Mnemosyne

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Mnemosyne - Supporting Reminiscence for Individuals with Dementia in Residential Care Settings

Andrea Baumann
Lancaster University
Lancaster, UK
a.baumann1@lancaster.ac.uk

Peter Shaw
Lancaster University
Lancaster, UK
p.shaw@lancaster.ac.uk

Ludwig Trotter
Lancaster University
Lancaster, UK
l.k.trotter@lancaster.ac.uk

Sarah Clinch
University of Manchester
Manchester, UK
sarah.clinch@manchester.ac.uk

Nigel Davies
Lancaster University
Lancaster, UK
n.a.davies@lancaster.ac.uk

ABSTRACT

Reminiscence is known to play an important part in helping to mitigate the effects of dementia. Within the HCI community, work has typically focused on supporting reminiscence at an individual or social level but less attention has been given to supporting reminiscence in residential care settings. This lack of research became particularly apparent during the COVID pandemic when traditional forms of reminiscence involving physical artefacts and face-to-face interactions became especially challenging. In this paper we report on the design, development and evaluation of a reminiscence system, deployed in a residential care home over a two-year-period that included the pandemic. *Mnemosyne* comprises a pervasive display network and a browser-based application whose adoption and use we explored using a mixed methods approach. Our findings offer insights that will help shape the development and evaluation of future systems, particularly those that use pervasive displays to support unsupervised reminiscence.

CCS CONCEPTS

• **Human-centered computing** → **Empirical studies in ubiquitous and mobile computing**; *Field studies.*

KEYWORDS

reminiscence, dementia, residential care, pervasive displays

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1 INTRODUCTION

Over the last decade there has been a 50% increase in people diagnosed with dementia in the UK, reaching 496,846 cases in 2022 (55m worldwide). By 2050, this number is predicted to increase up to 1.6m (UK) and 139m globally [55]. Although people of any age can get dementia, it is a disease occurring primarily late in life with people over 65 more likely to be affected [54]. In fact, after passing 60, the likelihood of developing dementia doubles every five years [21].

While the term dementia serves as a catch-all description for a range of mental disorders, not all of them incurable, the most prevalent non-treatable variations such as Alzheimer's disease, vascular dementia and frontotemporal dementia, are accompanied by progressive degeneration of the brain [17]. In its early stages, Alzheimer's disease affects a person's episodic memory and causes an impairment in the ability to encode, store and retrieve new or autobiographic information. In the later stages, the disease further leads to a decline in semantic memory [31]. This results in a deterioration in verbal fluency as words and their meaning as well as knowledge of the world as a whole become lost [7].
As the disease progresses, people with dementia often move into full-time or residential care as the amount of care required to fulfil their needs exceeds that which family members can provide [49]. The prevalence of dementia in people in care is estimated at 69.0% (62.7% males and 71.2% females) [44].

While these residential facilities provide a safe and supportive environment, individuals with dementia often encounter difficulties in maintaining social connections and preserving their sense of identity and belonging [4, 6, 40].

However, although recent information and memories are often lost for people with dementia, they usually possess many intact memories of their childhood and early adulthood. By using suitable memory triggers, these memories can be recalled, even for people in the advanced stages of the disease. This process is referred to as reminiscence [41].

In people with dementia, reminiscence therapy has the potential to increase the quality and quantity of communication, cognition, and emotional well-being while reducing feelings of social isolation and behavioural problems such as agitation, aggression and unrest [14, 28, 51, 59]. Literature also underscores the therapeutic benefits of media in reminiscence activities, influencing mood, triggering memories, and stimulating personal reflection and creativity.

As a result of the perceived benefits, previous HCI research has explored how technology can support reminiscence. However, this work has typically focused on reminiscence at an individual [26, 39] or social level [2, 43, 56] with less attention given to supporting reminiscence in residential care environments. This is unfortunate because reminiscence has been shown to be particularly important for people in care home settings [59] yet hard to achieve – the time required to prepare the material needed for traditional reminiscence therapy session is such that caregivers often shortcut the procedure or tend to conduct sessions as group therapy rather than as one-on-one [1, 34]. Furthermore, during the COVID-19 pandemic some care homes faced between 10% and 50% of staff absences due to the virus which in turn impacted the time that could be spent on residents [24].

In addition to these time constraints, caregivers often also lack cues rich enough, for reminiscence to be conducted successfully [34] and staff are often reluctant to adopt technology-based reminiscence systems which add to their already heavy workload [18]. However, the use of technology in reminiscence therapy has the potential to offer opportunities for individualised and group-based activities, reduce therapists' preparation time, and facilitate remote access to reminiscence materials for all users [18].

Our work explores *Mnemosyne*, a reminiscence system developed during COVID that enables care home staff and residents' family members to share pictures and videos personal to the residents. The system has been deployed for two years in a residential care home. This work's main contributions include (i) design implications for systems built for reminiscence; (ii) discussion of the suitability of traditional success metrics; (iii) the role of pervasive displays in supporting unsupervised reminiscence

2 RELATED WORK

2.1 Reminiscence

During reminiscence tangible cues such as photographs, music or sound are used to discuss past events, activities and experiences to bring distant memories back into awareness [11, 12, 14]. Those memories can in turn be used as a tool for communication which has the dual purpose of offering a stimulating activity and providing a way to maintain a connection with others [17].

Because of its effectiveness in improving cognitive functions and depressive symptoms, regular reminiscence therapy is often recommended [23, 28]. It is, however, essential that the cues used for the reminiscing are selected carefully. If the aim is general reminiscence and discussion rather than the recall of specific memories, the selected cues can be impersonal to the viewer [19]. However, to reminiscence about specific memories, cues have to memorable or at least recognisable. Suitable cues tend to be distinctive or personally significant to the person doing the reminiscing. They can further be separated into one of four categories: people cues, object cues, place cues and action cues [19].

Over the years, HCI research has focused on the value of technology-enabled memory cues such as photos [45], videos [33], and life-logging [22, 25, 35] for reminiscence. An exemplary life-logging technology, the "SenseCam" project by Hodges et al. [26], captures pictures of everyday life through a wearable camera.

As such, SenseCam makes it easy to capture personal memory cues which have proven effective in supporting memories of past events; significantly improving autobiographical memory in individuals with Alzheimer's disease [14, 47, 58]. It is, however, important to consider that life-logging technologies often generate a vast amount of data, erring on the side of comprehensiveness. This can be particularly challenging for individuals with memory problems who may have limited cognitive resources to devote to reviewing extensive data and it, therefore, requires careful selection and curation of content suitable for reminiscence [34]. The system itself also does not support the viewing of captured images. Additional research projects looked into using tangible objects [50], sound [15], and taste [20] to support reminiscence. LookBack [29] is an example of a commercially available assistive media system aimed at supporting reminiscence by using virtual reality to revisit locations of the users' past.

Although, previous research has focused on supporting people of different ages, and people with memory impairments such as dementia in their reminiscing, to date, few projects have focused on improving reminiscence for individuals with dementia in residential care environments. Notable exceptions include Memento by Paay et al. [41], Com-Phone [18], Networked Reminiscence [32], Virtual worlds [48], Photostroller [19], and CIRCA [1].

Paay et al. [41] introduced *Memento*, a system utilising proximity beacons to detect objects of interest in residents' vicinity. The system sends relevant reminiscence text cues to a caregiver's smartwatch, enabling spontaneous integration of reminiscence therapy into daily conversations without increasing the caregivers' workload. This spontaneously triggered reminiscence (rather than planned traditional group sessions) has been shown to be particularly effective when engaged in as often as possible. Frohlich et al. [18] developed *Com-Phone*, a mobile application that enabled residents, family members, and caregivers to record events and activities as "stories". By sharing those stories with one another residents and family members can stay up to date with each other's lives while having rich reminiscence cues readily accessible. *Networked Reminiscence* by Kuwahara et al. [32] is a reminiscence therapy system that connects individuals with therapists via IP videophones. The system uses photo- and video-sharing of content stored on a community platform to support reminiscence.

Since personal memory cues are often hard to obtain in care home environments, *Virtual worlds* by Siriaraya et al. [48], *Photostroller* by Gaver et al. [19] and *CIRCA* by Alm et al. [1] are examples of projects using generic cues to stimulate reminiscence. *Virtual Worlds* by Siriaraya et al. [48] enables users to explore three different virtual worlds (reminiscence room, virtual tour and gardening) by utilising Microsoft Kinect to enable gestured-base interactions. *Photostroller* by Gaver et al. [19], presented a continuous slideshow of Flickr™ images based on six predefined categories. Residents and caregivers could change the selected category via a specially designed tuner. *CIRCA* by Alm et al. [1] consisted of a touchscreen interface which enabled residents to explore content from the categories: recreation, entertainment and local history.

