

Co-Designing Flavor-Based Memory Cues with Older Adults

Tom Gayler
School of Computing and
Communications
Lancaster University
Lancaster, UK
t.gayler@lancaster.ac.uk

Corina Sas
School of Computing and
Communications
Lancaster University
Lancaster, UK
c.sas@lancaster.ac.uk

Vaiva Kalnikaite
Dovetailed
Cambridge, UK
vaiva@dovetailed.io

ABSTRACT

This initial study explores the design of flavor-based cues with older adults for their self-defining memories. It proposes using food to leverage the connections between odor and memory to develop new multisensory memory cues. Working with 4 older adults, we identified 6 self-defining autobiographical memories for each participant, 3 related to food, 3 unrelated to food. Flavor-based cues were then created for each memory through a co-design process. Findings indicate the dominance of relationship themes in the identified self-defining memories and that flavor-based cues related mostly to multiple ingredient dishes. We discuss how these findings can support further research and design into flavor-based memory cues through 3D food printing.

CCS CONCEPTS

•Human-centered computing ~ Human computer interaction (HCI) •Human-centered computing ~ Interaction design-Interaction design process and methods ~ Participatory design

KEYWORDS

Food; Co-design; Self-defining memories; Older adults; Memory cues; Multisensory design; Odor; Flavor.

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1 Introduction

A wealth of research emphasizes the value of smell for prompting the recall of personal memories [17,37], in particular the role of odor cues for autobiographical memory and their neural correlates [2,5,14,17,22]. However, the prevalence of visual, aural

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and haptic modalities, has left the sense of smell less explored for the design of interactive systems. Given the challenges of providing odor stimuli within computing systems such as delivery, repeatability of stimuli and a lack of effective design tools [3,25], this work explores the potential of 3D printed food to provide odor based memory cues. We report on preliminary findings of a study with 4 participants co-designing personalized flavor-based memory cues for their self-defining, i.e., emotional autobiographical memories. The study engages older adults (over-60) who are at higher risk of mild cognitive impairments [34]. The aim of this research is to explore flavor-based cues as part of memory aid systems and food as a novel modality with unique qualities that may support HCI research on memory technologies [20]. This study sets out to answer two questions:

- What self-defining memories are selected to be cued with a flavor-based cue?
- What flavor-based cues are designed for self-defining memories which include food and do not include food?

2 Related Work

2.1 Human-Food Interaction in HCI

Food as a resource for design has received growing HCI interest [1,4,11] given its value for supporting emotional communication [12]. By focusing on the act of eating food; the mouth and the body can themselves become sites for interactive experience, moving towards more integrated conceptions of how bodies and technology can interact [11]. One of the drivers of the growth of food in HCI is the development of new technologies. For instance, 3D food printing has been used to support emotional experience [10] as well as communication between lovers [12] and the potential for flavor-based memory cues has been suggested. Such cues could support narrative and temporal experiences with food [11] curated around personally meaningful memories [10,12].

2.2 HCI Research on Memory Cues

A memory cue is something that serves the function of triggering memory recall [20]. Cues have been designed across a range of application domains in HCI, one of which is supporting those with memory impairments associated with aging [15] in part due to impairments in autobiographical memories having knock-on negative effects on an individual's sense of self [28]. Self-defining memories are a type of autobiographical memory that features

rich emotional qualities and support a person's sense of self [28] and are thus important to preserve. HCI work exploring the potential benefit of such memories and their cues [29] extends Hoven & Eggen's work on autobiographical memory and their design recommendations for segmented memory systems [19].

The specific modalities of memory cues have been of great interest in HCI [13,21,26,36], including how different sensory pathways may offer benefits, not only in terms of accuracy of memory retrieval, but also the emotional aspects that make a memory feel more 'real' [17]. While visual and aural cues have been much explored [23,30–32], the use of sense of smell in HCI as a powerful route to memory cueing [7,25] has received less attention, in part due to challenges of implementing odorant-based systems that require sourcing of specialist volatile fragrances [25]. Food, however, is a much more common and accessible material with which to craft odor-based memory cues and via tools such as 3D food printing, can be integrated within interactive systems [7]. Food also supports the recommendations for memory cues [19], including by being *physical* [21,36], both in the sense that it is material stuff, but also in the way that it is experienced by the body. It is highly diverse as a resource for design that can support adaptive [21] applications, sensitive to cultural and personal perspectives [26]. Through the use of 3D food printing it is also possible to envisage usage and experiences both user-initiated [21] and unsolicited [13,19].

