

Exploring Self-Defining Memories in Old Age and their Digital Cues

1st Author Name

Affiliation
City, Country
e-mail address

2nd Author Name

Affiliation
City, Country
e-mail address

3rd Author Name

Affiliation
City, Country
e-mail address

ABSTRACT

Self-defining memories represent significant emotional events capturing the most important concerns in our lives. While much HCI work on memory technologies has focused on autobiographic memories and lifelogging technologies for capturing them, there has been little exploration of self-defining memories and how they may be supported by appropriate cues. This is important as such memories are key in the development and maintenance of sense of self, particularly in old age. We report on interviews with 8 older adults in their homes. Findings advance the understanding of self-defining memories and their possible cues with new insights into their relationship with self identities and cues' specific qualities supporting richer emotional recall. Our findings led to several design implications such as novel technologies for curating self-defining memories and their cues, for embedding layered meaning in such cues across the lifespan, and for crafting them.

Author Keywords

Self-defining memories; memory cues; self; older adults.

ACM Classification Keywords

H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

INTRODUCTION

Sense of self is crucial for our perception of continuity through time, and invaluable for wellbeing [32]. It captures perceptions and attitudes about oneself, often as a set of identities such as personal, relational or collective self [18,39,42]. Sense of self is actively supported by personal memories [54], and in particular by self-defining ones defined as autobiographical memories capturing lasting concerns or unresolved conflicts [4,21,28] around significant events, which help people explain how they have become who they are [9].

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Fig. 1. Crafted objects as cues for self-defining memory: handmade doll cloth (P1) (left) and embroidery of a regimental badge (P7) (right).

When memory weakens because of cognitive decline of healthy aging or dementia, the sense of self also weakens, with findings showing the painful impact of the disintegrating self on dementia sufferers and their families [5]. Much HCI research on memory technologies has focused on the value of lifelogging systems for capturing and archiving large amount of digital memories to support total recall [41]. Such emphasis on capture technologies however does not account for the significance that people attach to their memories and for the specific cues they identify for them. In addition, despite the importance of supporting self-defining memories, and their much exploration in memory research area [4,21,42], we know little about if and how such memories may be cued in healthy ageing and dementia. Relevant HCI work on cueing has focused mostly on autobiographical memories [11,15,24,36,40,55] with less exploration of self-defining memories.

We argue that if the aim is to strengthen the sense of self in old age, then we must move beyond the main emphasis on capture technologies to explore the cues that people identify for their self-defining memories and how they may be supported. To address such gap, this paper aims to investigate self-defining memories in older people, and in particular the possible cues that they identify for recalling them. The idea that people can identify memory cues, before they cue, has been previously argued based on meta-memory judgments [53], and on emerging findings on self-chosen cues supporting recall of self-defining memories of people living with dementia [21]. An understanding of what can cue self-defining memories, the content and format of

such cues, where they are stored, and how they are retrieved should support the design of technology to capture, store, and retrieve digital memory across the lifespan, and in particular to help strengthen the sense of self in old age. We report on interviews with 8 older adults in their homes about such memories and how they can be appropriately cued. Our study addresses the following research questions:

- What *types* of self-defining memories do people identify? What are their affect, content and reflected self identities?
- What *types* of possible cues do people associate with self-defining memories, *where* do they store them, and what *challenges* do they face in identifying such cues?
- What *qualities* do self-defining memory cues have?

RELATED WORK

The study outlined in this paper draws from previous HCI research on memory cues, and memory technologies for aging, and of the growing body of work in psychology of memory and in particular self-defining memories.

Memory Cues in HCI

Most HCI research has focused on technologies for capturing and supporting recall of episodic memories [40,55]. There are two main types of cues supporting this recall namely internal ones consisting of sensorial experiences and feelings, and external cues present in physical environment [53]. The latter may include objects, people, activities and places, and their capture through photos, physical and tangible objects has been particularly explored in interaction design [53].

Much work has looked into the impact on recall of different modalities of memory cues, mostly visual [40] and audio cues [15], although the investigation of other cues such as location-based [24], or crafted cues [36] has also started to emerge. Beyond the exploration of cue modalities in isolation, other scholars have looked at combining them. One such example is HP *memory box* [19] which integrates sound-based narrative with stored memorabilia to support episodic recall. A few studies have explored the enduring impact of cue types on retrieval, such as photo, sound, video, odor, or physical objects on one-month old autobiographical memories [52]. Findings indicate that no cues condition led to more memory-details than cued conditions. However, with the exception of physical objects crafted by participants, the rest of the cues were generated by researchers, and hence may not have been typical or unique; characteristics considered key for successful cueing.

