, our findings suggest items that relate to social connections would be likely to become regarded as valuable, if this connection is indeed seen as such.

Limits to what technology could accomplish

The aforementioned dimensions all require trade-offs to be made considering the desirability of involuntary cueing from a user's perspective. For example, obtrusiveness of cueing relates to insensitive timing and/or misjudging exposure to a cue for an undesired memory. Whether a system can be successful depends on how well it is able to understand the context of its use and how well it adapts to such knowledge. The challenge is to judge this desirability within the means of technology, and handle the cases where it cannot adequately know in an appropriate manner.

Getting the necessary understanding may depend on machine learning algorithms that may or may not be sufficiently capable to do so given hard to measure data such as personal attachment to an item or openness to consider one's past. The latter issue implies a fully involuntarily experienced system may be imperfect, and a balance with some voluntary interactions could serve people's needs better (e.g., using retrospectively marking of certain cues as desired or not). Furthermore, there are aspects that are hard to prepare for with a technological system, as shown in earlier work on inheritance of digital data [e.g., 13, 22]. However, the ways imperfect moments play out are malleable. We believe designers should acknowledge the limitations of technology by not relying

extensively on it and rather opt for a dialogue, similar to how physical items, their meaning, and visible (dis)placement form a dialogue with their owner through manipulation of place (e.g., hiding things).

Reflections on HCI research for remembering

Having made the argument that meaningful connections between items, the self and memories are forged over time, this has implications for design research. Careful study of designed interventions should consider the effects of repeated user engagement, and would therefore benefit from longitudinal evaluation. Most of the design examples discussed in this text were studied for a limited period of time (as are many not discussed here), perhaps falling short of the time necessary to become related to at a deeper level. Because passage of time may alter our perspective on earlier events, remembering experiences after two years can yield different insights from doing so after one month, the former closer to a real life use case. An emphasis on longitudinal evaluation can thus provide necessary insight on designing for remembering support.

CONCLUSIONS

We believe understanding what makes people remember their past and how this colors their experience is important to inform designs that aim to support everyday remembering. Our work contributes to the literature by integrating diary self-reports with follow-up interviews to further our understanding about the relation between involuntary memories and the things that cue such memories, and how people relate to particularly meaningful items. The findings illustrate memory cueing happens everywhere: meaningful cues are not limited to the home, nor should its study be limited to that environment.

Repeated encounters in daily life, in which the item may be tangential to the task at hand, provide opportunities for items to take on meaning. Such practices do not easily extend to digital items, although nowadays many potential cues are digital. While physical items can be put on display or used for common tasks (e.g., inherited cutlery), we believe this proves a challenge for digital items to be used for everyday remembering as these are often not encountered on a regular basis (or serendipitously for that matter). Even though easy capture of media for future recall seems a problem solved – too well perhaps [29, 30] – our work addressed how these items are currently encountered and can be used as support for reminiscing and wellbeing.

Considering our insights we can now state what we believe to be effective practices for interaction design to support everyday remembering. Integrating with common activities that stimulate the mind to wander provide opportunities for reminiscing through design; involuntary cueing can lead to surprise revisiting of memories, including undesired ones. Designs should allow for some control over (non) exposure to certain cues. Meaningful connections grow over time: designs can support this process. Evaluation of HCI designs for remembering can benefit from a longitudinal focus.

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