

## Foregrounding everyday sounds in dementia

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# Foregrounding Everyday Sounds in Dementia

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## ABSTRACT

There has been an increased interest in researching the beneficial effects of everyday sounds, other than music on people with dementia. However, to turn this potential into concrete design applications, a qualitative understanding of how people engage with sound is needed. This paper presents the outcomes of three workshops, exploring the personal experiences evoked by soundscapes of people in early to mid-stages of dementia. Using the *dementia soundboard*, we provide key insights into how sounds from everyday life triggered personal associations, memories of the past, emotional responses, and the sharing of experiences. Furthermore, we identified several design considerations and practical insights for sound-based technologies in the context of dementia care. This paper sets out a path for further design-research explorations and development of concrete sound-based interventions, for enriching the everyday lives of people with dementia.

## Author Keywords

Dementia; design; everyday sounds; experience; soundscapes.

## CSS Concepts

• Human-centered computing → Empirical studies in HCI

## INTRODUCTION

Dementia is increasingly the subject of research in HCI, exploring how interaction design can contribute to the everyday lives of people with dementia. Currently, this research is shifting the focus from remediating deficits in cognitive and physical abilities, to addressing individuals' potential and experience of dementia [34,42,47]. In this context, there exists a large body of work exploring the role of music in providing meaningful activities, that enrich social and daily life in care facilities [5,6,23,26,48,52]. Music has been proven to be beneficial for people with dementia as it can relieve stress and boredom [52], stimulate reminiscence

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**Figure 1.** Placing the everyday object (e.g. seashell) on the *dementia soundboard* triggered the corresponding soundscape (e.g. beach). By touching the surrounding touchpads, each layer (e.g. beach\_children) could be activated or deactivated.

[5], encourage physical movement [45], facilitate social interactions [23] and act as a stimulus for exploring and maintaining identity [7]. Music is however only a small part of the broad spectrum of sounds we consciously or unconsciously perceive in our surroundings. Everyday sounds, other than music, support human beings in their everyday lives by facilitating communication, providing contextual information, building expectations, and cueing behaviors [8,21]. Over the years we develop strong and personal associations with our auditory surroundings [59], which are not only linked to time and space but also deeply embedded within our physical and social surroundings [54]. For these reasons, there is a growing interest in studying the role of everyday sounds in the lives of people with dementia [10,11,16,19,28,30].

While demonstrating the beneficial effects of everyday sounds on mood and behavior, (e.g. [11]), related research investigates the overall psychological and physiological symptoms. However, dementia affects cognitive and physical abilities in such a way that each person's experience is different [38], and so individual experiences need to be considered. The qualitative understandings of how people with dementia individually engage with sound are currently still under-researched. Therefore, by building on the successes of music therapy [6,52], we can identify new design considerations and increase the scope for meaningful sound-based interventions in the care context. For example, as people with dementia can relive past experiences by listening to music from their youth [5], everyday sounds from a person's home environment might evoke childhood

memories, create a sense of familiarity and comfort, and trigger social interactions [36].

Design artifacts are known to be a successful means for triggering personal opinions, thoughts and reflections for people with dementia [12,61]. So, to gain qualitative insight into the personal experiences evoked by everyday sounds, we employed a research-oriented design approach [22]. This paper presents the findings of an exploratory study consisting of three interactive workshops, where people in early to mid-stages of dementia listened and interacted with various soundscapes through a design artifact, namely the *dementia soundboard* (see Figure 1). In this study we found 1) key insights into the personal experiences of people with dementia when listening to everyday sounds, and 2) how social interactions play a role in these experiences. The study outcomes contribute to existing literature by providing innovative insights into how everyday sounds triggered personal associations, memories or a re-experiencing of the past, emotionally loaded responses and sharing of experiences. Furthermore, we offer considerations for the design and implementation of sound-based interventions in the context of dementia care, and practical insights based on our experience of designing sound for dementia. The research in this paper sets the stage for new design-research explorations and the development of sound-based technologies to enrich the everyday lives of people living with dementia.

## STATE-OF-THE-ART

### Everyday sounds and dementia

The impact of music on people with dementia has been extensively studied, however, the experiences of everyday sounds are surprisingly under-researched in the field of design. Over the years, the acoustics of care facilities have received little attention but have been shown to be a source of stress and agitation for residents [30]. This research originated from a similar concern about the influence of the auditory environment on people with cognitive disabilities in general [3,10]. Existing research, in the field of psychology, primarily focused on how everyday sounds impact mood by looking at changes of emotional states, e.g. [2,11], or can be used to remediate perceived behavioral disorders, e.g. [19]. Similarly, research has demonstrated that everyday sounds, when perceived as enjoyable or pleasant, can positively influence mood and behavior of people with cognitive disabilities in general [10,11,16,19]. For instance, everyday sounds used in therapy sessions can reduce agitation and provide relief from stress for people with dementia [16]. In addition, everyday sounds can be applied to create a sense of place and structure, providing a feeling of safety within a care environment [10].

Care practitioners suggest that, in order to leverage these positive effects, everyday sounds could be integrated into the daily activity pattern of the care facility [19]. But, care practitioners thought that involving people with dementia in the process was not feasible due to their limited cognitive

abilities [1,10,19]. While practitioners can provide insight into how everyday sounds can be integrated into the routines of the care staff, this still leaves a gap in knowledge on how people with dementia personally experience and engage with sound.