2.2 Discussion

Table 1 presents a comparison of key HCI research projects designed to support reminiscence in individuals with dementia in

	Content			System		Study	
	Personal Cues	Generic Cues	Readily Accessible	Scaleability	Carer required	Duration	Dementia severity
Memento	✓	✓	✓	(✓)	✓	2 hours	mild
Com-Phone	✓	✓		✓	✓	4 weeks	moderate
Networked Reminiscence	✓	✓		✓	(✓)	17 sessions	mild to moderate
Virtual Worlds		✓	✓		(✓)	8 sessions	varying
Photostroller		✓	✓			2 months	mild
CIRCA		✓	✓		(✓)	extended period	moderate to severe

Table 1: table

Comparison of previous research and systems aimed at supporting reminiscence for individuals with dementia in long-term care environments.

care homes. In terms of content, Memento, Com-Phone, and Networked Reminiscence allow for reminiscence with both personal and generic cues. While one could argue that Com-Phone only supports personal cues, as content is either captured by the resident or their family members, residents typically won't be able to recall specific memories when reminiscing with the stories captured by their families. However, the cues can still lead to general reminiscence. Virtual Worlds, Photostroller and CIRCA are restricted to generic cues only. Com-Phone is the only system where the content is not readily accessible outside the care home. Although "stories" could be shared via YouTube, residents did not have access to the platform which restricted family members and residents to sharing content during in-person visits.

While it is possible to add more reminiscence cues for residents using Memento by equipping more objects with proximity beacons, this is restricted to objects within the residents' proximity which renders the Memento only partially scalable. Further, it is not possible for residents to use the system independently of care staff. Com-Phone on the other hand is very scalable as more stories can be created at leisure, but residents are not able to capture stories without a carer's assistance. Although reminiscence content can be readily expanded by adding to Networked Reminiscence's community platform, the system is only usable within the context of an arranged therapy session. However, since these sessions are with remote therapists, Networked Reminiscence does not require the assistance of care home staff. Due to the systems' restrictions to predefined worlds/categories, neither Virtual Worlds nor Photostroller or CIRCA are scalable without changes to the systems themselves. Residents are able to use the systems independently, however, Virtual Worlds yielded only limited success without carers assistance during use and CIRCA tends to be used in the context of reminiscence sessions with care staff.

Our work on *Mnemosyne* differs from previous work in a number of important ways. Firstly, in the time that has passed since those projects, technology and individual's sharing models have undergone significant changes over the years. The landscape of technology itself has evolved rapidly, with the establishment of more sophisticated digital platforms, widespread internet access, and the integration of multimedia. Furthermore, shifts in social dynamics (e.g. the percentage of elderly in long-term care vs. cared for by family [30]) and the changing healthcare landscape [53] have also played a role in shaping the way we approach reminiscence in care homes. In our work, we acknowledge and build upon the foundations laid by previous research, while taking those changes into consideration. By doing so, we aim to develop and implement a reminiscence system that aligns with the current needs and capabilities of care home residents, caregivers, and residents' family members.

Secondly, *Mnemosyne* utilises pervasive display technology for content delivery. The growing ubiquity of public and semi-public displays makes them obvious candidates for use in care settings but the use of such displays to support reminiscence in residential dementia care has been little explored. Thirdly, when comparing how these systems have been evaluated, all projects but CIRCA were subject to short-term evaluations with time scales ranging from individual observation based sessions to deployments of up to two months. CIRCA stated a deployment duration over an extended

period but did not specify any further. The projects were validated mostly on residents with early to moderate dementia with the exception of CIRCA where some participants also suffered from the later stages of the disease. The multi-year duration of *Mnemosyne*'s design and deployment allowed stakeholders to gather the experience necessary to provide informed feedback about the system which in turn enables us to form design guidelines for reminiscence systems using displays in private environments such as bedrooms.

Finally, *Mnemosyne* was designed, developed and deployed over a period of time that included a global pandemic – providing a genuinely unrepeatable insight into working with care homes in this context. Consequently, we can provide updated insights into user acceptance, design guidelines for reminiscence systems focused on bedroom screens, and valuable observations into the use of the technology during a once-in-a-generation global event.

3 DESIGN CONTEXT AND PROCESS

Mnemosyne was developed through an extended collaboration between Lancaster University and Heathfield Residential Home, a family-owned residential care home in the North of England. The home provides residential care for up to 25 female older adults, typically those over eighty years who can no longer live independently, and has particular expertise in dementia care. Each resident has their own private room where they are surrounded by familiar objects (e.g. photos, household items, small pieces of furniture), and there are three large shared rooms for social activities.

Prior to this research collaboration, the residential home had been recognised for its innovative use of dementia technologies and collaboration with research organisations developing those technologies. In particular, at the time of our first engagement, the home was actively using the Portrait [57] tablet application to provide staff with information about residents' life experiences (e.g. to inform care, build relationships and support structured reminiscence therapy sessions).

The home also had digital photo frames available in residents' private rooms, with the intention to provide familiarity for residents in their bedrooms. Whilst both Portrait and the digital photo frames were in active use at the beginning of our collaboration, the residential home owners were quick to highlight the labour intensive nature of providing content to both systems. They also noted that maintenance and support for Portrait was limited as the funded project under which it had been developed had come to an end and the staff involved had moved on to other research roles – ultimately this meant that the home was unable to continue using Portrait.

During a series of visits and discussions over a period of a year, the research team and staff from the residential home explored ideas for new uses of multimedia within the home. This principally centred on the creation of a large video wall in one of the shared spaces in the near term (similar to that reported in [46]), with a longer-term goal to support the home in addressing challenges associated with use of Portrait and the digital photo frames. The primary goals for the proposed video wall were to: *(a)* improve an under-utilised shared space, *(b)* provide a semi-immersive environment that could be used to situate residents in familiar but inaccessible spaces (e.g. due to mobility constraints, or a desire to revisit a significant moment in time), and *(c)* positively impact residents' wellbeing and cognitive health. These goals were somewhat fluid, and represented the care home owners' strong interest in adopting novel technologies with a view to improve their care provision.

Real-world deployment brings extensive relational labour to both the researcher and space owners/users, together with a likelihood of misaligned intention, goals, and understanding [27]. Despite the care home owners' relatively high levels of prior experience, they were not skilled in system design, engineering or deployment. Further, they only had a loose set of goals motivating creation of the system. Engaging in participatory design from the outset would have been challenging for all involved, and risked over-burdening care home staff [27]. Thus, our development process for the video wall was initially researcher-led, informed and directed by the previously mentioned discussions and visits. However, once hardware and software was in place, and care home owners were tooled to utilise the video wall, the research-team deliberately avoided engaging in further intervention. Instead, care home staff were left to familiarise themselves with, adopt and appropriate the technology as they saw fit. Quarterly visits during the first year of deployment allowed the research team to maintain contact with the care home staff and address any support needs. At the end of the first and second years of deployment, the research team conducted a longer set of visits (including ethnographic observations and semi-structured interviews), as well as some analysis of content shown, allowing us to understand the care home's use of the video wall and technology needs going forward.

By this point, the care home owners had valuable and distinct knowledge when compared to the research team, and the processes became increasingly participatory.

One of the ways the care home owners thought the video wall could be improved pertained to the fact that content shown on the video wall was limited to videos or pictures found online. Having been able to observe the positive influence of the video wall on residents, the owners of the care home broached the idea of finding a way which enables residents to engage with more personalised content. To address the challenge of sourcing content personal to residents, the care home owners desired a system that enabled family members to contribute and provide images and videos which could be viewed by their in care relative.

During a workshop with HCI experts initial designs for such a system were developed, taking the discussions with the care home staff into consideration. Those designs were then shared with both the care home owners and residents' family members and refined over an iterative process.

The start of the COVID-19 pandemic and the need to reduce in-person social interaction shifted the focus of this research away from the video wall and towards ways to support individuals on smaller screens and in their personal spaces.

As such, we adapted the previously created designs and adjusted them during rapid, iterative design cycles based on inputs provided by the care home owners.