Other strand of HCI work has explored physical or digital possessions and their value for remembering [30,31], building on the link between possessions and sense of identity, and in particular Belk's [2] theory that possessions are components and determinants of sense of self consisting of: collections, money, pets, other people, and body parts. Later work has identified alternative categorizations of possessions in objects of power, self-continuity, and

relationships [12], or, for their role in recall, in mementos (reminders of special events), souvenirs (reminders of special places) or heirlooms (family or inherited objects) [13]. Souvenirs relate mostly to holiday memories, are on display in house's public rooms and used for reminiscing [51], while mementos were categorized in artwork, photos or symbols of achievements often on display in public spaces [33]. Memorabilia (serving specific function and occasionally used), and idiosyncratic deeply personal objects tend to be privately stored [33]. A few studies have focused on how older adults' memory and identity are challenged by moving in later life to residential care or downsized homes. Findings suggest that to address limited space and fewer cherished possessions they can be brought with, people document and engage in tagging or telling stories of lost objects [27]. Apart from supporting recall, an emerging body of work has looked into how possessions may be questioned when cueing strong negative emotional events no longer relevant for the current self [37,38].

To summarize, much work has focused on cueing autobiographical memories to support recall [11,15,24,36,40,55] or explore forgetting [37,38]. Most cues are printed photos or physical objects [53] created by researchers or belonging to participants' possessions. Although few prior studies have touched upon the relationship between possessions and self [27,33,37], there has been however limited exploration of self-defining memories and how they may be cued.

Memory Technologies for Aging in HCI

A particular strand of memory research in HCI has focused on older adults to support their memory impairment due to aging or dementia [23,40,56]. A much used technology is SenseCam, a wearable device which automatically captures photos in daily life. Consistent findings have shown its value in supporting the recall of episodic memories [22], particularly those of personal relevance to people suffering from memory impairment [25]. Other work integrated SenseCam photos with ambient displays for showing both past and recent photos, which has supported the sense of self of people suffering from Alzheimer's disease [11]. These authors also describe *multimedia biographies* co-designed as collages of personal photos, videos, and narratives on life stages and themes by people with memory impairment. Findings suggest that this practice supports the reminiscence of positive events, but its value for strengthening the sense of self has not been investigated. Another interesting system is *Memento* [57] which creates hybrid physical-digital scrapbooks allowing older adults to reminisce and share their memories.

For older adults living independently, HCI researchers have explored technologies such as *digital family portraits* communicating daily activities from sensory information to remote family members [29], or *CareNet display* [7] providing information to older adult's support network to reduce carers' stress and assist their coordination.

To conclude, most HCI work on memory technologies has focused on curating and capturing life events to support older people's recall and share of their episodic memories, or to inform remote carers of older people's daily activities. The emphasis here is on digital caption of past or very recent life events, but with a few exceptions [11], their value for sense of self and in particular for remembering self-defining memories has been less explored.

Memory Research on Self-Defining Memories

Autobiographical memories contain crucial information about the self [10,34,35] in the form of personal semantics comprising general knowledge and facts about oneself [28], and episodic memories of personal events located in a specific time and space and re-experienced through mental travel of the self [48]. Self-defining memories share characteristics with both episodic memories such as rich phenomenological details and specific spatio-temporal context, and with personal semantics in the form of more generic memories of personal events clustering in patterns over time [42]. What sets self-defining memories apart is one's enduring concerns reflected in events focused on self-discovery, self-understanding and identity [4,21]. Findings have also shown that self-defining memories related to negative emotional events are more challenging to process albeit crucial for one's wellbeing [32].

With respect to content, prior work identified different types of self-defining events such as narratives of threat, disrupted relationships, conflict-free relationships, achievement, failure, exploration, or guilt/shame [4]. Additional studies have also shown that the content of self-defining memories is structured around concerns, unresolved conflicts, and current goals [3].

In terms of healthy aging's impact on self-defining memories previous findings showed that when compared to college students, older people recall less detailed and more summarized and positive self-defining memories encoded across the lifespan and focusing on meaningful themes such as achievements (32%), relationships (27.5%), life-threatening events (21%), recreation (8%), or guilt (5.5%) [42]. De Vries and colleagues [14] also showed that in life review, older people focus more on career and illness than younger people, suggesting that the former have more self-defining memories around life-threatening events.

In terms of the endurance of sense of self in old age, following interviews with people living with dementia in nursing home, Cohen-Mansfield and colleagues [5,6] have shown that all roles deteriorate (professional, family, leisure and personal), while the family role is best maintained.

There is also a wealth of research on self-defining memories in dementia, with consistent findings showing their decline due to the required high level of specificity [28]. Such decline is made responsible for the loss of sense of identity in people living with dementia [4,21]. Unfortunately there is a paucity of studies exploring the

retrieval of self-defining memories in dementia. A noticeable exception is Haj and colleagues' work [21]. They showed that exposure to music supports better retrieval of self-defining memories than autobiographical memories, when the music was self-chosen by participants instead of selected by researcher. This important finding can be explained by dementia sufferers' active involvement in the selection of favourite music.

To summarize, self-defining memories are key in maintaining the sense of self, but prone to aggressive deterioration in old age and dementia. With a few exceptions there is a lack of studies exploring the possible cues for retrieval of self-defining memories in old age.