### Personal experiences of dementia

Understandings about people with dementia have shifted from seeing them as a homogeneous patient group to individuals, each with having different and unique personal experiences of dementia [38]. This view is fundamental to person-centered care (PCC) [15] which is currently regarded as the primary approach in dementia care [24]. PCC emphasizes the role of care practitioners in building personal relations with people with dementia in order to support their individual experience [39]. Parallels can be drawn with the field of HCI, and the role of technology in the lives of people with dementia. Initially, the research scope was limited to assistive technologies to overcome cognitive and physical disabilities as a result of dementia [9]. However current literature [34,42,47,48,61] focusses on the personal experiences of dementia and explores the role of design in this respect. This approach does not aim to replace assistive design but offers a new perspective [47]. The power of design is that it can engage with the personal experiences of people with dementia through designed artifacts that elicit reflections on personal relations, beliefs, values and thoughts [61]. In this context, there is an increasing interest in research, design and the evaluation of immersive multisensory technologies that address and enrich personal experience e.g. [34,46,53,60]. This related work has mainly focused on visual aspects but has emphasized the potential of sound. However, to implement this potential successfully into design artifacts or applications for dementia care, knowledge about the personal experiences of everyday sounds is needed. Therefore, the research presented in this paper aims to actively involve people with dementia in the design process.

### Involving people with dementia in design

Participatory design approaches have primarily relied on the cognitive abilities of participants, such as the communication of thought and ability to work with abstraction. But, these approaches are difficult for people with dementia to engage with [32]. Exploring inclusive approaches to actively engage people with dementia in participatory design has been a growing area of research, e.g. [12,31,33,55,56]. Participatory sessions that center around creativity and expression minimize the burden of participants by providing meaningful activity in a comfortable, enjoyable and social setting [37]. Furthermore, by establishing an informal and pleasurable atmosphere, designers can develop social connectedness and equal-power relations [24]. These relations enable facilitators of participatory sessions to observe and value reactions, responses, and actions that may seem insignificant in other circumstances, but have specific meaning and provide insights into the responses, personality and social background of participants [31].

### Embodied interaction using tools, props, and materials

Researchers have attended to creative activities in care facilities, that involved people with dementia actively engaging in creating art or making music, offering pleasure and enjoyable social interactions, and stimulating self-esteem [17]. Extensive field studies (e.g. [41]) of such activities have provided valuable insights for designers on how to empower people with dementia by providing tools that enable different ways of self-expression beyond verbal communication [43]. People with dementia can meaningfully interact and communicate non-verbally using their bodies through movement, making gestures, singing and laughing [42].

Similarly, everyday objects frequently serve as stimuli in reminiscence therapy sessions [62]. By introducing playful tangible objects, people with dementia can engage in forms of participation such as holding, feeling and smelling [57]. These multisensorial stimuli offer cues for remembering past experiences and triggering emotional responses that are strongly associated with those experiences [58]. Similarly, in music therapy sessions, props and physical objects play an important role in facilitating connectedness between participants by acts of giving, passing along and moving together [48]. Therefore, when working with sound in the context of dementia, other senses such as touch also need to be considered.

### METHOD

This study consisted of three workshops, to explore the personal experiences and social interactions of people with dementia when listening to everyday sounds. The workshops centered around a tangible design artifact, namely the *dementia soundboard* which provided meaningful activity by stimulating social engagement [37]. This setting aimed to actively engage participants in the discovery and exploration of everyday sounds and to encourage them in sharing their thoughts, feelings, and memories in a comfortable group setting. As each experience is different, social interactions such as sharing, comparing, listening and reacting to each other were strongly encouraged. Researchers did not only observe but also interacted with participants to perceive and value their verbal and physical expressions [31].

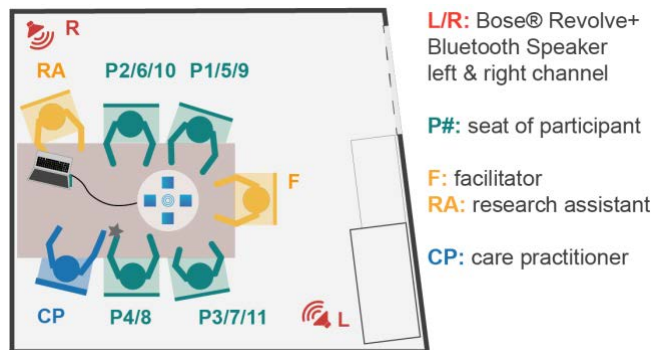


Figure 2. The participants were seated in reach of the soundboard, with 2 Bluetooth speakers (Bose Revolve+) positioned diagonally across the space.

### Setting and participants

In total, eleven people in early to mid-stages of dementia participated in the workshops (see Table 1). Each workshop involved a maximum of four participants, accompanied by a care practitioner from the care organization, who was familiar with the participants. The care practitioner recruited the participants and the following inclusion criteria were adhered to: 1) participant is diagnosed with dementia caused by Alzheimer's Disease (frontotemporal lobar degeneration and Lewy bodies were excluded from this study); 2) participant is in early to mid-stages of dementia, indicated by the care organization; 3) participant still lives at home and visits the care facility several days per week; 4) participant has no severe visual and auditory processing disorders; 5) participant has sufficient physical abilities to participate in the workshop; 6) participant is willing to participate in a group workshop.