4 THE *MNEMOSYNE* MEDIA PLATFORM

4.1 Overview

Our goal was to develop a system that supported three distinct sets of stakeholders, i.e. residents of care homes living with dementia, families of residents who wanted to supply material that could be used as cues for reminiscence and, finally, professional caregivers within residential settings. Given the vulnerable nature of people in care, special consideration had to be given to the unique needs of the different end-users of our system [13]. We, therefore, worked in close collaboration with care home managers and, given residents' limited technological experience, our design prioritised caregiver-mediated interactions, in line with the findings from Paay *et al.* (2022) [41]. *Mnemosyne*'s application design resulted from iterative feedback with the care home management to enhance usability. *Mnemosyne* is comprised of two subsystems (see Figure 1 for an overview):

- The ***Content Presentation*** subsystem takes the form of a pervasive display network responsible for scheduling and presenting content, as a fullscreen slideshow, onto display devices in the residents' bedrooms, for viewing by residents and care home staff.
- The ***Content Sharing*** subsystem comprises a *Browser-based Application* that supports care home staff and family members to upload their content to a *Content Store* that is based on the open source digital signage content management system *e-Channels* [9].

4.2 The *Content Presentation* Subsystem

The ***Content Presentation*** subsystem takes the form of an open source pervasive display network responsible for scheduling and presenting content, as a fullscreen slideshow, onto display devices in the residents' bedrooms, for viewing by residents and care home staff. The display network is based on a client-server architecture, with "thick client" displays running the *Yarely* digital signage player [8] to schedule and playback content. *Yarely* is a fully-featured signage player designed specifically to support research into pervasive display systems. In particular it uses a highly modular internal architecture that enables individual components such as content schedulers, media renderers and interaction support to be updated with new components designed to explore specific research questions in the field. Within the context of our work we utilise *Yarely*'s ability to operate in disconnected mode (i.e. to continue operation in the face of network failures) and its ability to draw content from multiple sources and create appropriate presentation schedules using novel scheduling techniques such as lottery scheduling [37]. Content is sourced from the *Content Sharing* subsystem's *Content Store*. The *Content Presentation* subsystem is configured to cycle through static content items (i.e. images) at 30 second intervals, and to play dynamic content (i.e. videos) in full before progressing to the next item.

4.3 The *Content Sharing* Subsystem

Within the *Content Sharing* subsystem, the *Browser-based Application* provides a means for care home staff and residents' family members to upload content for display on devices in the residents' bedrooms (this workflow is depicted in Figure 2). The *Browser-based Application* also allows staff and family members to view existing content (and associated descriptions) in order to support reminiscence conversations.

The *Browser-based Application* has the following features:

- Users are provided with personal access credentials, that ensure they are able to view and upload content for the correct resident(s) [Figure 2a-c]. Specifically, care staff are able to upload and view content for all residents, and family members are restricted to upload/view content for their own relatives.
- Users can upload and manage photos and videos [Figure 2d-e]. These multimedia formats have previously been shown to be popular and effective tools for reminiscence [45], and are well-supported by digital signage platforms.
- On upload, content can be assigned descriptions and tags [Figure 2d-e]. This can be done on an individual basis or by assigning a description and tags to an entire batch. Both descriptions and tags are used exclusively in the browser-based application where they can be used to filter content to support browsing and content management.
- Previously uploaded content can be edited or deleted at any time [Figure 2e]. Selected content can be viewed with its description as a slideshow. Staff can use this to familiarise themselves with the uploaded content by reading the corresponding descriptions.
- Tags can be created, edited, and deleted [Figure 2d-e]. Each tag consists of a name and one of 16 predefined colours. In order to allow for appropriation we left name and colour selection open to the users' interpretation [16].

Staff and family members were provided with a login hyperlink and credentials. They were supported in their use of the *Browser-based Application* through a user guide that described the basic functionality of the *Browser-based Application*. This user guide further explained where, and to whom, content uploaded to the *Mnemosyne* would be accessible – i.e. that it could be viewed by anyone logged into *Browser-based Application* with the relevant permissions, as well as on televisions located in appropriate residents' private rooms. Staff and family members were given no directions or prompts on the types of content they should upload. Logging within *Browser-based Application* captures information about user activities (i.e. login times).

4.4 Deployment

Mnemosyne was deployed into a family-run residential care home in the North-West of England (UK). The care home had prior experience of using a variety of technologies to support reminiscence, including digital picture frames and tablet applications for photo browsing, and wall-sized displays for creating immersive experiences.

Furthermore, each of the residents' private bedrooms contained a smart TV device, installed prior to this research and used primarily to show television content. Despite sector-leading technology experience, the process for using technologies to support individual reminiscence was often considered to be labour-intensive by care home staff. Furthermore, control of these systems was limited

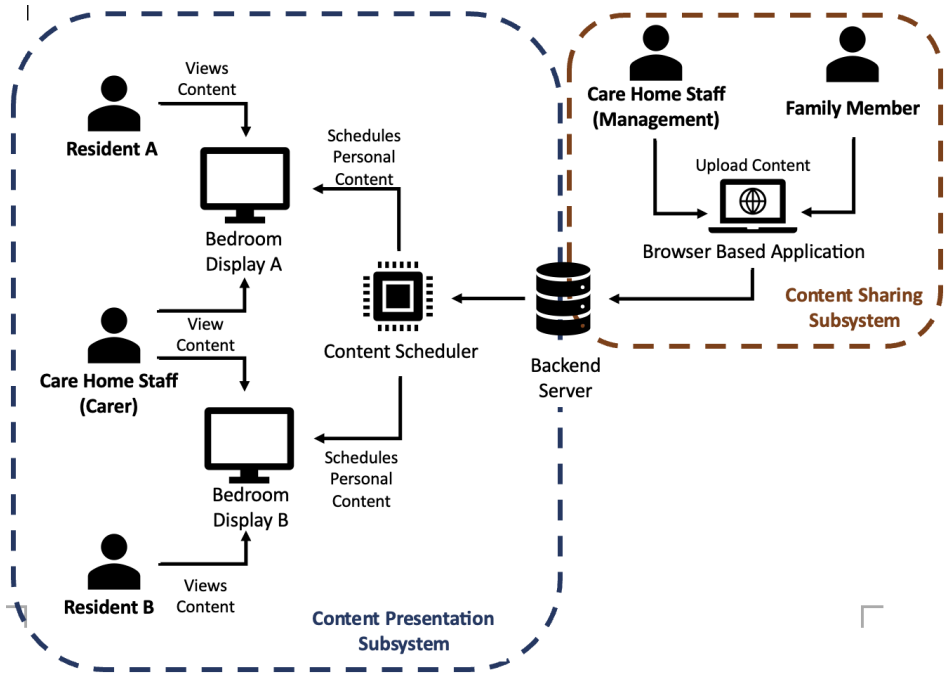

Figure 1: The *Mnemosyne* system architecture. A *Content Presentation* subsystem displays content on screens in residents' bedrooms, whilst a *Content Sharing* system supports care home staff and family members in their upload of content.

to (select) staff, meaning that family members could only share content by using these staff members as a proxy, limiting family engagement.

In order to make the system as unobtrusive as possible, we decided to enhance the existing smart TVs in resident's bedrooms (see Figure 3), rather than introducing new devices and hence connected a *Yarely* digital signage player to each TV.

The development of *Mnemosyne* coincided with the early stages of the COVID-19 pandemic, with nationwide lock-downs that restricted family visitations into care homes. Within the care home, reminiscence activities that involved physical artefacts and/or close physical proximity (e.g. those based around a tablet application) also became increasingly challenging.

5 LONGITUDINAL USER STUDY

We used a mixed-methods deployment-based study to better understand use and experiences of *Mnemosyne*. In particular, we used log and content analysis and engaged in semi-structured interviews with stakeholders. Our deployment had run for two years at point of study – expanding in terms of the number of deployed screens and users over this time. The system remains operational and continues to be used at the time of writing.

Note that our work is not designed as a clinical trial in which we attempt to systematically measure the impact on individual residents or the accuracy of individual reminisces. Instead this deployment explores the use of *Mnemosyne* as part of the overall care environment and seeks to understand the extent to which the system is perceived by carers and family members to enhance the residents' quality of life. Given that residents were not able to engage in interviews themselves, rather than attempting to determine quality of life by measuring a proxy such as levels of pain or engagement we employed semi-structured interviews with those involved in the resident's care to gain an understanding of the system's influence.

5.1 Participants and Recruitment

We sought to recruit participants that represented all three of our stakeholder groups, i.e. residents, family members and care-givers. For residents their usage of the system was analysed but we did not interview residents due to the degree of dementia they were experiencing. For other stakeholders we analysed both quantitative data reflecting their use of the system and conducted semi-structured interviews. Hence we involved both passive and active participants.