2.3 Food, Odor and Memory Relationship

Food's connection with memory comes from the flavor experience, which is a compound multisensory experience that is mostly derived from our sense of smell [35]. Therefore food experience is closely linked to the experience of odors that have been shown to be a strong cue for memory [2,5,14,17,22]. This is due in part to the neural physiology resulting in direct connections between the olfactory bulb and the parts of the brain related to memory [2,18]. However, as of yet there is limited evidence into the function of food as a memory cue. Previous work has explored claims that odors represent the 'best' memory cues [16,17] based on comparisons with verbal, visual, and tactile cues [16]. Odor cues were found to be equivalent to other modalities in terms of memory accuracy but more emotional, in particular, countering anecdotal perspectives on the emotionality of tactile cues [16]. In work specifically targeting autobiographical memory, odors were again found to be more emotional and evocative than visual, verbal or auditory cues but no more specific or vivid [17]. Within memory research in HCI there is increased interest in multisensory cueing, leveraging the capabilities of different modalities to construct more powerful and efficient cues [23,26]. Age has been seen to impact on the function of odor-evoked memories, since older adults who were found to have a higher number of autobiographical memories that could be triggered by odors than younger people [38]. This indicates that older adults are prime candidates for interventions with odor-based memory aids, however declining taste and odor sensitivity associated with aging also needs to be considered [6].

3 Method

The aim of the study is to explore how to co-design food-based memory cues with older adults. Participants were 4 older adults (aged 60+, 3 females, 1 male) with no taste or memory impairments recruited through convenience sampling.

The study involved two parts. Part 1 focused on sensitizing participants to identify food-based experiences by completing a bespoke visual probe kit to describe and reflect on food-based experiences. The visual probe kit was inspired by previous work [12], and consisted of several parts such as exercises in sensory deprivation, body mapping and flavor description, each intended to explore different aspects of food experience. The kit also invited participants to connect their memories to food-based experiences by selecting specific memories and writing recipes that can best describe them. It was completed over two weeks in participants' homes to allow them to engage with food experiences in their familiar context where most such experiences are usually situated. The probe kit required completion of paper-based documents and the capture of digital images to support participants during the co-design phase.

Part 2 consisted of individual workshops for co-designing personalized flavor-based memory cues for 6 self-defining memories that we elicited: 3 memories included food (FM), for example, a wedding breakfast, and 3 memories which did not include food (NFM), for instance starting at university. Participants first freely recalled each of the 6 memories in as much detail as possible and were prompted further by three questions to capture associated feelings, social context, and event's place and time. Before the co-design of cues for each memory, participants were given samples of 3D printed food similar to the method described in [10], one for each of the 5 basic tastes (sweet, bitter, salty, sour and umami) in order to familiarize participants with them as benchmarks in the co-design process. These small samples were solutions of sugar, coffee, salt, lemon juice and miso paste to represent each basic taste respectively.

For the co-design of cues for the 3 food-related memories, participants were asked to identify and describe the foodstuff involved in these memories using the flavor design sheet. The sheet included space for noting ingredients, flavor descriptors and cooking processes as text, as well as Likert scales to record the taste profile relative to the 5 basic tastes, the texture, and how lingering the flavor should be. When co-designing the cues for non-food related memories, participants had to first describe associations between the memory and foods before they could provide details on the chosen cue. Prompts were given for associations between the memory and food, via connections to related people, feelings, places and events. Possibilities were generated between researcher and participant, with the latter making the decision on the final cue for each of the 3 non-food related memories. The study concluded with semi-structured interviews to reflect on the co-design of flavor-based memory cues for self-defining memories. The interviews and the design process were audio recorded and fully transcribed and preliminary findings from the thematic analysis described below.

4 Findings

4.1 Food and Non-food Memories

To understand the characteristics of the memories chosen by participants we classified them according to categories from previous work on older adults' self-defining memories [28,34] which consist of those focused on life-threatening events, relationships, achievement/mastery, redemption, large scale events, guilt/shame, and drug and alcohol. Findings indicate that from the 24 identified self-defining memories, the most frequent theme was *relationships* (75% of all memories, referenced in n = 18 memories, 9 FM, 9 NFM), *achievements* (29.2%, n = 7, 4 FM, 3 NFM) and *life threatening events* (8.3%, n = 2, 2 NFM), 3 memories were classified with more than one theme. We found that both FM and NFM were dominated by *relationship* themes, often associated with social and recreational experiences. This focus within FM arose from activities such as visiting restaurants for special occasions (P1, Honeymoon Lobster thermidor), holidays abroad with loved ones (P1, Spit-roast chicken in Naples) or having food-based celebrations (P2, mackerel BBQ at anniversary party). The dominance of *relationship* type amongst NFM reflects previous work on self-defining memories with older adults [28].