PN	Session	Age	M/F	Dementia stage*
P1	1	77	male	early
P2	1	73	female	early
P3	1	66	female	early
P4	1	64	female	early
P5	2	69	female	early
P6	2	67	female	early
P7	2	86	female	early
P8	2	72	female	early
P9	3	81	male	moderate
P10	3	87	male	moderate
P11	3	87	male	moderate

Table 1. In total 11 participants in early to mid-stages of dementia participated in this study, divided over three workshops. (\*as indicated by the care organization)

The facilitator (F) maintained the flow of the different steps of the workshops and initiated the group discussions. A research assistant (RA) was present to assist with practical issues, such as handing props and adjusting the volume of the soundscapes. The RA also took observational fieldnotes during the workshops. The care practitioner (CP) supported the facilitator with the workshop flow and safeguarded the participants. The RA and the CP did not actively participate in the workshop but they did occasionally interact with the participants.

### Activity set at daycare facility

The workshops were conducted at a daycare facility in Eindhoven, the Netherlands. The participants visit the facility several days per week, but are still living at home with an informal caregiver (e.g. spouse). The daycare facility delivers a secure and safe environment for data collection, as the participants are familiar with the setting and in some cases know each other. The intimate group setting (see Figure 2) afforded an informal and friendly ambiance for reducing possible experiences of social pressure, embarrassment or awkwardness. Furthermore, this setting gave the opportunity for participants to remain passive if



desired, for instance by watching or listening to other participants. The space where the workshop took place was selected for its favorable acoustics, low ambient noise (e.g. air conditioning), and minimal sources of distraction for the participants.

**Workshop: procedure and props**

*Soundscapes of everyday sounds*

In each workshop, four soundscapes [49] were assessed, each representing a collection of sounds which can be perceived in a specific everyday environment. Two soundscapes depicted a natural setting, i.e. *beach* and *forest*, and the other two non-natural settings, namely *city*, and *home*. These settings were selected due to the likelihood of provoking meaningful reactions, assuming most participants would be familiar with these everyday sounds. Each soundscape was made up out of 4 separate sound layers, to give the participants ‘building blocks’ of everyday sounds to explore and interact with. The four layers are largely based on the notion of *soundscape ecology* [50], a theoretical approach for describing the entirety of sounds in a specific landscape. The three main components *anthrophony*, *biophony*, and *geophony* [51], were respectively translated into a *human*, *animal*, and a *water* and *background* layer (see Table 2). High-quality recordings for the layers were then carefully selected and retrieved from an online database [63]. The individual sound layers were mixed so that when activated together, it would produce a harmonious soundscape. Prior to the workshops, the overall perception of the soundscapes, regarding volume, mixing and quality of the used recordings was assessed by students, sound experts, and a group of twelve researchers with experience in working with people with dementia. Their comments were taken into account in the final mixing process of the soundscapes.

Soundscape/ Layer	<i>Beach</i>	<i>Forest</i>	<i>City</i>	<i>Home</i>
<b>Human</b>	<i>Children</i>	<i>Footsteps</i>	<i>Market</i>	<i>Kitchen</i>
<b>Animal</b>	<i>Gulls</i>	<i>Birds</i>	<i>Pigeons</i>	<i>Cat</i>
<b>Water</b>	<i>Waves</i>	<i>Creek</i>	<i>Fountain</i>	<i>Thunder</i>
<b>Background</b>	<i>Wind</i>	<i>Trees</i>	<i>Traffic</i>	<i>Fireplace</i>

**Table 2. Each soundscape was made up out of four layers of everyday sounds. In the text, the layers are referenced as *soundscape\_layer*, e.g. *beach\_gulls*.**

*Everyday objects*

In a pilot workshop, prior to this research, the authors worked with caregivers and stakeholders of people with dementia to explore the opportunities of everyday sounds. It became apparent that not everyone engaged with everyday ambient sounds and that some people had little interest in exploring or recalling sounds. This informed the research study as it suggested there was a risk of disengagement and incomprehensibility for people with dementia, who have difficulty with understanding abstract concepts. Therefore to make the abstract concept of everyday sounds more tangible, each soundscape was represented by an everyday object [25]

(see Figure 1). The main criterion for selecting the objects was the relatability to one of the sounds of the corresponding soundscape. Therefore *beach*, *forest*, *city*, and *home* were respectively represented by a *seashell*, *tree leaf*, *small bell*, and a *coffee mug*. A second criterion was the affordance for familiar handlings or actions, such as holding a seashell to your ear, rippling tree leaves, ringing the bell and drinking from a mug. A third criterion was the rigidity of the objects, in order to withstand rough handling or dropping. Therefore, we used a paper *tree leaf*, as a real leaf would easily degenerate or break.

*Dementia soundboard*

Each soundscape was triggered and explored through a design artifact, more specifically by the *dementia soundboard* (see Figure 1). The soundboard served as a physical means with which to support the workshop. The interaction design needed to be minimal and easy to understand. When placed upon the soundboard, the everyday objects (recognized by an RFID reader) automatically triggered the corresponding soundscape, with all four layers activated at once. The Arduino in the soundboard was connected to a Processing sketch running on a laptop, which played the soundscapes through two connected Bluetooth speakers (see Figure 2). Participants could then deactivate or reactivate each layer by tapping one of the four touchpads. Blue LEDs provided visual feedback on the state of each layer so that the presence of a sound could always be associated with an illuminated touchpad. The touchpads were intentionally not labeled to avoid distraction or influence of the participants’ interpretation of the everyday sounds. Lastly, the circular symmetrical design lends itself to be used in a group setting, as there are no hierarchical differences and the board can be easily moved around the table.