METHOD

For our exploratory study, we recruited a convenience sample of 8 older adults (age range 65- 82), 7 female and 1 male (P4). The rationale for this choice is threefold: older adults have more self-defining memories to report, arguably larger collections of possessions which may be used to cue recall; and are more inclined to contemplate and reflect on their lives in order to develop coherent narratives [16]. Participants are from the UK so the empirical data is drawn from a similar Western context as most of reviewed work.

Study involved contextual interviews in participants' homes prior to which they were asked to think of three self-defining memories described according to Singer and Salovey [43] as remembered clearly, important to them, leading to strong feelings, and helping understand who they are and how they come to be the person they currently are. We sensitively focused only on positive self-defining memories in order to limit the risks of revisiting previous trauma which may be associated with negative self-defining memories [44]. Participants were also asked to give a house tour to identify among their possessions those cueing self-defining memories, leaving it open to them to select physical or digital artifacts. Interviews took about an hour, were audio recorded and fully transcribed.

Data analysis involved a hybrid approach with existing concepts informing the deductive coding, while new ones, grounded in the empirical data, contributed to the inductive coding [17]. The deductive coding included concepts from autobiographical and self-defining memory research [28,42,48], with codes capturing the content and types of such memories and their cues [15,24,36,40], and different self identities [6,18,42]. Participants' memories were identified as self-defined if they contained specific spatio-temporal and phenomenological details such as thoughts and feelings, as well as integrative meaning as lessons extracted beyond the recalled event [4] contributing to their identity construction, enduring concerns or unresolved conflicts [28]. The coding list was iteratively refined in the light of the interview data, as new codes emerged such as negative self-defining memories, redemption memories, crafted cues, and cues' qualities.

FINDINGS

This section describes the identified self-defining memories in terms affect and content, and how they reflect different self identities. Then we focus on the possible cues for these memories, and the challenges of identifying them.

Self-defining Memories: Retrieval Process

Only two participants (P2 and P8) reported directly their top three self-defining memories. The others started their free recall with life story narratives identifying self-defining memories throughout life periods. Because of this approach, participants were able to recollect the sequence of events leading up to their self-defining memories, demonstrating also how those continued to affect them long after the initial event.

While previous work also indicated that older people's self-defining memories are spread across the lifespan [42], our findings provided new insights into the life periods when such memories were encoded and their relative weight: childhood (25%), adolescence (15%), young adulthood (15%), adulthood (41%), and old age (4%). Such emphasis on the early life, providing over half of self-defining memories, extends similar findings on episodic memories [28] and reminiscence bump theory [34]. Our findings also contrast those on the life periods from where mementos emerge, i.e., less from formative years and more from recent past and adulthood [33]. This may underscore a critical distinction between self-defining memories' cues and mementos, as the former may be significantly shaped by earlier life periods when self-identities are emerging.

Self-Defining Memories: Affect and Content

Participants reported 28 self-defining memories; slightly more than 3 per person. The majority of self-defining memories (82%) related to positive emotions, while remaining 18% to negative emotions. Most self-defining memories eliciting positive emotions related to positive events such as achievements and loving relationships (46%), or to negative ones transformed into redemption narratives (36%). The latter could be either relationship-focused: taking responsibility for less fortunate others; or self-focused: overcoming personal challenges through self-mastery. These outcomes confirm those on positive self-defining memories of older people [42] underpinned by successful relationships and personal achievements [3,5,6,42]. The content of negative self-defining memories relates to loss or transgression, confirming previous findings on unresolved conflicts [3,28] and disrupted relationships [4] albeit not mortality and guilt [3,4,42,45].

Self-Defining Memories: Identities

Sedikides and Marilynn [39] conceptualized self identity across three levels: personal self (aspects of the self that differentiate the self from all others), relational self (derived from intimate relationships), and collective self (derived from membership in large social groups). Our findings show the following weights of self-defining memories: relational self (50%), personal self (39%), and collective

self (11%), confirming outcomes on older adults' emphasis on relational self, followed by personal and collective self [1]. We now describe the identified self-defined memories in terms of self identities, as well as content and affect.

Relational Self: Loving Relationships

All participants recalled self-defining memories capturing key relationships with loved ones. These include memorable events of meeting the spouse-to-be, the first pregnancy, or family leisure time. P8 reports the memory of acquiring a handmade toy (Fig. 2a) in a country fair, signifying the romance with her husband: "*My husband and I went out for a Sunday drive and they were having a country fair, which was unusual for Australia. So we stopped and looked around, and there was a stall where this girl had stuffed toys she handmade, and I fell in love with it. It was twenty dollars, I'll never forget because I thought it was so cheap, [but] it's still going strong, it's a lovely thing. I can't remember if I knew I was pregnant or not, but it was a lovely day, not too hot, and there was this great big field full of stores. That was a happy day. That opens up memories of when my son was born, and of course one of the best memories of my life was when I saw him. This elephant was bigger than him to start with. [And] when we came over to the UK ... my husband came over a few months later holding the elephant with him, and he walked through customs holding onto it*" [P8]. This quote illustrates that the relational identity wraps around multiple roles, both of wife and mother, and the toy's ability to connect in a nexus, key self-defining events about both roles, signifying romance as well as pregnancy, unknown at the time, followed by the birth of her son.