Memories were overwhelmingly emotionally positive (87.5%, n = 21, 12 FM, 9 NFM), and even more so for food related ones, which were all positive compared to 75% of NFM. While most memories related to experiences in *small groups* (2-3 collocated people) (58%, n=14, 7 FM, 7 NFM), *large group* ones were less frequent (29%, n=7, 4 FM, 3 NFM) and *alone* experiences the least (13%, n=3, 1 FM, 2 NFM). Such sociality aspects did not differ significantly between food and non-food related memories. There were a similar number of food related and non-food related memories for both one-off events (87.5%, n=21, 10 FM, 11 NFM) and for repeated ones (12.5%, n=3, 2 FM, 1 NFM). Self-defining memories by their nature are often singular events but the inclusion of the repeated events can be attributed to how repeated interactions with food, such as the crisp sandwich at Grandma's house (P4) or salty crisps eaten at the seaside (P2), can elevate repeated events to meaningful memories [13]. Surprisingly, memories were more weighted towards those from adulthood (71%, 8 from middle age, 9 from older adulthood), with only 29% of memories coming from before, or during the 'reminiscence bump', as suggested by previous findings on odor-cued memories [22]. In addition, our findings also confirm those indicating greater prevalence of autobiographic memories related to odors amongst older adults [38], probably due to their greater cumulated experience. This outcome is important as it indicates the potential of food to address the self-defining memories' bias towards earlier life [28] and to support these memories along the entire life span.

4.2 Flavor-based Memory Cues

Participants co-designed a flavor-based cue for each of their 6 self-defining memories (3 FM and 3 NFM). For each cue participants described the relative levels of the 5 basic tastes. Findings indicate that umami was the highest or joint highest for 13/24 of the designed cues, salty for 9, sweet 8, with sour and bitter for 1, each.

The preference for umami and salty type flavors for most of the positive experiences contrasts with previous work which indicated sweet flavors were best used for positive emotional expression and coregulation [10,12]. Flavor-based memory cues were described in terms of *ingredients* (75%, n = 18, 10 FM, 8 NFM), *recipes* (58%, n = 14, 7 FM, 7 NFM) and *dishes* (58%, 8 FM, 6 NFM) often through combinations of, rather than single, ingredients. Most *dishes* consisted of known or existing combinations or recipes (11/14). However, in 3 cases these mentioned new, creative combinations of foods that commonly occur side-by-side but do not belong to a single dish such as coffee and flapjack: "you've got this bitter strong flavor and then you've got the sort of chewy sweeter flavor but not too sweet" (P2) or bacon and coffee (P3), fruitcake and champagne (P3).

The foods chosen for cues were most often *self-made* (33%, n = 8, 4 FM, 4 NFM) such as stewed apples (P1) and tuna and cucumber sandwich (P3). This perhaps reflects the extra value invested in food that is made by oneself and resembles the IKEA effect [33] in comparison to foods ordered or purchased. Other foodstuff used to co-design the cues included *ready-made* foods (3/24 cues), food made by *somebody in the past* (3), and *catered* foods (3). Interestingly, no *restaurant* foods were reported for NFM, whilst 2 were for FM, likely because they involve experiences in food centric settings whereas NFM were not related to a specific meal. Flavor-based cues were also described by the *cooking style* (11 times), which was used to specify the details of both self-made foods and those made by somebody else: "bacon, [my mother] used to cook it until it was an absolute crisp. She'd just leave it in the oven and it was very crispy. Still tasty, but different texture to how you have ever eaten bacon before" (P1). This allowed participants to elevate mundane foods towards specific flavor experiences, going beyond *bacon* as a ubiquitous experience to *mum's very crispy bacon* which has a specific and meaningful resonance, with particular odor and texture qualities.