*Workshop procedure*

Before the start of the workshops, the facilitator and the research assistant introduced themselves to the participants, and engaged in informal small talk over a cup of coffee to establish a comfortable and safe setting. Following the introductions, the participants were extensively briefed about the aim and procedure of the workshop. Lastly, the participants were reminded of their rights to withdraw their participation at any point during the workshop.

The workshop itself was structured into three consecutively steps that are repeated for each soundscape: 1) *familiarizing*, 2) *listening* and 3) *exploring*. At each step, the facilitator observed the reactions of the participants and invited them accordingly to share opinions, likes or dislikes, stories or feelings evoked by everyday sounds. During *step 1: familiarizing*, one of the everyday objects was passed along to the participants. Such a relatively straightforward exercise served as an icebreaker, to offer a sense of comfort in the workshop setting and to reduce potential feelings of being socially awkward or embarrassed. The goal of *step 2: listening* was to listen to the soundscape with all four layers on. The facilitator would ask a participant, alternating for

each soundscape, to place the object onto the soundboard, resulting in the corresponding soundscape being played. After a first listen, the group discussion was initiated by the facilitator. The research assistant then lowered the volume, so the soundscapes could still be heard but did not disturb the discussion. Lastly, *step 3 exploring* aimed to explore the separate layers of the soundscape. The facilitator explained how the layers could be turned on or off with the touchpads. Each participant was then invited to explore the soundscape, by selecting the layers they preferred the most. At the end of each workshop, the participants were debriefed and asked about their overall experiences of the workshop. Afterwards, the care practitioner who attended the workshops provided feedback in a semi-structured exit interview with the facilitator.

### Ethics

This research was approved by the Ethics Review Board of Tilburg School of Social and Behavioral Sciences (EC-2018.70). All participants were able to give consent for participating themselves, and all informal caregivers (e.g. spouse) were informed about the study by the care practitioner. Participating in this study required only a small time investment of approximately an hour and a half. The workshops were organized to replace a regular activity at the daycare facility. Therefore, the activity was less obtrusive and did not cost extra time for both participants and care staff. During the workshops, the physical and mental burden was minimized by employing a participatory approach [37] that provided social engagement and meaningful activity. By establishing this informal ambiance, we also aimed to offset the perceived time burden of the participants. A familiar care practitioner of the daycare facility was always present to function as a gatekeeper. The gatekeeper decided continuously whether participating was still suitable for the involved participants. The informed consent was thus not considered as a one-time affirmation, but as a continuous dialogue between the researchers, the care practitioner and the participants [18,20].

### Data collection and qualitative analysis

The data gathered in this study consisted of: 1) participant information such as name, age, gender and stage of dementia; 2) audio recordings of the workshops; 3) video recordings of the workshops; 4) reflective fieldnotes of the facilitator; 5) observational fieldnotes of the research assistant; 6) audio recording of the exit interview with the care practitioner; 7) photographic documentation; and 8) digitally logged interactions of the soundboard.

The audio recordings of the three workshops and the exit interview with the care practitioner were transcribed verbatim by the researcher. The transcriptions of the workshops were combined with log files from the soundboard, in order to distinguish what sounds were played at the time. The video footage (see Figure 3) was muted and tagged with notes indicating bodily expressions in terms of intensity, such as yawning or being surprised, and frequency, such as

reoccurring gestures. All the data was then aggregated and analyzed in ATLAS.ti by thematic analysis using an inductive approach [13]. As all participants were Dutch, the quotes used in this paper were translated to English after the analysis.



**Figure 3. Screenshot of the video recordings, providing a clear overview of the setting to monitor bodily responses.**

## RESULTS

### Making personal associations

The initial responses of the participants to the everyday sounds were attempts to recognize and identify what they had heard. These responses varied considerably among the participants. For instance, when listening to *beach*, participants [P3, P5, P6-7, P11] instantly recognized *beach\_waves*, while others [P1-2, P4] heard mainly *beach\_gulls* and described the overall soundscape as: “*A big flock of birds passing by!*” [P2]. Three participants [P3, P6, P11] also clearly recognized *beach\_children* in combination with *beach\_waves* and remarked how this reminded them of “*A very busy beach, you can hear all those children...*” [P3] These different personal associations became a topic of discussion, with the participants expressing and comparing what they had heard.

### Association beyond recognition

Associations made with the everyday sounds were not fixed, as these were also influenced by interactions with other participants. For instance, *home\_cat* was for most participants [P1-2, P5-8] difficult to recognize at first. It received little to no attention, with participants perceiving it as unpleasant and resembling the “*snoring of a man*” [P6] or “*scraping of a [metal] wire*” [P7]. After one of the participants had recognized *home\_cat* [P3, P6], the others responded differently, such as laughing together when they suddenly heard a ‘meow’: “*Ha-ha, yes a cat, yes... purring... Then they have a good time, you can hear it!*” [P2]

Additionally, participants [P1-8, P10-11] mistook everyday sounds for other sounds. For instance, P1-2 did not notice the soundscape had changed from *beach* to *forest*, and associated *forest\_trees* with *beach\_waves*. However, it is important not to consider this a ‘wrong’ answer, as it still elicited meaningful associations and emotions. The facilitator did not correct P2, leaving her to continue telling her story about going to the beach: “*Yes at the beach... we’d go walking, and we brought a lot of stuff with us... to make [sand]castles.*”

P11 associated *forest footsteps* with “*walking through freshly fallen snow,*” which elicited memories of how the river in his local town “*was often frozen during the winter.*” Rather than identifying the correct sounds, building meaningful associations with everyday sounds was key in eliciting participant responses.