Initial recruitment of family members (and, by association, residents) to use *Mnemosyne* was conducted through care home management staff. Participants who are care-givers were recruited from care home management staff who had uploaded content using the *Browser-based Application* and care home staff (carers) who had not uploaded content using the *Browser-based Application*, but had experiences of seeing content on the displays. Care home management staff acted as the recruitment gatekeeper – only once a participant had agreed in principle, did the researchers approach them for a more detailed briefing and consent process before they began using the system.

All residents of the care home are female; ages ranging from 73 to 96 (M=87.21, SD=6.96) who could no longer live independently and have moderate to severe dementia. The entire sample consisted of residents from various regions of England, with a predominant

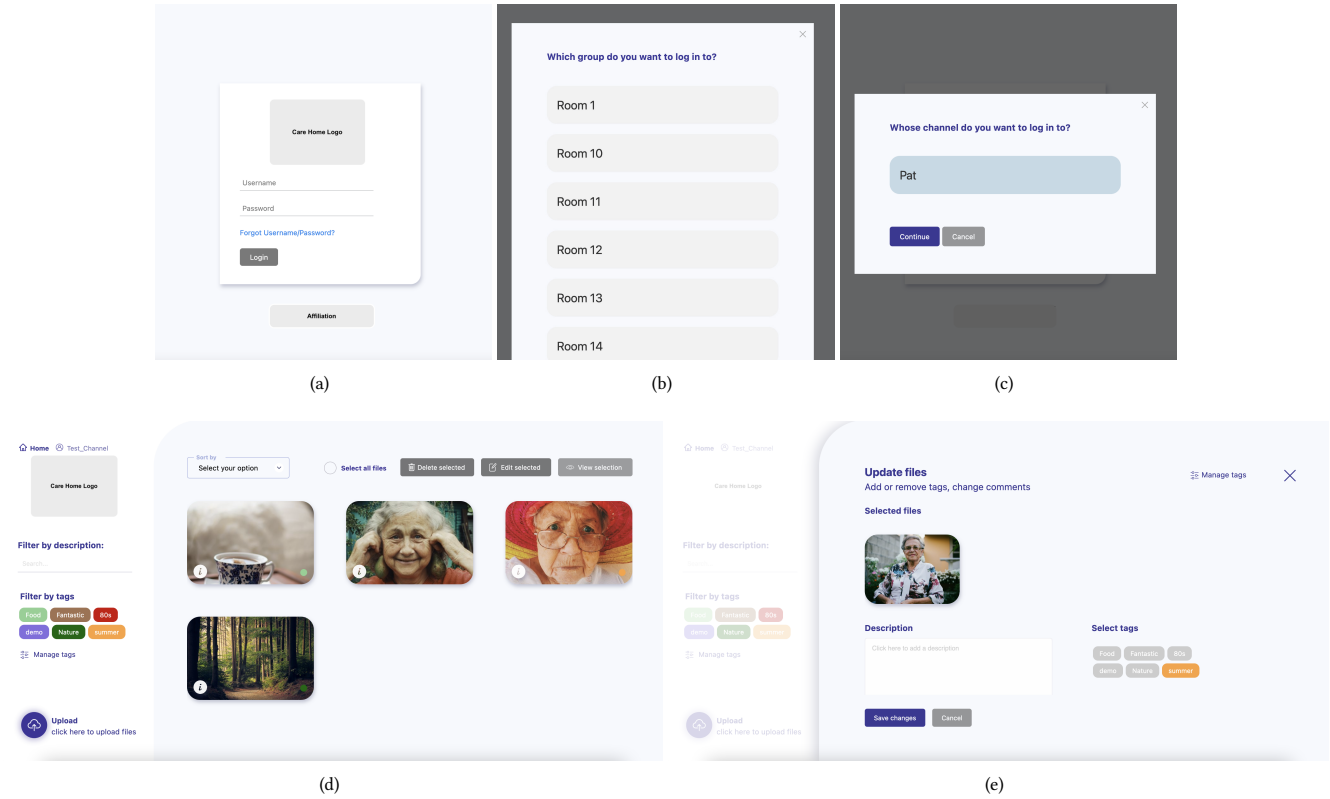

Figure 2: Workflow for uploading content to *Mnemosyne* starting with (a) login, followed by (b) room and (c) resident selection which leads to (d) *Mnemosyne* main page where (e) previously uploaded images can be edited. Content upload is achieved through either dragging content from the local file system into the non-sidebar portion of (d), or by clicking the"Upload" icon in the bottom left corner of (d) and selecting files through the operating system file selector dialog; this content upload action results in a new edit overlay (e) with all uploaded files appearing in the "Selected files" area.

Figure 3: Example of a display located in private bedroom (personalised content shown on the display has been obfuscated).

majority hailing from the North of England. Notably, 37.5% of the residents were specifically from the town where the care home is located. Additionally, the entire cohort represented a homogenous ethnic background, as all residents identified as belonging to the white ethnicity group.

While explicit socio-demographic data regarding family members was not directly collected, family members tend to be the children or grandchildren of residents. Considering that residents on average are in their eighties and share a common geographical origin, reasonable inferences can be drawn regarding the probable age range and nationality of their family members. This indirect understanding contributes to a broader contextual awareness of the socio-demographic composition surrounding the family members in this study.

The care staff involved in this study exhibit a diverse range of ages, spanning from 20 to 80 years, with a predominant concentration falling within the 40 to 70 age range. The gender distribution among care staff comprises 18 females and 1 male. The staff members also come from varied socio-economic backgrounds, contributing to a more varied representation within the caregiving team as compared to the residents.

The research was reviewed by our institution's ethics committee and users were asked to sign a participation form that set out how content uploaded to, and data generated by, the application would

be used. Family members consented on behalf of residents in line with the practices in place within the care home. All data was anonymised.

Individual participants were not compensated for their involvement. However, the care home as whole benefited from the ongoing technology provision and support (no further incentives for participation were provided to the home).

Our content analysis takes place over data that was uploaded by 33 *Browser-based Application* users (thirty family members and three care home staff) and the presentation of this content in nineteen female residents' [R1 - R19] bedrooms.

Due to COVID-19 restrictions, the workload of the care management, and new residents moving into the care home, participants were not on-boarded all at once but in a total of nine batches with the last batch in February 2023.

5.2 Semi-Structured Interviews

We used a set of semi-structured interviews with questions chosen to reflect the individual stakeholder's role (family member[*], content uploading staff[†], non-content uploading staff[‡]). Based on these categories the number of guiding questions ranged between 10 (non-content uploading staff), 11 (content uploading staff) and 15 (family members) (see table 4).

The questions were shaped by the insights we gained from evaluating both the use of the browser-based application and the content that was uploaded. They focused on participants' content-sharing behaviour in everyday life, relatives' relationship with residents before their move into care, the kind of content shared, the use and experience of the system, and the perceived impact of the system on residents' well-being. Responses were analysed through inductive thematic analysis to examine emerging themes. Subsequently, researchers engaged in discussions to achieve consensus on these identified themes.

In total we interviewed five participants via Teams for between 10 to 30 minutes (mean = 21.2 minutes, median = 24 minutes): two family members [F1 - F2] (two adult children; one female, one male) and three staff [S1-S3] (two female, one male) of which two were non-content uploading carers (S1 & S3) and one a content uploading care manager (S2). During the interviews audio was recorded with the interviewees' explicit permission, to allow for verbatim transcription.

6 RESULTS

6.1 Log Analysis

Figure 5 illustrates on how many separate days content uploading care home staff and residents' family members (summarised as Uploaders going forward) have accessed the browser-based application. This access could be for content upload, exploration or content management. Out of the 33 individuals, only 20 (58.82%) accessed the application on a second day and only one (a member of staff) used the system on more than 25 individual days. On average the browser-based application was used on a total of 6.64 days (Median = 2, SD = 12.13) throughout the study. Content was uploaded by 17 out of 33 Uploaders (see table 2 for a detailed overview).

Table 3 showcases how the tagging and description feature have been used in the browser-based application. Since both features could be used cross-user by anyone with access to a specific resident's content, the data is presented per resident rather than by Uploaders. Over the duration of the deployment, a total of 1002 content items were uploaded to the system. At the time of this evaluation 557 content items were distributed across 13 out of 19 residents (68.42%). For 6 residents no content had been uploaded by family members or staff which rendered the residents unable to engage with *Mnemosyne*. The tagging feature was used on the content of four out of 19 residents (21.05%) and, therefore, remained largely unused. The description feature, on the other hand, was used on the content of almost half the residents (47.37%). Furthermore, 30 content items across three residents contained descriptions as part of the picture *"…. on the beach, holiday Wales May 2021"*. These descriptions were used as both a substitute for the description feature as well as an addition to it.