For NFM, participants associated foods or flavors with their specific memories. Most associations were to foods that were temporally proximal to the memory being described (7/12), either *during*, *before*, or *after* the event of that memory. 3 memories were associated with food present *during* the event but not core to the memory, such as salted crisps on a trip to the seaside. Only one example related to food prepared *before* the memory. 3 memories were linked to food experienced *after* the event captured by these memories. *After* the event was not only the next thing eaten immediately after the memory (1 instance) but also longer term such as in the months or year following (2), often relating to foods eaten as a result of the impacts of the remembered event, i.e., food eaten as a result of having broken an arm (P4), or moving to University (P4).

Non-food memories were also associated with *feelings* generated by the event (3) such as joy and elation, including for instance two uses of champagne. Also present were associations to the favorite food of other *living creatures* (humans and a cat). Finally, one single food cue related to the *place* of the memory as something regularly consumed in that environment: ratatouille served in the university canteen (P4).

5 Discussion

We now turn to the research questions set-out at the start of this paper. Firstly, *what self-defining memories are chosen to be cued with a flavor-based cue?* Our findings indicate that memories were mostly related to *relationships* (generally aligning with prior work [28,34]) and overwhelmingly positive. FM and NFM were mostly similar in nature, aside from a few emotionally negative NFMs. Our findings agree with prior work that flavor-based cues better supported positive emotions than negative ones [10,12], and indicate that flavor-based memory cues are more likely to be successful when prompting memorable positive experiences or events. The elicited self-defining memories were mostly socially shared, one-off events relating to experiences from adulthood. The prevalence of positive, social and relational memories with food indicates the character of food related memories to be well-suited for enjoyable reminiscence that emphasize positive experiences and offer connection to social situations. This may be of particular use to older adults who may suffer from depression and social isolation [27]. Positive autobiographical memories also have the greatest potential for therapeutic use as indicated in studies on odor-evoked memories [12] and the proposed use of flavor as a memory cue could leverage this potential. One way that flavor-based memory cues may extend existing approaches is their potential value to cue events taking place not just in the reminiscence bump period, but throughout the entire lifespan.

The second question was; *what flavor-based cues are designed for self-defining memories which include food and do not include food?* In regard to all memories, umami, salty, and sweet taste-based cues were most popular, reporting a more nuanced relationship between positive experience and tastes than had been found in studies for more abstract emotion experiences in HCI [10,12]. The episodic and unique character of the memories appears to support more complex meaning-making with taste as part of flavor experiences that also comprise odors and textures. These taste findings align closely to the perspective on taste-emotion mappings of chefs and food designers [8]. Participants mostly opted to describe flavor-based cues through *dishes*, usually made by the person themselves, representing a personal engagement with food that extended beyond it being eaten. In previous work on flavor-based cues for emotional experience, both generic and idiosyncratic flavors were selected [12]. In this study, all the foods were complex and specific (and not generic) in part due to their relation to episodic moments. This specificity sometimes resulted in a creative construction of single flavor-cues which combined two normally separate but related foodstuffs such as coffee and flapjack. This combination of two common, yet independent flavors could be leveraged in future to create specific meaningful links between a memory and its cue. Specificity was also delivered through the cooking style which infused saliency to mundane foods, for instance, through the crispy bacon example we can see how the longer cooking times resulted in a different mix of odor compounds within the flavor experience created through extended heating [24].

In relation to NFM, the primary strategy employed to connect memories to food was temporal proximity. This indicates that

specific memories are most readily related to specific foods that were present at, or around the time when the memorable event occurred. The foods from around a memory appear to be connected to the felt experience at the time. This is particularly apparent in the case of foods that were associated to short term diet changes following breaking an arm, or while undergoing cancer treatment (P4). Temporal proximity was not only used in isolation, as participants meaning making could be compound as well. For example, champagne's proximity to moments of celebration also creates an associated feeling that can be used to strengthen the connection between a memory and a flavor-based cue. Use of a person's preferences reflected previous work on designing flavors for user experience [12]. To conclude, our preliminary findings indicate that a range of co-design strategies were observed that can be drawn upon to refine the approach of future work on flavor-memory cues.

6 Future Work

This work presents an initial exploration into the co-design of flavor-based memory cues for self-defining memories in old age. Following the preliminary work presented here, a study is planned to produce and evaluate flavor-based cues with a larger sample and involve the production of flavor cues via 3D food printing. Through connecting edible experiences with digital technology it is also possible to design systems in which cueing can occur spontaneously [19] or be used as part of planned therapeutic programs [12]. Despite the suitability of odor cues for older adults, there remains questions to this group's acceptance of 3D printed food [9] therefore consideration of adoption will be important to increase impact.

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