#### *Associations through personal experiences from the past*

Participants needed to be familiar with the sounds to build meaningful associations, as P1 expressed: “*I never had a cat, so I do not know the sound.*” Participants [P1-4, P6, P9-11] related the everyday sounds to their own experiences. P4 associated *beach* with a memorable moment she once experienced on holiday:

*“I immediately think of a situation I once experienced [...] A very large colony [...] more than two hundred thousand seabirds [...] and then you heard the waves knocking against rocks, I heard that here too, and that was indeed a cacophony of sound... that was very beautiful!”* [P4]

Through this association, P4 recognized *beach children* as birds, as she remarked: “*I have the idea you also listen from your own experience because those children on the beach were birds for me.*” The influence of past experiences in making associations was also illustrated by P9 who recognized *forest footsteps* as “*Some device... it's an overtone, and it indicates that I'm working with that device,*” or recognized *home thunder* as: “*Well if the car starts in the garage, you get this sound.*” P9 further explained that he had worked in a timber factory, where he used to operate heavy machinery that always produced a lot of noise. These examples offered insight into how participants during the workshop perceived and associated sounds through their personal experiences.

#### *Relating to everyday physical and social surroundings*

Participants [P3-7, P9] related sounds to their home environment, as P3 mentioned: “*I always sleep with the window open, and then I wake up with bird songs.*” Furthermore, P6 stated how *city traffic* did not bother her, as she lives in a place which is “*not very busy but [...] where occasionally cars come by. And then, as the youth [passes by], you hear 'boom boom boom!'*” Participants also mentioned loved-ones such as spouse [P6-7], children [P1, P3, P6] and family [P7, P9, P11]. For instance, P11 started to chuckle in himself upon hearing *beach children*. When he was asked why he started to laugh, P11 stated: “*It reminds me of someone who is teaching his mother-in-law... (bursts out into laughter) ... of someone who is teaching his mother-in-law how to swim [...] Ha-ha... a bit disrespectful... because she's just such a lovely woman!*”

These personal associations offered cues for the participants to relate to aspects of their everyday life which they considered valuable, such as their home or family.

#### **Reliving past experiences**

The soundscapes proved to be powerful in stimulating reminiscence [14,62] and experiences from the participants'

past. Participants shared rich descriptions of memories that were explicitly triggered by the soundscapes.

#### *Childhood memories*

The everyday sounds elicited numerous childhood memories from the participants [P1, P3, P5-7, P10]. For instance, *home fireplace* reminded P6 of: “*lighting a campfire... then you heard that too!*” This cued P6 to further elaborate on her childhood by telling stories of how she spent more time playing with boys than with girls, partially because she grew up in a household with three brothers: “*Yes I was always among the boys ... we made campfires, build huts ... we were always outside.*” For P10 who is in a mid-stage of dementia, *forest* triggered a specific memory from when he, as a child, was on his way to church and encountered a tree that was fully covered with birds:

*“Back in the days, when we were heading to church, we always walked by under a tree, and that were trees like those we just heard, and they always created these beautiful sounds [...], but they were with so many birds, and they always sat together in one tree, and the chaplain and the pastor were not so happy with that. The leaves came down very quickly, and so they actually destroyed the shape of the tree, I remember that, but otherwise nothing, but at least it was clear that the owner of the tree and... the birds, they were not happy about that...”* [P10]

P10 experienced a sense of empowerment and self-fulfillment in how he was still able to recall this encounter, which as a child had left a big impression on him: “*Nice [I am] still able... I can still remember that! ... Yes, I still remember it very clearly, as a child I already found it impressive that so many birds were sitting together...*”

By reliving childhood memories, the participants experienced a sense of enjoyment in the present as well. When listening to *beach wind*, P7 described a joyful moment she once experienced on the seaside boulevard:

*“Storm! ... That's nice to walk through ... I still have photos of this, my friend and I, we used to wear these lacquer raincoats, and we had them on, and then we were simply pushed forward by the wind in our backs. Yes, that was lovely! Those are nice memories, I've also been young you know!”* [P7]

#### *Meaningful experiences from the past*

Several participants [P4, P6-7, P10-11] described thoroughly memories of meaningful and unique moments they once experienced and had left an impression on them. For P11, *forest birds* stirred a memory with remarkable detail, of an encounter with an Austrian, who in his workplace had a large number of birds:

*“Yes, I am just thinking about something that I have ever experienced. It was in Austria, and there was a cobbler with a half-open workshop sitting there making shoes, and there were all these cages with finches in them, and if they... yes [when] they started singing, then that cobbler knew exactly*



which finch was [singing], because they have a so-called beat, end of a certain tone, and then it was so [...] This was about ten years ago.” [P11]

#### **Anecdotes about loved ones**

The soundscapes evoked memories that were strongly linked to relatives and loved ones [P3, P6-7, P10-11]. Whereas P4 did not recognize *beach\_children*, P3 immediately thought of an overcrowded beach on holiday: “When I went to the beach with the kids, I always had a balloon with helium attached to the back of their shorts ... [because if] you turned around, she would be gone... Yes, but then [with the balloon] I thought ‘ok she is over there!’”