Another positive self-defining memory capturing the relational self is described as the moment of meeting one's future wife: "*I was 20 and still serving my apprenticeship as a joiner [...] and that was the biggest event of my life: meeting her. I was in the society where they would help people in need, so we used to have dances for the youths in the area. And, I hadn't been out with girls at that particular stage, so I used to do the doors and refreshments. And she came to one of the dances and that was it! [Laughs] I couldn't dance and I asked her to dance, [quiet mumbling], that has been the essence of my life*" [P4]. While this memory is about relational self, it also touches upon the personal self because its spatio-temporal context intersects that of apprenticeship stage with its value for personal self.

Relational Self: Challenging Relationships-Transgression & Loss

Three participants mentioned self-defining negative memories in relation to significant hard to reconcile losses, such as the loss of a child through accident or stillbirth, or transgressions such as physical abuse: "*My stepfather was such a bully: sometimes when he was whacking me, the only way I could make him stop was to fall on the floor and pretend to be unconscious. So, I became very afraid of confrontation, disagreement and for lots and lots of years was very much a doormat, and wouldn't hold my ground*

for anything really” [P3]. This quote indicates the enduring impact of such experiences on the current self. The fewer episodic details of such memories confirm prior findings on repression [3] as a defensive mechanism intrinsic to self-memory system [8]. Such self-defining memories share the same negative emotions as the original even, but unlike redemption-based memories, they remained unprocessed into a coherent positive resolution [32,56].

Personal Self: Personal Achievements

Five participants mentioned self-defining memories reflecting achievements such as academic success or professional recognition, which shaped their personal self. One such example is from P5 who attended a convent school where she won a handwriting prize: *“I always wanted a little statue of our Lady, which I couldn’t have, but the prize was this little wooden statue [...] I’d only be young, about 8 or 9. I entered the competition, and I won!”* [P5]. This memory illustrates her faith, education, and values she learned during school.

Other participant mentioned an early self-defining memory as a precocious child and her trait as a fast learner: *“I was three years old when I could read and write in two languages, and I knew my Math.”* [P1]. Although not celebrated with a specific award, the achievement and the drive behind it have shaped her identity as determined and ambitious: *“If I didn’t enjoy something, I wouldn’t waste my time doing it, but if I did, I would practice until I could be the best that I could”* [P1].



Fig. 2a. *“The elephant represents memories of when the children were born”* [P8]



Fig. 2b. Crafted wooden banister: apprenticeship and meeting of wife-to-be (P4)



Fig. 2c *“I entered the competition, and I won! I was so pleased”* [P5]

Personal Self: Redemption Narratives

Four participants mentioned redemption in their self-defining memories of overcoming hardship, poverty, accidents or disability, confirming previous findings on the importance of coherent, positive resolution [56,32]. An eloquent example is provided by P2 in relation to her perceived inadequacy and physical disability:

“I was failing my 11 year exams and remember sitting on the headmaster’s knee being told I’d failed. I knew from that moment I would go to a worse school than everybody else; it made me feel thick and stupid and inferior, and

thinking that people who were cast aside because they “weren’t good enough” actually had lots of positive strong characteristics and that, kind of followed on from when I had my leg differences. That was definitely a defining memory” [P2]. The quote illustrates how these limitations have underpinned the development of her personal self, driven by values of equality and diversity.

The predominance of positive affect around personal self’s defining memories confirms the positive core characteristics of personal self that people are motivated to protect, maintain, or elevate while resisting negative feedback [39]. In this light, redemption narratives represent specific types of personal achievements.

Collective Self: Negative Impactful Events

Collective self focuses on people’s identity as members of a valued social group and two participants mentioned large scale events with significant social impact: childhood memories of the World War II or adult memories of youth’s riots in 2011 in the UK cities: *“I love Manchester and when all that happened it really affected me [and] I thought for every one of them nasty kids, there are 10 good kids out there. And I kept thinking I’m going to go to the city [and] I plucked up the courage and went [...] when I stepped off the bus [...] I just wanted to cry, it was all down, all smashed”* [P6]. This quote indicates the collective identity of Mancunians and attempts to reclaim agency, despite the disempowering impact of such events. Later, P6 came to terms with this event expressing hope: *“I’ve got over the upset now, because the city has gotten back and people are building it back up again”* [P6].

To summarize, an important outcome is our integration of self-defining memories with self identities which prior work has limitedly addressed. More specifically, findings indicate that personal self is reflected in memories of achievements and redemption; relational self captures the significance of both loving and challenging relationships, while collective self reflects predominantly negative events with large social impact.

Possible Cues for Self-Defining Memories

Findings show that the majority (90%) of cues for self-defining memories are physical objects. Most of these are ready-made objects (65%) followed by crafted objects (35%). The other two types of cues are place-based (7%) and body-based cues (4%). The emphasis on objects, be them ready-made or crafted, extends findings on the prevalence of physical and tangible objects as external cues for autobiographical memories [53] to self-defining memories.