6.2 Content Analysis

Out of 171 descriptions 78.36 % contained the name of at least one person, oftentimes more, varying between a listing of people shown in an image and more elaborate descriptions of who is shown in the picture and what they were doing. However, only some (8.21%) of those descriptions contain references to the relationship between the resident and the people shown in the picture *"... (great-grandson) and his friend ... at the Queen's jubilee street party"*. The group description feature was used in three instances, all uploads for the same resident. However, a batch upload of 19 images was noticeable as the descriptions, although applied individually per item, contained generic context of who and where *(e.g. ... & ..., Las Vegas Holiday last week)* followed by a description of the intended focus of the picture *(e.g. Chocolate Fountain in the Bellagio Hotel)*. In Figure 6, a wordcloud depicts generated tags, prominently highlighting themes like family, animals, and nature.

Although both photos and videos could be uploaded, the vast majority of content consisted of photos with only 17 videos (1.70% out of all uploaded content) uploaded over the duration of the study. A visual examination of the currently uploaded 557 content items revealed differences in the nature of the chosen content. For about half of the residents uploaded content included pictures of them pursuing various activities within the care home such as baking, creating flower arrangements, or physical exercise *(R3, R6, R7, R9, R11, R13, R15, R16, R19)* which were uploaded by the care home staff (S2). The remaining content can be separated into the categories *Pictures of the resident's past* and *Pictures to keep in the loop. Pictures of the resident's past* consists of both the distant past such as pictures of places lived or visited (e.g. National Trust sites) *(R3, R15, R19)* and old family pictures (e.g. wedding days or holidays) *(R9, R11, R12, R15, R16, R19)* as well as the recent past depicting residents' with their family members in or outside the care home *(R15, R16)*. Content that falls into the category *Pictures to keep in the loop* on the other hand is shared by family members to keep the resident up to date on their family's life (F2). The category consists of pictures of residents' family members such as grandchildren or great-grandchildren *(R2, R3, R14, R15, R16, R17, R19)*, family members on holiday *(R5, R12, R15, R17)* or during important life milestones such as graduating

Upload Behaviour									
Uploader ID	Can upload content for resident	Total content uploaded	Mean	Median	Min	Max	Total upload sessions	Upload period	Onboarded
U1	all	99	3.81	2	1	14	26	15.07.20 - 27.02.23	15.07.20
U2	R15	79	39.5	39.5	25	54	2	18.06.21 & 29.08.21	25.02.21
U3	R15	47	15.67	19	1	27	3	10.05.21 - 23.05.21	03.03.21
U4	R15	44	4.4	1	1	20	10	01.05.21 - 25.09.21	28.04.21
U5	R3	22	7.33	9	2	11	3	04.05.21 - 05.06.21	28.04.21
U6	all	137	45.67	34	1	102	3	17.01.22 - 11.02.22	19.11.21
U7	R16	28	28	28	28	28	1	24.01.22	05.01.22
U8	R16	67	16.75	2	1	62	4	01.05.22 - 13.02.22	05.01.22
U9	R16	23	3.83	2	1	13	6	05.01.22 - 10.02.22	05.01.22
U10	R11	272	14.32	10	8	43	19	07.01.22 - 20.08.22	05.01.22
U11	R17	28	4	4	1	9	7	23.08.22 - 22.09.22	18.08.22
U12	R17	16	16	16	16	16	1	25.09.22	18.08.22
U13	R17	19	9.5	9.5	9	10	2	19.08.22 & 05.09.22	18.08.22
U14	R2	54	27	27	1	53	2	22.08.22 & 30.08.22	18.08.22
U15	R12	47	15.67	13	7	27	3	20.08.22 - 14.10.22	18.08.22
U16	R12	6	6	6	6	6	1	20.08.22	18.08.22
U17	R5	14	14	14	14	14	1	27.02.23	25.02.23

Table 2: Overview of individual Uploaders's upload behaviour. The "can upload content for resident" column indicates what resident(s) individuals were able to upload for. Uploaders without uploads were omitted from this table for the sake of clarity. Mean and Median refers to the average number of uploaded content items per upload session. Minimum and maximum are Uploaders's smallest and largest upload batch size over their upload period (first to last recorded upload per Uploaders). Upload sessions are individual upload days within the upload period. Onboarded refers to the day Uploaders were given access to the browser-based application.

System engagement					
Residents	Content Items	Tags Created	Number of Content with Tags	Descriptions via Description Feature	Descriptions Directly on Picture
R1	0	0	0	0	0
R2	53	0	0	28	1
R3	35	5	20	21	0
R4	0	0	0	0	0
R5	14	0	0	2	0
R6	5	0	0	0	0
R7	1	0	0	0	0
R8	0	0	0	0	0
R9	5	0	0	0	0
R10	0	0	0	0	0
R11	45	0	0	2	3
R12	42	0	0	7	0
R13	1	0	0	0	0
R14	0	0	0	0	0
R15	141	6	37	52	26
R16	131	1	4	18	0
R17	44	0	0	24	0
R18	0	0	0	0	0
R19	35	5	17	17	0

Table 3: Uploaded content and feature usage per resident

	Questions
1 *†	How often do you tend to share photos & videos in everyday life?
2 *†	How do you usually share these photos/videos?
3 *	How would you describe your relationship with your relative before they moved into [care home]?
4 *	Did you share photos/videos with your relative before this system? How? Why?
5 †‡	How did relatives share photos/videos with you before this system?
6 *†	Can you describe how you use the system?
7 *†	How did you decide what pictures/videos to upload?
8 *†‡	Did you and [the resident/your relative] interact with the content [on visits]? How so?
9 *	Would you normally talk about these photos with other members of your family (e.g. at home?)
10 *	Do you know if your relative sees the pictures when you're not here?
11 *	Do you think that seeing the photos/videos helps your relative feel better connected to you and the rest of their family? Why/Why not?
12 *	Do you think that they help you feel better connected to your relative? Why/Why not?
13 †‡	What impact do you think seeing the content had on the resident?
14 *†	Did you run into any challenges while using the system/ was anything hard to use? What do you think was good/bad?
15 *†	How much time do you think is needed to learn how to use the system?
16 *†‡	How do you think the system could be improved?
17 *	Is there anything else you want to tell us about your, your relative, or your family members' interactions with the system?
18 †‡	Is there anything else you want to tell us about the system?
19 ‡	Do you think relatives have found the system easy to use?
20 ‡	Do you think their expectations of what you do with the photos/videos have changed?
21 ‡	Do they talk to you about how you/they use the photos/videos?
22 ‡	Have you observed relatives and residents interacting with the content [on visits]?
23 ‡	How do you think that has impacted their interactions?

* Question for family members
†Question for content uploading staff
‡Question for non content uploading staff

Figure 4: Core questions semi-structured interview

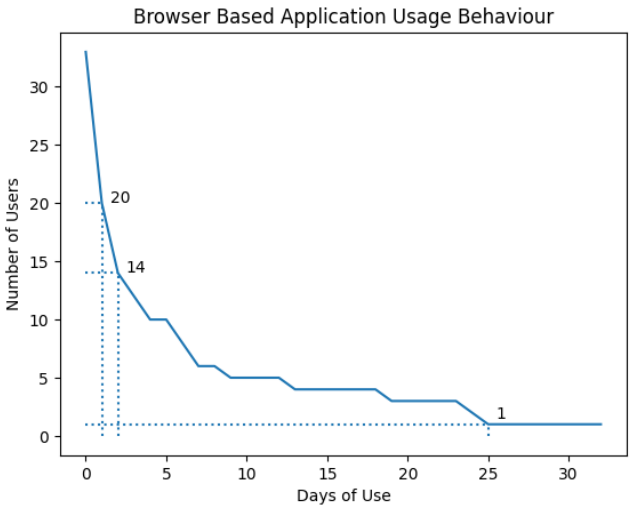

Figure 5: Number of Uploaders using *Mnemosyne*'s browser-based application over time

Figure 6: Word cloud of created Tags

university *(R15)*, and pictures of current events (e.g. pictures of flowers at Buckingham Palace after the Queens death - *R17*).