Similarly, when listening to *home\_kitchen*, P7 started to share an amusing anecdote, through which she elaborated on her loving and playful relationship with her husband:

“Oh, I would say to my husband: ‘What are we having for dinner tonight?’ and he said: ‘I don’t know, you have to prepare the food!’ ‘No!’ I said: ‘There’s nothing in the house, you have to go out to do the shopping!’ He has to do the shopping himself, and then he can also decide what food he wants! Ha-ha! Our children were always laughing at us!” [P7]

This re-experiencing of emotionally loaded memories from the past provided the participants with a sense of enjoyment in the present. Sounds that evoked detailed memories in particular were overall experienced as “pleasant” [P4]. This was prompted by reliving the memories that were evoked by the sounds: “I do not think it’s a bad sound. Because I’m thinking about the trees again with the pastor” [P10]. The act of being able to recall memories in itself elicited a sense of achievement and self-acknowledgment. This was also mentioned during the exit-interviews by the participants who expressed how they enjoyed the workshop, as they felt pleasure in reminiscing, and “recalling nice memories” [P6].

#### **Engaging in emotional experiences**

The analysis identified how all participants engaged in emotionally loaded experiences, that were evoked explicitly by everyday sounds.

#### **Enjoyment and pleasure**

When listening to the everyday sounds, participants P1-8 and P10 each expressed a feeling of enjoyment and appreciated the aesthetic qualities of the everyday sounds at one point during the workshop. The vibrant *forest\_birds* evoked several [P2, P6-8, P10] joyful responses: “Birds! (Laughs), beautiful! Yes, that is nice yes.” [P8], or “He really wants to be heard! Marvelous, really!” [P7] Furthermore, P1 expressed his fondness of *home\_thunder*: “But I myself find thunder always enjoying to listen to, that is if you are sitting someplace dry of course!”

#### **Relief from stress**

During the workshops, the participants indicated how everyday sounds could create atmospheres that provide a sense of relief and tranquility. For example, *home\_fireplace* had a “meditative” effect on P3 that could make her

“completely calm”. As P7 leaned back in her chair and closed her eyes, she remarked: “Well nice, nice and quiet, you can easily turn away. You can sleep well with this. If I sit back with my eyes closed, I think oh... (laughs)... nice yes.” The soundscapes, with all four sound layers on, were in general experienced as too chaotic and participants [P1, P3-4, P6-7] stressed the importance of how sound should provide relief from disordered thoughts and worries: “And then I notice that I just get the quiet sounds out of it. Rest in here (points to head). That’s just clear to me.” [P4]

#### **Coming alive in a group setting**

Participants P2 and P8, who were less engaged and more introvert than others, suddenly displayed increased forms of active participation. When listening to the *forest\_birds*, P2 suddenly started glancing around and smiling, as she suddenly was fully immersed in the soundscape. While explaining, P2 was heavily mimicking the movement of the *forest\_birds*, to emphasize how she enjoyed the way the sound was scattered around the space: “I sometimes get a little bit of jitters, so I go up there, with all those birds [...] I just love it! How everything flies up there!”

Similarly, P8 was also more passively involved in the workshop, as it was difficult for her at times to verbally express herself. When the facilitator asked her a question, several times she turned to the care practitioner and murmured something indistinctly. After the group had recognized *home\_cat*, there was a brief moment of silence, which P8 suddenly interrupted upon hearing a short ‘meow’: “Oh ha-ha, there he is! Hehe!” (starts laughing out loud) While verbally expressing herself seemed difficult during the first half of the workshop, this sudden response was spontaneous and indicated that she recognized and enjoyed the sound.



**Figure 4. P7 (left) bursting out in laughter after acting silly.**

P7 was fully engaged during the whole workshop, sharing memories and anecdotes from her past, and providing the group with her own opinion and preferences. While exploring the soundboard, she triggered *forest\_creek*, and upon hearing the sound of water running, she looked surprised [RA] and begun to act silly by intentionally overreacting to the sound (see Figure 4). Afterwards she started laughing intensely together with the others [P5-6, P8, CP] and smiled at the facilitator [RA]. This was a moment



for her to not take the workshop too seriously, by enjoying herself and the group in an act of silliness.

These responses indicate how listening to everyday sounds in itself can be a joyful and pleasant experience, which affords opportunities for pleasure, relief, excitement, and silliness.

### Sharing of experiences

Upon hearing the soundscapes, the participants as an initial response engaged in a 'guessing game', in which they discussed and compared with each other what they thought they had heard, and searched for the acknowledgment of others. This resulted in an informal atmosphere, which allowed for teasing, making jokes and acting silly:

P2: "You can hear [purring of cats] when they are having a good time."

P1: (looks at P2) "Well, then you should start already!"

P2: "What did you say?! Oh, you!" (laughing back to P1)

This atmosphere provided a safe and comfortable setting in which the participants felt encouraged to share their own opinions, preferences, experiences, and memories with the group, as observed by F, RA, and CP. Participants also verbally responded to each other's stories [P6-7, P10-11], rather than only reacting to the soundscapes. In these cases, the everyday sounds served as a conversation starter and stimulated social connectedness, as participants were engaged in each other's stories and memories.



Figure 5. Playful objects, such as a seashell (left) and a small bell (right) introduced each soundscape to the participants.

In addition to verbal forms of expression, participants [P1-4, P6-8, P11] expressed their thoughts and emotions to each other through bodily responses, e.g. smiling, frowning or making gestures. While listening to each other, participants provided signs of acknowledgment and validation, such as nodding along. For participants who had difficulty in verbally expressing themselves, bodily responses became a way of participating in the conversation by smiling or laughing along with the group [P2, P5, P8]. Participants made gestures for expressing sounds, such as mimicking ringing a bell [P1-4] (see Figure 5), releasing pigeons [P7], or tapping fingers on the table [P2-3]. By doing this, the participants easily connected and engaged in an embodied way that was comprehensible to all.