An important finding is people’s limited preference for photos as possible cues for their self-defining memories, although photos figure prominently among digital cherished possessions and mementos [31,37,52]. To further explore the preference for different types of cues, we looked at their link with self identities, content and affect (Table 1).

Self	Content	Affect	Identified Cues (#)
Personal	Achievements (P1,P2,P3,P4,P5)	Positive	Ready-made objects (6) Crafted-objects (2)
Relational	Loving relations (P1,P5,P6,P7,P8)	Positive	Ready-made objects (10) Crafted objects (5)
	Redemption narratives (P1,P2,P4,P6)	Positive	Crafted objects (2) Body-based cues (1)
Collective	Challenging relationships (P3,P4,P6)	Negative	None
	Large scale events (P6,P7)	Negative	Place-based cues (2)

Table 1: Relationship between self identities, content and affect of self-defining memories and their possible cue

Personal Self: Achievement Objects as Possible Cues

Five participants mentioned achievement-related objects usually in paper or object format, including for example old school notebooks with high marks (P1,P2), certificates of academic or professional exams subsequently framed (P2), prizes from school competitions (P5) (Fig. 2c), and objects of professional recognition (P4) (Fig. 3).



Fig.3. Awards for professional recognition: emblems (left), oak leaves cufflinks (center), medal (right) (P4)

Such objects are deeply valued for their ability to represent positive emotions related to self-mastery, as key aspect of personal self [18] and content of self-defining memories [3,45,46]. For example, P5's recall of being awarded a handwriting prize in a school competition became richer when the Mary statue was fetched and handled (Fig. 2c). Indeed, P5 expressed more intense emotions illustrating the value of such artifact in recall: "I was so pleased to get that [smiles intently as she thinks]. It could stand up, you see, and I could put little tiny jars of flowers and things [giggles] I loved every minute of school" [P5]. She also expressed much care while handling because of its material fragility: "it is so faded, it's been in a tin" [P5].

Relational Self: Possessions and Crafted Objects as Cues

An important finding is that a third of positive self-defining memories of loving relationships have been linked to handmade crafted objects. Their ability to facilitate rich emotional recall suggests their value as possible cues. Three participants mentioned such possible cues as crafted objects made by themselves through embroidery (P1) or woodcraft (P4), or by others through sewing or weaving (P2). P2's appreciation for her elephant toy has been earlier described and two other such cues are further detailed. One is the wooden banister (Fig. 2b) mentioned by P4 with respect to

the self-defining memory of meeting his wife. He crafted the banister for a church and kept because it represented not only the formative time of his joiner apprenticeship, but more importantly the event at which he met his wife organized by the same church: "I can go back even now to the churches that I've worked at, and it gives a great deal of satisfaction to see it" [P4]. Another such cue is a doll cloth handmade by P1 for her daughter to celebrate their bond and for passing on the sewing skills (Fig. 1 left).

Collective Self: Places as Possible Cues

Given the limited number of identified self-defining memories related to collective self, it is not surprising that we have found only a few such cues. However, given the predominantly negative affect characterizing such memories, it is surprising that such possible cues were even suggested. Two participants identified place-based cues as large scale spaces with socially shared meaning. For example, P6 described the music shop destroyed during the UK riots earlier described: "What really upset me was the music shop. Because my memories took me back to me in town with my grandson" [P6]. This quote indicates a perceived transgression of P6's favorite music shop and its precious musical instruments where she has spent made many moments with her grandson.

The second place-based cue is described by P7, as the place in Normandy where her husband has been wounded during the War World II: "We went to Normandy on the 6th of June, for services in memory and respect, but it brought my husband a lot of memories of the war [...] we carried on to the place where he was wounded. He was fascinated" [P6]. Interestingly, this place in Normandy has not been photographed, although the family took pictures during this commemoration trip. Even more striking is the crafting of a cue through embroidery (Fig. 1 right): "My husband made that stitching of the unit he was with in Normandy to help his fingers after he was wounded" [P6]. Although the choice of craft was pragmatic, it allows not just the capture but also the processing of negative emotions. This may open up the design space of exploring craft for cueing self-defining memories related to personal self. This finding also indicates that significant others are in position to identify possible cues which may scaffold the recall of loved ones' self-defining memories.

Personal Self: Body-Based Cues for Redemption Narratives

Another interesting cue type is provided by P2 in relation to her physical disability (Fig. 4): "My leg is really central to how I defined who I was; not a great, strong perfect person but somebody inferior [...] I felt I was never perfect [...] But actually, within that, I gathered a real strength that made me feel very strong and different [...] my legs were key to me growing up [and] they will always be central values to me about differences: different ways of measuring people, and different ways of being, and I think we have to celebrate difference and diversity" [P2].



Fig. 4. “My leg is part of me and my being, and probably defines me really, really strongly” [P2]

Less surprising is finding limited cues for negative self-defining memories of challenging or ended relationships. This may be not because such cues are not necessarily there [37,38], but because people are not much motivated to cue the recall of painful memories. The limited reference to cues for negative self-defining memories focused on relational self may also be the reason for finding fewer cues for relational as opposed to personal self. Together, these findings suggest that people have a strong bias towards identifying possible cues for positive rather than negative self-defining memories.