We further classified the content items as *People Cues, Object Cues, Place Cues* or *Action Cues* based on Gaver *et al.*'s [19] specification of good memory cues (see table 4). However, in order to not classify animals as either people or object cues, we decided to add an additional category *"Animal Cues.* In cases where content items were between two categories, we increased the count for both

categories *(e.g. a picture of grandchildren playing the piano would be seen as both a person cue and an action cue)*. This results in a total of 318 People Cues, 144 Action Cues, 34 Object Cues, 52 Place Cues and 41 Animal Cues. It is worth mentioning, that the majority of images of residents in the care home can be classified as action cues while the vast majority of content uploaded by family members are people cues, showing either the resident or friends and family.

One family member (F1) reported that the selection criteria for photos they would upload to the system changed along with their relative's progressing dementia. *"With the old ones I was looking for pictures where you could see the faces clearly and where it was an event where a few years ago she would have remembered very clearly and told me all about. For the recent one's just something where it's obvious what's going on so that it doesn't need to be explained. And where she's got a hope of recognising the people. And happy things. Obviously only good things"*.

6.3 Staff and Family Members Motivation for Use

Questions 1 and 2 indicate, that all three content uploading interviewees differentiate what platform they use to share content in everyday life, depending on context and technical affinity. *"I'm not a great social media user. I might attach [pictures] to a text message. (F2)"* S2 uses Facebook to keep residents' family members in the loop by posting pictures showing residents during various activities multiple times a week. However, S2 and F2 share personal content only via WhatsApp instead of using social media. F1 on the other hand, uses Facebook for sharing personal pictures with the occasional video, but uploads only once to twice a month. F1 additionally uses Google Photos to share all their pictures taken with their husband.

When asked about the response Uploaders expected from people who see that shared content, all Uploaders expected content to be commented on *"Everyone would respond with a funny line (F2)"* or interacted with via "likes" (S2, F1). For both interviewed family members posting pictures can evoke feelings of increased connectedness with individuals even in cases where interaction via posted photos is the main method of keeping in touch. *"A lot is friends I don't meet up with anymore so that's our whole method of keeping in touch. (F1)"*

However, the same is not necessarily the case for content shared via *Mnemosyne* (Q11). *"It never seems to crossover into something where it's still there when I'm talking to her. Uploading [pictures] it always felt like a nice thing to do, but it's just kind of a hope into the beyond. If I ask her about it, she never said she'd seen them. And I know that that's not in any way a statement that she hasn't seen them, but she never retained that memory long enough to tell me about it. So, it didn't really help with the connection, although it might have made her day better, which is why I kept on doing it. (F1)"*

Next, we focused on family members' content share behaviour with the resident before the availability of the system and their relationship and interactions with the resident (Q4 & Q3). Before their mothers moved into care, both interviewed family members shared photos on their phones or computers during visits, or in paper form either printed or as part of photo books. *"We would [...] make a photo book from holiday and give her a copy of that, or we did one when she turned 80. [...] (F1)"* Content that has now been uploaded to the system, has in the past either not been shared at all or only shared occasionally during in-person visits where the content was brought in as printed physical pictures or shown on the relative's phone (S2, F2) (Q5). *"We [...] would make more of an effort to print photos to leave there with her (F2)"*.

Comparing the frequency of interactions family members had with their in care relative to before they had to move into the care home, F1 mentioned that changes happened because of national coronavirus restrictions. Additionally, both family members stated residents' progressing dementia as a reason for a decline in interaction frequency. Due to distance, in person visits between F1 and their mother were restricted to two to three month intervals. However, they would talk on the phone once or twice a week. This increased to daily conversations in the later stages of the disease when the mother was still living on their own. After the move into care this changed back to once or twice a week as *"it just gradually became obvious that [daily calls weren't] helpful. It was triggering anxiety when she didn't know what to say to me (F1)"*. F2 has lived in close proximity to their mother both before and since moving into care. Before the move, visits were daily but because of the progressing dementia *"it became kind of a strained relationship [...] so that makes it a challenge (F2)"*. Since their mother's move into care, visits have decreased to once a week which has positively impacted the relationship.

6.4 Perceived Usability and Upload Behaviour

Questions 14 and 15 focused on the perceived usability of the browser-based application which is closely tied to users' technical proficiency. While some find the application to be very *"straightforward (F1)"* and not difficult to use (S2), for one of our families, a lack of technical expertise became an abandonment threshold *"I struggled getting the link to work (F2)"*.

To support content-uploading participants in their description of their system usage in question 6, we provided them with their system usage statistics, including upload frequency and quantity. For staff, fluctuations in upload frequency were due to their very busy work day and the need to find the necessary time *"It was usually finding a slot in my program. My day is very busy. The need to maintain the system is always high on the list but it's finding a slot (S2)"*. They have, therefore, expressed a desire for a simplified upload process, *"if it were possible from your phone, it would become far easier to use (S2)"*, to increase frequency of use. F1 on the other hand would much rather have the application remain browser-based. For family members, reasons for a drop off in system usage came down to a lack of suitable photos (F1, F2), the pressure of work (F1), a lack of feedback regarding the uploaded contents' usefulness (F1, F2), and the aforementioned lack of technical aptitude (F2). We, additionally, focused on Uploaders selection criteria for the uploaded content in questions 7 and 8. One family member reported that after an initial upload of pictures which they *"thought might trigger some memories (F1)"* they *"had to wait for something to happen (F1)"* to upload more content. These pictures were often selected with multiple family members engaged in the activity of going through albums and active discussion of *"do you think that would be a good one (F1)"*. F2 reflected that *"at first it is kind of easy to find*

	Cue types				
	People Cues	Object Cues	Place Cues	Action Cues	Animal Cues
R1	0	0	1	0	0
R2	43	2	0	3	3
R3	11	1	9	10	2
R4	0	0	0	0	0
R5	2	2	7	0	3
R6	2	0	1	3	0
R7	0	0	0	1	0
R8	0	0	1	0	0
R9	0	0	1	4	1
R10	0	0	0	0	0
R11	16	2	2	26	0
R12	31	3	3	8	2
R13	0	0	0	1	0
R14	0	0	0	0	0
R15	95	8	16	25	7
R16	71	8	6	43	13
R17	33	7	2	1	8
R18	0	0	1	0	0
R19	14	1	2	19	2

Table 4: Cue type distribution of uploaded content

things to share, then you have to think harder about what to share and then you're getting less interest from [your] mum generally [because of the dementia] which means that you have good intentions, but don't use it as much as you probably should (F2)." F2 themselves had not uploaded any content during the duration of the study as they were not a very technically oriented person and found the system *"a little bit difficult to use and maybe I didn't try hard enough [but] we fell back on our normal way of sharing (F2)"*. F2's sister and niece who live further away and are able to visit less often, uploaded pictures but, their use of the system also tailed off due to a lack of feedback. Increased pressure of work around the same time F1, was on-boarded to the system soon caused a break of habit and apparent abandonment of the system. *"Once you fall out of habit, I mean, that was only a month that I was doing the teaching. But then I kind of forgot that that was something I was supposed to be doing regularly."* The lack of feedback is something the home's management has already taken steps to rectify independently. Recognising both the usefulness of the system and the decline in families' interactions with the system, the home has engaged someone to interact more with family members going forward. By sharing the positive impact seeing the uploaded content has on residents, they hope to motivate and remind family members to use the system more regularly (S2). *"We are going to give [...] feedback to the families. [...] I think [...] it motivates them if they know that this has a good result, a good outcome. (S1)"*

We further inquired how *Mnemosyne* might be improved with question 16. In regards to the browser-based application, users express a desire for greater transparency regarding the purpose of the tagging and description features (F1), as well as step-by-step usage instructions to enhance system accessibility (F2). Furthermore, care staff have voiced a desire for a feature that enables them to manually adjust the display duration of content. One staff member explained *"if there is a picture that's not very interesting to the resident [...] we wouldn't have to spend as much time on it as for example a picture with children (S1)"*

6.5 Impact on Reminiscence

When asked about their perceived impact of *Mnemosyne* on residents in question 13, all of the carers interviewed reported, that seeing the uploaded content resulted in changes to residents' behaviour and mood. They were more cooperative when carers tried to help them get ready for bed as they wanted to settle down quicker to see their family pictures and reminisce (S3). Residents, further, became more animated by repeatedly expressing interest, excitement and surprise over the displayed pictures (S1). *"There is one lady that likes cats and the family uploaded pictures of their cats. She responded positively to that picture even though she didn't know who these cats belonged to. She was interested and excited and said: 'Oh those beautiful cats, who are those cats.' She was asking questions about it, she was interested about it and wanted to know more information about what she was seeing. (S1)"*. The content can, additionally, serve as a distraction, especially in the evening when residents are tired and confused, as it can *"help to engage residents and take their mind away from confusion they got or whatever else they're thinking about (S2)"*. As such, care staff turn the bedroom displays on during residents' alone time in their rooms (S2, S3).