### Use of props: dementia soundboard and objects

The everyday objects (see Figure 5) introduced the soundscapes and the general setting of the workshop in a way that was "approachable" [CP] and easy for the participants: "Yes, it's just a leaf of a tree... and I've seen a lot of it in my life. (Laughs)" [P10]. Participants made associations that were similar to the corresponding soundscapes, such as relating the *seashell* to a beach [P1-9, P11]. These associations were considered "a first chat" [CP], which established and explained the format of the group discussions.

In contrast to our expectations, attention to the objects completely disappeared when placed upon the soundboard: "I do not know whether people at some point also associated the sound with the object [...] that didn't matter anymore." For instance, after associating the *leaf* with "nature" and "trees", P1-2 still associated *forest* with *beach*. Moreover, during *step 2: listening* and *step 3: exploring* with the object placed on the soundboard, there was no mention of it at all.



Figure 6. The dementia soundboard was a tangible interface by which the participants could interact with the soundscapes.

### Tangible and comprehensible interactions with sound

There was a substantial difference in how each of the participants interacted with the soundboard. P3-4 were very keen on using the soundboard for discovering the hidden sounds and creating their own preferred soundscape: "That's my sound!" [P4]. For them, it felt like they were playing a game of exploring and guessing all the different sounds: "now you can play!" [P3], as shown in Figure 6. Other participants [P2, P5-10] were less spontaneous and needed to be asked by the facilitator whether they wanted to turn a layer of sound on or off. Nevertheless, they did seem to understand the concept of the touchpads with the LED feedback. Only for P9 and P10, the operating of the soundboard seemed unclear as they had confused the RFID reader for the objects as one of the touchpads. When interest in interacting fell, the facilitator or care practitioner interacted with the soundboard to adapt the soundscapes. Although interaction by the participants with the soundboard waned at times, it proved to be a tangible medium to adapt the everyday sounds in a way that was understandable. Participants could either explore the soundscapes themselves or witness someone else turn a sound on or off. Every interaction became a visible event that

refocused the attention of participants, as they expected a change in the soundscape that was played at the time.

#### *Thinking about outcome and potential applications*

The presence of a real design artifact triggered feedback about the research and potential outcomes of it. The participants considered the *dementia soundboard* as a finished product or application. They appreciated the modern and simple aesthetics of the soundboard and displayed interest in the technical working: “*How did you manage that?*” [P1]. During the exit interviews, participants [P1-4, P6, P11] spontaneously began discussing the potential of sound-based applications and the effects of music and sound in general: “*Yes, I am trying to understand what the system is that you are working with, and I think you will indeed have a nice and beautiful experience with it.*” [P11]

P3-4 stressed the importance of modifying the soundscapes to personal preferences, and even suggested the idea of creating a soundscape yourself: “*Because imagine that there are more levels in it [...] then you could assemble your own forest [soundscape]*” [P3]. The personal aspect of sound prompted a discussion concerning the social context in which potential sound-based applications could or should be set. P3-4 expressed their preference for listening unaccompanied with headphones in all “*peace and quietness*” while P1-2 considered that “*asocial*” and remarked that when in group settings, it is more enjoyable to listen together, as this creates a friendly and sociable ambiance. These examples illustrate the creative attitude and engagement of the participants towards the soundboard.

## **DISCUSSION**

The above findings contribute to existing research on sound and dementia by describing extensively how everyday sounds triggered personal associations, memories of the past, emotional responses, and sharing of participant experiences. We will further discuss the implications of these results for design research, and outline practical insights and considerations for the development of sound-based technologies for people living with dementia.

During the workshops, generic everyday sounds evoked numerous personal and emotional participant responses. The participants recognized everyday sounds through their own lived experiences, by associating sound to their personal background, past experiences, social network, and everyday physical surroundings. This aligns with research which investigated differences between generic and personal photographs and demonstrated how personal content could be confronting if, for example, family members are not recognized [27]. Generic content, on the other hand, is more likely to prompt longer stories, as the focus shifts away from giving the ‘correct’ answer such as naming people, places, and events, to reliving the memory itself [4]. Similarly, the workshops outcomes indicated how meaningful associations were of high value in evoking responses, whether or not the association was ‘correct’. Everyday sounds offer universal cues for making personal unjudged associations and reliving

past experiences, that are not explicitly bound to the details of a specific time or place.

Our results demonstrated how everyday sounds stimulated reminiscence [62], by evoking memories that were strongly linked to specific sounds people had experienced in the past. These findings contribute to the large body of work demonstrating the beneficial effects of reminiscence therapy for people with dementia [4,14,27,40,44,62]. Facilitators of these activities employ different types of media, such as music, images or video to prompt memories [44]. The results of this study indicate that everyday sounds can do the same. Furthermore, the immersive character of sound adds value to the experience, by letting participants relive their memories and express emotions in the present [57].

By doing so in a group setting, the sharing of personal stories and memories in itself becomes a collective in-the-moment experience [14]. The exploration of adaptable soundscapes of everyday sounds enabled pleasurable social interactions and opportunities for expressing emotions and receiving acknowledgment of others. Everyday sounds functioned as a conversation starter and stimulated social connectedness, as participants engaged further in meaningful interactions with each other. The emotional experiences evoked by sound are thus not only individual but also situated in social activities and contexts [42].