Possible Cues for Self-Defining Memory: Challenges

We now discuss the challenges of identifying possible cues for self-defining memories. They should be identifiable: cues that people can think of, with or without the ability to reach them physically; retrievable, i.e., easy to be physically found; and accessible, i.e., physically seen or touched.

Difficult to Identify

An important finding is that for almost a third of self-defining memories, participants failed to identify specific cues. Most of these memories relate to negative events, either as redemption-based memories, or as memories of unresolved issues pertaining to challenging relationships. While people may lack incentives for cueing the recall of memories of unresolved issues, such cues may be valuable in developing coherent life story once successfully processed [32]. It is surprising however, that some redemption-based memories also lack cues. Apart from their negative affect, it is possible that this lack of cues reflects the challenges of identifying them among their cherished possessions. We do not argue that such cues cannot be found or created, just that during the interviews, participants did not succeed identifying them.

Although most participants have collections of cherished possessions, their link with specific self-defining memories is missing: “*there are loads of things around my house I collect [which] I don’t keep consciously to remind me about who I am. I have collected them because they have reminded me about different periods of my life*” [P2]. This is an important finding which may be due either to the fact that people do not usually reflect on how specific artefacts may cue their self-defining memories, or because such artefacts need to meet specific qualities which are not commonly embodied by cherished possessions.

Hidden among Cherished Possessions

Another challenge is that even when participants succeed identifying possible cues, they sometimes fail to physically retrieve them. This can occur because such self-defining memory cues have been unwillingly disposed of:

“I did have [school] reports but my mother got rid of them all, which was always about me not being very good but if I’d had those records I would have collected them, but I haven’t anymore” [P2].

This quote suggests that such cues may fail to be recognized as important by others because of their mundane, unassuming appearance obscuring their meaning revealed only to their owners [50]. Another reason for inaccessible self-defining memory cues is that cherished possessions become scattered in the old age by being passed down to adult children: “*I found a great box which I kept for safe keeping, and my daughter went through and got most of it, more of it than me!*” [P1].

Lost Due to Moving in Later Life

HCI work on ageing and memories has shown that older adults’ sense of self is challenged by moving to residential care or downsized homes, which forces them to part with cherished possessions [27]. Our outcomes provide support for this argument by highlighting the negative impact of losing during downsizing or moving house (P1,P3) not only cherished possessions but also possible cues for self-defining memories hidden among them.

Although participants were able to fetch and show some self-defining memory cues, they were often able to recall other object-based cues which they were no longer able to physically locate. For example, in relation to her self-defining memory of a fast learner, P1 mentioned a second memory box with cherished possessions such as books, newspaper clippings, or recipes from her mother, as well as a special schoolbook that she has kept since she was four years old. It had pages of sums written in different colour crayons, and most memorable: the sums were all marked correctly which relates to her self-defining memory of fast learner. However, after moving house, she was no longer able to remember where she has put it. Memory boxes were mentioned by other three participants (P2,P3,P5) who indicated the importance of safeguarding their content. It is in such private places where most possible cues for self-defining memories tend to be stored, with less than a quarter being on display.

To conclude identifying possible cues for self-defining memories is not trivial, particularly for those with negative emotional content. Possible cues consisting of ready-available objects are often unassuming objects, hidden among cherished possessions, for which people may lack the sensitivity to recognise their recall value. Moreover, collections of cherished possessions are difficult to maintain in old age, becoming lost, scattered or downsized.

THEORETICAL IMPLICATIONS

We now discuss the findings and how they address the research questions outlined in the introduction. The outcomes advance the understanding of self-defining memories and their cues with new insights into their relationship with self identities. We also discuss the types of such cues and particularly detail their specific qualities supporting richer emotional recall. Such qualities are important as they can open up novel design opportunities for memory technologies in old age. We also acknowledge the limitation of the sample consisting mainly of female participants and its possible impact on cues generated through the gendered practice of craft. Despite the relationship between gender and emotional aspects of autobiographical memories [20], previous findings indicated limited gender impact on self-defining memories [4]. Future work is however needed for generalizing the findings particularly to male population, and for experimentally assessing the impact of identified cues on richer recall of dementia sufferers.

New Insights on Self-Defining Memories and Identities

Our approach to link identities with self-defining memories is innovative, offering additional insights into their relationship between self identities. For example P8's memory of meeting his future wife, P3 and P6's experience of transgression in relational and social self indicate how personal self is also affected. Our findings also show an emerging relationship between self identities on the one hand, and the affect and content of their self-defining memories on the other hand.

Personal self is reflected predominantly in positive memories of achievement or mastery in front of adversities; relational self on positive loving relationships and less on negative challenging ones, while collective self on negative large scale events. Our outcomes on positive affect, characterizing in decreasing order personal, relational, and collective self, echo those showing that people protect and invest significantly more efforts in personal self [39].