Carers were, further, able to use the system to reminisce with residents during their one-on-one time (Q8). *"We very often talk with the residents about the families and discuss the various pictures that are on the screen and try and recall memories with them of when the photographs were taken. You know, try and name the people that actually are on the screens. It's very good for them. (S3)"* The system

was, further, not only beneficial for the residents, but it also had a positive impact on carers' ability to interact with residents. *"It's very interactive really it's like a two-way system. I'm able to learn about their families and the information that we get we can store and talk to them throughout when we're in and try to get them to recall memories from those pictures (S3)"*. However, carers were not always aware of the identity of the people shown, or their relation to the resident *"There were a few pictures where I didn't know what it was or what it was about, so it was quite difficult to make a conversation (S1)"*.

Through discussions with carers regarding possible ways in which the system could be improved (question 16), further impacts on both daily care practices and interaction opportunities between residents and family emerged. Specifically, while S1 and S3, both carers, are very enthusiastic about the system, not all carers at the home showed the same degree of system engagement (S2) *"I think if all team members participate in it and put [the displays] on at regular times throughout the day when they're interacting with the residents, they'll get more benefits from it (S3)"*. In an effort by the home's management to change this, the system has now been incorporated into carers' digital care timeline, a recent addition resulting from the care homes' digitalisation, that shows which tasks need to be completed throughout the day with specific times attached (S2).

S3 also emphasised the opportunities that could be facilitated if family members were using the content on the screens to interact with their relatives. They could *"talk to them about [what they are seeing], that will give them more recollection of things that have happened in their lives, earlier interests and it may stir something up again that may want to take up something again that they've enjoyed in the past (S2)."* However, family members usually do not spend time in residents' bedrooms during visits, but rather in the living room which does not provide access to screens (S2, F1). F2 forms an exception to this, as their mother, due to her health, spends most of her time in bed which moved the location of visits to her bedroom. Albeit it is no longer possible to engage her in structured conversation, due to the advanced stages of her dementia, F2 reported that their mother would give positive feedback by reacting and smiling to the photos.

7 DISCUSSION

This study investigated the use of *Mnemosyne* in aiding supervised and unsupervised reminiscence for residential care home residents with dementia.

Our usage analytics of the Browser-based Application and qualitative data gathered during the interviews reflect the disparity between Uploaders use of the Browser-based Application and the *Mnemosyne*'s value for residents.

Considering the importance of the content provided by Uploaders for residents' reminiscence, this disparity highlights a power imbalance between content providers and consumers. It further reflects the challenges of creating systems that result in lasting engagement.

Looking at individual upload behaviour, only two individuals started uploading content as soon as they were given access to the system. However, based family members' reports regarding their content selection process, most users took their time to look for suitable material before upload. Further, Uploaders tended to upload in bulk rather than uploading one item at a time. It is, therefore, likely that family members, especially those with very few sessions, uploaded all the content they thought suitable and then stopped using the system. While this practise served its purpose of ensuring residents had access to sufficient reminiscence content, residents' content needs are likely to change over time as their dementia progresses. Consequently, requiring Uploaders to reengage with the system and provide new content. As such, it is essential that systems have mechanisms in place which facilitate and encourage such reengagement.

Staff and family members have different motivations for uploading content to *Mnemosyne*. While family members want to take the time and turn content upload into an activity involving multiple members of the family, staff has to fit the upload into their very busy workday. To make it easier for staff to upload contend despite their time restrictions systems aiming for regular engagement should consider mobile support.

In order to make reminiscing with the displayed content a more seamless process, reminiscence systems should provide a choice between manual and automatic content change as not all pieces of content hold the same level of interest to residents. A manual setting would allow carers to change to the next item quickly if the resident shows little interest, and spend more time on items residents show more interest in. Other times an automatic change might be preferable, especially when residents are interacting with the system independently.

Reminiscence systems utilising personalised content should, furthermore, show information about the displayed content alongside the image. This will support carers who may not always be familiar with the identities or relationships of individuals shown. Contrary to our initial belief, care staff, most likely due to heavy workload did not familiarise themselves with the uploaded content in the Browser-based Application before using it for any reminiscing with residents. Knowing that the descriptions attached to uploaded pictures might help a carer better understand what they are seeing and thus be able to reminisce better with residents, might also have an influence on the descriptions users apply. Instead of listing the names of all the people shown in an image, they might add more context about the event the picture was taken at, who the shown people are in relation to the resident, etc. Moreover, people with dementia often struggle to recall past experiences even when presented with pictures of the experience. Descriptions of content that fits into the *Pictures of the resident's past* category should therefore include important highlights of memories family members want the resident to recall with the picture so that the memory can be relearned rather than remembered [34]. For content of the *Pictures to keep in the loop* category descriptions will set the shown content into context. Additionally, a feature that enables family members to tag specific elements within a picture could also prove valuable, as this functionality could further support caregivers who find it difficult to correctly identify individuals relevant to residents.

This prompts questions about the optimal timing for system modifications. Although a two-year duration may appear ample for implementing the aforementioned enhancements throughout the deployment, we intentionally abstained from making any alterations. As reflected in interviews with the care staff, the assimilation

of new systems tends to be a gradual process. Despite the care home management's optimism about the system's effectiveness and potential benefits, care staff typically requires firsthand experience of the system's positive impact on residents before prioritising interactions with it in their daily routines. The COVID-19 pandemic further complicated this acceptance process. Caregivers who had not yet witnessed the system's advantages likely viewed interactions with *Mnemosyne* as additional tasks during an already demanding period, especially when in-person interactions with residents had to be minimised. Waiting for this prolonged period stakeholders were able to gather the experiences necessary to provide informed feedback about what changes to the system they desired going forwards. As a result we avoided long lists of speculative feature requests from users and rather the feedback focused on experiences and changes that they felt would deliver real improvements to their use of the system.

7.1 Improving Personhood through Personal Content

Without being explicitly told what kind of content they should upload to the system, family members chose memory cues that are highly personal and are intended to trigger specific memories during reminiscing. They also uploaded content where they want to keep the resident up-to-date on their family's life and of current events that family members thought might be interesting or important to the resident. These insights are especially relevant when considering that the accounting for personal interests might have a pronounced effect on personhood in dementia [36]. In contrast to DementiaWall by Sas et al. [46] where content shown via wall sized public display had more general meaning to viewers due to confidentiality issues and the lack of privacy of the deployment location, we are able to display content personal to each user without concerns of breaches in privacy by setting the reminiscence locations to residents' bedrooms. The system is, in addition, able to support resident's reminiscence needs during different stages of their dementia. Based on the data gathered during the interviews, personal memory cues can shift into generic memory cues with the progression of a resident's dementia. While the picture of a resident's great-grandchild might, in the earlier stages of their dementia, result in the recollection of a specific memory that allows carers to engage with residents further, the resident might no longer be able to recognise their great-grandchild during the later stages of the disease. They will, however, still be able to use said picture for general reminiscence. This insight supports Sas et al.'s [46] challenge of the dichotomy between generic and personalised cues. In order to strengthen residents' personhood further, future iterations of *Mnemosyne* as well as systems similar to it, should look into utilising dementia-friendly control units (e.g. a large, coloured button), to allow residents to, for example, turn the system on or off when they desire to. This amplifies residents' capabilities and gives them agency to decide when to engage with the system [13, 18].

7.2 Designing for Reminiscence vs. Designing for Connection

The *Mnemosyne* system was designed to enable dementia care home residents to reminisce with personal content during a period where social interactions were severely restricted. As such, the primary goal was to provide residents with a way for reminiscence while alone in their rooms. However, upon examining the content uploaded by family members and considering their feedback gathered during interviews, it became evident that *Mnemosyne* had an additional, unexpected dimension — it offered a way for remote family members to maintain a sense of connection with their loved ones in care.

Family members' frequency of interactions with residents is influenced by multiple factors such as physical distance, residents' progressing dementia, and, during the earlier stages of this study, COVID-19 restrictions. Research has shown that COVID-19 related visitation restrictions on residential care homes impacted on family members' emotional and mental well-being and led to worries about residents' care and their mental health [10, 60]. Although these measures have now lifted, one could argue that the inability for frequent visits of remote living relatives might have similar effects.

Being able to share content with their in care relative provided family members with piece of mind, knowing they might be able to positively impact their relative's day. Even though there was uncertainty about whether residents would see or process the uploaded content, the act of providing this content offered a semblance of assurance (F1). However, due to this aspect of the system being an unexpected dimension, the Browser-based Application was not designed to support family members' feelings of connection. As such, the lack of feedback as to whether residents were seeing the uploaded content and whether seeing the content had an impact on residents, eventually demotivated family members from using the system and prevented actual feelings of connectedness.

This raises questions about the level of awareness required to establish feelings of connection in remote living family members. These could range from simple verbal feedback from carers to more technologically involved solutions. When sharing everyday content online, feedback consists of likes and comments, which has been reported as adequate to create feelings of connectedness (F1, F2). Will reports from care staff regarding *Mnemosyne*'s positive impact on residents, therefore, be enough to establish connectedness? Or are more quantitative reflections required such as impact measurements by carers or statistics reflecting the amount of times content has been displayed? This could then be taken a step further by delving into the possibilities of capturing implicit impressions, providing family members with awareness that content has not only been displayed but their relative has also been in the room and seen the content. However, the introduction of monitoring technologies (e.g. gaze tracking) introduces a host of ethical considerations, particularly regarding privacy.

Furthermore, discussions between residents and family members regarding the uploaded content may contribute to a sense of connection among family members. However, this aspect was not explored further in the current study. According to interview findings, engaging in planned conversations about content viewed through *Mnemosyne* poses significant challenges due to residents' dementia (F1). Consequently, any discussions about the displayed content would depend on real-time connections through phone or video calls. Yet, this approach would necessitate the presence of a mediator (caregiver) to assist the resident in managing the call and

conveying information about the showcased content to family members which in turn would add to caregivers already heavy workload. This raises questions on how such real-time conversations might be integrated in the future.

7.3 Understanding Success and Unsupervised Reminiscence

Merely taking the use of the Browser-based Application as an indication for *Mnemosyne*'s success, one might consider the system a failure. However, when considering the comments from care-givers, matters are vastly different. In addition, while usage patterns are able to give indications about the Browser-based Application's ability to create lasting engagement as well as *Mnemosyne*'s perceived value to family members and care home staff (both management and care), they are inconclusive about the system's success in stimulating reminiscence.

Residents, who are the intended recipients of reminiscence content and who engage in the reminiscing process, due to their dementia, are unable to provide feedback or evaluate the system's success directly. Given the principal users' (residents) inability to evaluate success, the burden of assessment falls on caregivers (staff) and family members.

As such, we have used outcome-oriented metrics that consider changes in residents' behaviour, mood, and overall well-being as indicators of success. We, additionally, measured success by the extent to which *Mnemosyne* facilitates meaningful interactions between residents and caregivers during reminiscence sessions.

One of the key findings of our study was the impact of *Mnemosyne* on residents' behaviour and mood. It was observed that residents exhibited greater cooperation during bedtime routines, perhaps as a result of viewing their family pictures and engaging in reminiscence (S3). This indicates that the system not only serves as a source of nostalgia but also has a practical benefit in supporting care-giving working practices.

Furthermore, the residents' heightened engagement with the displayed pictures, marked by expressions of interest, excitement, and surprise (S1), suggests that the system effectively captures their attention and stimulates cognitive and emotional responses to the content. Notably, even residents who may not recognise the subjects in the photos displayed found genuine interest in the content, exemplified by the anecdote of a resident's fascination with pictures of cats (S1). This demonstrates the system's capacity to spark curiosity and stimulate conversations.

Another noteworthy outcome of the system is its potential as a distraction during times where residents experience fatigue and confusion (S2). By providing engaging content, the system effectively redirects residents' focus away from their cognitive challenges and offers a therapeutic means to engage with their surroundings. This finding underscores the system's ability to serve as a valuable tool for caregivers in managing residents' behaviour and mood.

Beyond its impact on residents, *Mnemosyne* plays a role in enhancing carer-resident interactions. Carers reported using the system during one-on-one time to discuss family memories and identify individuals in the displayed photographs (S3). This two-way interaction strengthens the emotional connection between carers and residents, which can help to partially mitigate the adverse effects of dementia [3] and facilitates reminiscence, allowing residents to recall and share their life experiences. Additionally, the system empowers carers with insights into residents' families and personal histories, enabling them to create more personalised care-giving experiences (S3). This was especially valuable during COVID-19. While in-person interactions were restricted to a minimum, care staff's integration of the system into care activities such as morning or evening routines (S3) allowed for richer interactions between caregivers and residents than might else have been the case.

However, staff members face constraints in assessing the system's impact. They can share insights into how the system facilitates reminiscing during one-on-one interactions and offer observations on residents' behaviour and mood but the system does not facilitate communicating this to family members. Carers also do not know whether the system encourages independent reminiscence among residents. Likewise, family members, while they can express their feelings of connection when uploading content and judge content's potential suitability to trigger memories, are ill-equipped to evaluate the system's success in fostering reminiscence among residents. Their feedback is more reflective of their own engagement with the system rather than the impact it has on the residents' reminiscing experiences.

Evaluating the effectiveness of reminiscence support systems, therefore, poses a methodological challenge. New approaches are needed because traditional metrics relying on user feedback and satisfaction may not be applicable, as the principal users cannot provide direct input.

While prior research has encountered comparable challenges, as seen in the field of evaluating assisted living devices [5], it's worth noting that many of the suggested solutions still rely on self-evaluations. Systems such as PainChek®[42] may indicate potential paths forward. It is further important to recognise that *Mnemosyne* is not a medical-grade technology and as such requires a fresh perspective and thoughtful consideration of the most appropriate evaluation methods. Future studies could, for example, involve collaboration with medical professionals who possess the expertise to conduct assessments in parallel to the system's deployment. This interdisciplinary approach could shed a new light on the impact of systems like *Mnemosyne* on residents' well-being and cognitive functioning.

Overall, the implications of our results extend beyond the specific care home setting where we conducted this study as our findings can be applied to care homes without pervasive display networks by, for example utilising digital photo frames. This practice has been tried in a number of homes over the years with, so far, limited success.

8 CONCLUSION AND FUTURE WORK

Reminiscence can help mitigate the adverse effects of dementia. However, reminiscence support systems are typically designed for individuals and/or their families and are dependent on physical artefacts or face-to-face interactions. Care homes, in contrast, often lack appropriate content for successful reminiscence sessions and must operate at scale with limited time to spend on individual residents. We created *Mnemosyne*, a system that enables family members to

share personal content with residents outside of in-person visits. By utilising pervasive display technology in residents' bedrooms, residents' privacy can be maintained. Residents are able to interact with the content during their alone time inside their bedrooms, and staff can also integrate it during one-on-one reminiscence sessions. This integration of regular reminiscence comes without significant increases to care-giver's workload. Our exploration of *Mnemosyne* over its two-year-long deployment showcased the system's value to care home staff. It also highlighted the infrequent nature of interaction by family members; highlighting the difficulties of creating systems that result in lasting engagement, which may be required as residents cognitive abilities change. We, additionally, highlight the challenge of measuring success of reminiscence systems as a methodological problem. During our study we also discovered an unexpected dimension to *Mnemosyne*; the system's use by family members to feel connected to residents. Our findings, therefore, distinguish between designing for reminiscence and designing for connection, offering insights that will shape the development of future systems.

Future versions of *Mnemosyne* should consider automatic content personalisation based on factors such as individuals' vicinity to the system, time of day or residents' mood. If for example residents react positively to a certain piece of content when presented in the morning the system could automatically schedule that item. Our selection of *Yarely* as a signage player was in part motivated by its ability to support personalisation through systems such as Tacita [38]. However, automatic personalisation also necessitates the presence of a designated feedback element which in turn comes with its own set of challenges as it has to capture the impact of each individual content item on residents while factoring in elements such as time, mood, and whether the content is viewed alone by the resident or in the presence of care givers. Moreover, questions as to the design of such a feedback modality are non trivial and will require careful thought to guarantee maximum efficiency while keeping caregivers workload as low as possible.

Finally, we are exploring the design of a dementia friendly control unit that allows residents to interact with *Mnemosyne*'s content. This control unit will be designed to support different levels of dementia, building on insights gained by [1, 19, 52]. Moreover, going forward we hope to conduct a systematic evaluation of different content types and their impact on residents. While this has been done in the past for generic content presented in communal environments [46], the question remains as to whether those results would be mirrored for contend uploaded by family members.

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