Types of Possible Cues for Self-Defining Memories

Possible cues for self-defining memories include mostly objects tailored to the self identities they aim to support. Cues as ready-made achievement and crafted objects extend the function of mementos from supporting recall of autobiographical memories [33] to self-defining memories. However, our findings suggest that unlike mementos, cues for self-defining memories do not consist of artwork, photos or memorabilia [33]. We argue that this may be because such cues are predominantly self-relevant, only on display when symbolizing achievements, and seldom interacted with unlike memorabilia.

We now reflect on the distinction between ready-made and crafted objects as possible cues. For the ready-made cues, the encoding of the memory and the identification of its cue tend to take place simultaneously. Often such objects become part of collections of cherished possessions. The

value of crafted objects as possible cues emerges when ready-made ones are neither available nor recognized as important. Crafted objects can be identified as powerful cues either during (Fig 2a and 2b) or after the memory has been encoded (Fig1 right). Due to the personal involvement in the generation of these cues, they are arguably more effective in supporting recall.

As consistent findings have also shown the impact on retrieval of self-generated encoding cues [26], we argue for the importance of directly involving the self in the making of cues for self-defining memories. The craft practice for making such objects is gendered, with women favoring female-oriented crafting such as embroidery, knitting or sewing, and male engaging in woodcraft. This finding extends Csikszentmihalyi's [12] categories of household crafted objects relevant for the self with the dimension of gendered craft.

We also argue for the novelty of body-based cues which received limited attention in cueing episodic memories. Despite that only one participant identified such a cue, our argument for their value is supported by Belk's [2] theory on components of self including body parts as a distinct category. In addition, as our findings indicate, body-based cues have particular value for self-defining memories of redemption narratives relating to personal self.

The identified place-based cues also build on previous work on location-based cues [24], extending them with insights emphasizing less the tracking of the place but the construction of its meaning. Moreover, for cueing negative memories with large social impact such as battlefields or riots, photos may be too evocative [36]. We also argue that place-based cues have distinct characteristics from object- or body-based cues pertaining to positive emotions of personal and relational self and their defining memories. Instead they tend to be of a larger scale: cities or battle fields versus handheld objects, and public rather than private thus able to safely contain the recall of and sharing with others negative and collective self-defining memories.

Qualities of Self-Defining Memories' Cues

We argue that because of their content and qualities, the identified cues for self-defining memories have the potential of supporting richer recall. Despite the exploratory nature of our study, findings indicate that when such cues are handled, the mere act of holding and often gently caressing them opens up participants' access to richer emotional content in their recall of associated self-defining memories. This is an important finding, given the considerable decline of self-defining memories in dementia [28]. The richer emotional content triggered by such cues can facilitate access to more specific details required by successful recall of self-defining memories, which in turn can help people with dementia strengthen their sense of identity [4,21]. Another important quality strengthening their value is the ability of such cues to embody layered meaning.

Layered Meanings

An interesting characteristic which makes for strong self-defining memory cues is *layered meanings*, which we define as relating to more than one personal goal or theme embodied in a self-defining memory, to a cluster of self-defining memories occurring close in time, or multiple self-identities involved in the event. For example, the elephant mentioned by P8 (Fig. 2a) cues a powerful memory capturing two crucial themes around love and motherhood and the object imparts its powerful meaning with three family members. Such cue was acquired at a life transition when the participant was pregnant, in a spatio-temporal context symbolizing romance, abundance and fecundity. Another example is the wooden banister described by P4 capturing both self-mastery as a young apprentice, and the romance of meeting his future wife. This characteristic is also supported by findings showing that some mementos are also rooted in more than one reason [33].

Identification & Accessibility

Cues for positive self-defining memories tend to focus on achievements or relationships, and take mostly the form of ready-made or crafted objects. Cues for negative self-defining memories which focus on significant personal or social losses rather than mortality and guilt as previously suggested [3,45,46], tend to be less available. Interestingly, when available, they are not directly accessible taking the form of place-based cues such as outdoor places seldom visited. Findings also indicate that once identified, self-defining memory cues are valuable in supporting rich recall. However, such object-based cues can become inaccessible at times, as described by almost a third of participants. This can be due to the cues being disposed of by others, misplaced or lost during downsizing or moving house, or being parted with for the benefit of the adult children. Another surprising finding is the lack of crafted objects for cueing negative self-defining memories, despite the value of craft for processing negative emotions [47].

Privately Stored versus On Display

An important finding is that the majority of accessible self-defining memory cues are stored in private spaces, with fewer being on display. Most of the objects in the public spaces of the house are achievement-related, i.e., framed certificates. In contrast, other achievement-related objects (usually smaller and linked to early school years) or relationship-related objects tend to be kept in private rooms. Such outcomes support previous ones showing that private spaces store mementos as idiosyncratic objects related to intense emotions, and in particular negative ones which are never on display in public spaces [33].

We found that this insight is even more relevant to objects cueing self-defining memories, as there is a clear distinction between those kept on display, and those kept privately. This is reflected in participants' emotions whilst recalling their self-defining memories. While the objects on display were talked about and showed with enthusiasm, those stored privately such as the school prize of Mary statue

(Fig. 2c) were more emotionally handled; both however facilitated emotionally richer recall. An important quality of such cues is their unique material *fragility* which strongly limits people's interaction with them. For example, participants P5 expressed concerns of even taking out from her memory box the small booklet where she was practicing her handwriting prior to winning the school prize. Such findings confirm those showing that people tend to have boxes of memories with strong reminiscing power, and that fragility of some mementos requires careful storage [33].

IMPLICATIONS FOR DESIGN

Study findings offer several implications for the design of memory technology to support self-defining memories. They address the challenge of curating self-defining memories and their cues, the value of embedded layered meaning in such cues, and of crafting them when people fail to identify existing cues for their self-defining memories.

Curating Self-Defining Memories and their Cues

Findings indicate that people experience difficulties in identifying their self-defining memories. It may be that from the richness of autobiographical memories, they are not used to discriminate those which are self-defining from other episodic memories or personal semantics. We suggest novel memory technologies which may scaffold people's effort to identify their self-defining memories. For example, such technologies may integrate life review with a variant of card sorting method to iteratively sort such memories, relate them to major goals within life periods, and in particular to themes of achievements, relationships, redemption, and negative unresolved issues as suggested by our findings.

People also have many self-defining memories without identifiable cues. This is surprising given the vast collections of physical and digital possessions that people acquire throughout life. Such challenge can be addressed through novel tools supporting reflective reminiscing on self-defining memories in order to explicitly identify their cues among personal collections. For example, these may support engagement with cherished possessions, stored both digitally and in private memory boxes, with the aim of creating links between such artefacts and specific self-defining memories. Metadata of digital collections can be used for selecting such cues from digital trails captured through lifelogging or social media.

Embedding Cues with Layered Meaning across Lifespan

Findings indicate that richer recall is particularly supported by cues able to prompt retrieval of multiple themes associated with a self-defining memory, multiple such memories or self-identities related to them. We can think of novel memory technologies to support not just the identification of self-defining memories' cues but also the evolving construction of the meaning embedded in them. This may exploit cues acquired or crafted at life transitions when multiple identities intersect, offsetting the risk of not

recognizing their associated memories as self-defining at the time. The HCI emerging interest in life stages and transitions offers a useful lens to support the identification of cues for such self-defining memories even before they are encoded [37].

The lifespan approach to identifying and developing these cues is also valuable in addressing the challenge of them being disposed of, lost during downsizing, or unwillingly parted with. Augmenting cherished objects with digital memories has been previously suggested [33], particularly for tracking such cues during the moving in later life in residential or care home [27]. Arguably, such curatorial acts can be even more valuable when performed across the entire lifespan. Stories attached to self-defining memory cues could mitigate the risk of having them disposed by others, as such stories uncover the deep personal meaning hidden within otherwise unassuming objects. They can also help communicate to adult children the value of such objects for supporting the personal self of their old parents, and mitigate the risk of older people unwillingly parting with them. In addition, digital stories could mitigate the risk of misplacing or losing these cues across the lifespan.

Crafting Self-Defining Memories' Cues

An important finding is that almost a third of self-defining memories have unidentifiable cues. This may be because identifying possible cues for self-defining memories is challenging particularly for those with negative emotional content. Such challenge opens up design opportunities shifting the focus away from personal possessions and possible cues buried in them, to novel technologies for crafting new cues. Moreover, crafting is particularly valuable in facilitating self-involvement whose role in recall has been consistently shown [21,26]. Our study methodology asked participants to actively identify and select their cues, an additional factor which may be responsible for their success. This is supported by findings showing that self-chosen music can cue self-defining memories of people living with dementia [21]. Building on this argument, we could consider extending people's involvement from cue selection to cue generation, since consistent findings have also shown the impact of self-generated encoding cues on recall of autobiographical memories [26]. We argue that precisely this involvement is provided by crafted objects, which may explain their emphasis in our findings. We can imagine novel interactive systems integrating tangible interfaces with elements of art therapy to support not just capturing the event, but more importantly reflecting on and processing of negative self-defining memories and their progression into redemption narratives.

CONCLUSION

This study investigates older adults' identification of self-defining memories and their possible cues. We advance the understanding of such memories and cues with new insights into their relationship with self identities. Personal self is

reflected in memories of achievements and redemption; relational self captures loving or challenging relationships, while collective self reflects negative events with large social impact. These tend to be cued by achievement objects, body-based cues, crafted objects, and place-based objects, respectively. The key qualities of such cues include being ordinarily unassuming, difficult to identify and access as they are hidden among cherished possessions, often fragile and privately stored, and rich in layered meanings which allow for strong emotional recall. Our findings suggest novel memory technologies with potential to better support self-defining memories and their cueing than lifelogging technologies. The shift of focus from capture technologies towards those emphasizing the curation of self-defining memories and their cues, the embedding of layered meaning in such cues across lifespan, and of crafting these cues could better support such memories and the fragile sense of self in old age.

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