## **Design considerations for sound-based interventions**

### *Personal experience*

Generalized statements about how people with dementia experience sound should be carefully considered. For instance, research suggests that mechanical sounds result in feeling unsafe and experiencing discomfort [3]. During the workshops however, one participant made several associations with mechanical sounds from a factory. This evoked strong personal responses, as he had spent a long time working in a timber factory and still had many meaningful memories from this significant period of his life. This example stresses the need for addressing personal experiences and engaging individually, rather than looking for overall group responses in terms of changes in behavior and mood.

This individual approach is fundamental to person-centered care [15], which is built upon the notions of personhood and supportive social relations [24]. Therefore we can link the experience of sound to current research in HCI, exploring ways how design can provide insight into personhood of people with dementia [28,42,61]. In this study, everyday sounds elicited deeply held memories, values, beliefs and facilitated meaningful and enjoyable social interactions with other residents and care practitioners. Conversating about associations made with personal life offered opportunities for exploring and recognizing identity [61]. Therefore, everyday sounds can be used as a powerful tool for developing creative approaches that encourage the recognition of identity, and stimulate social connection in future design proposals and research projects.

### *Adaptable to social contexts*

The responses evoked from the participants were strongly influenced by the social interactions and contexts in which they were observed. Therefore, consideration is needed for the different social contexts in which sound-based design proposals are applied. During the first workshop, two participants remarked that they would like to listen to everyday sounds on their own, while the other two participants argued that would be asocial. Therefore, the ability to dynamically adapt sound to different social contexts must be further explored. This again accounts for individual responses and preferences, and reinforces the importance of not treating people with dementia as a homogenous group.

### *Meaningful activity in care environment*

The workshops were organized as one of the activities at a dementia daycare facility. This provided direct insight into how sound-based interventions can be integrated in this context. The attending care practitioner remarked that this activity could fit within the current program of the daycare facility. The activity in itself does continuously facilitate conversations between participants and the care practitioner. The use of generic everyday sounds to evoke strong personal responses offers a meaningful activity [37] through which caregivers can build supportive relations with their clients [39]. As everyday sounds offer cues for triggering unexpected stories and topics, this also releases part of the burden of the care practitioner in preparing and facilitating time and cost consuming activities [40].

The interaction design of the *dementia soundboard*, using tangible objects and touchpads, enabled live selection of sound content. Aside from personal preferences, soundscapes could be instantly modified to the participant's current responses, mood, and behavior. Furthermore, the soundboard added a playful element, as some participants considered the activity as a game, or a pleasant voyage of discovery, which was different from the activities they usually participate in.

### **Practical insights for sound design for dementia**

Based on our experience of designing and evaluating everyday sounds with people living with dementia, we offer practical insights for sound-based applications.

### *Tranquility and moments of silence*

The soundscapes were in general perceived as overwhelming and chaotic. This was remarked upon by both the research assistant and the attending care practitioner. The participants stressed multiple times how they preferred calmness and tranquility. This was confirmed by the reactions to the individual layers of everyday sounds, which elicited more verbal and non-verbal responses compared to when all four layers were played at once. Furthermore, it was essential to allow for silence and to provide moments of relief and rest. The *familiarizing* step (where the object was passed along, and no sound is played) served as a 'palate cleanser' before the next soundscape was triggered. This offered moments of silence and rest for the participants during the workshops.

### *Quality of reproducing everyday sounds*

Participants had remarked that several sounds did not sound quite the same as those they had built associations with. This can be attributed to the artificial aspect of reproducing sounds electronically (e.g. 'uncanny valley of sound' [29]), as it can never sound as how the participants had experienced it in reality. Furthermore, to ensure all the participants heard the soundscapes clearly, the audio files were played at high volume. For sounds that in real life are rather quiet, such as *home\_cat*, this created an unrealistic distorted effect. This raises considerations for producing sound more authentically through mechanically actuating materials, rather than using electronic loudspeakers [35].

### **CONCLUSION**

In conclusion, this paper has provided new knowledge on the personal experiences evoked by everyday sounds for people in early to mid-stages of dementia. We have offered practical insights into sound design and have outlined design considerations for sound-based technologies in dementia care. We cannot overgeneralize sound associations, as each individual perceives this differently through their own experience. Furthermore, the emotional experiences evoked by sound have to be considered within social context and activity. As the scope of this research is limited to people in early to mid-stages of dementia, more research is necessary to gain an understanding of the relation between sound and people in a later stage of dementia. Potentially, the results of this study could also be applied to people with other cognitive impairments. In essence, we aim to raise awareness of the role of sound in the care context and to demonstrate how sound is a powerful tool for caregivers and designers.

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### **REFERENCES**

- [1] Francesco Aletta, Tara Vander Mynsbrugge, Dominique Van de Velde, Patricia De Vriendt, Pieter Thomas, Karlo Filipan, Dick Botteldooren, and Paul Devos. 2018. Awareness of 'sound' in nursing homes: A large-scale soundscape survey in Flanders (Belgium). *Build. Acoust.* 25, 1 (March 2018), 43–59. DOI:<https://doi.org/10.1177/1351010X17748113>
- [2] Tjeerd C. Andringa and Kirsten A. van den Bosch. 2013. Core affect and soundscape assessment: fore- and background soundscape design for quality of life. In *Proceedings of Internoise 2013 - 42nd International Congress on Noise Control Engineering: Noise Control for Quality of Life*, 2273–2282.
- [3] Tjeerd C. Andringa and J. Jolie L. Lanser. 2013. How pleasant sounds promote and annoying sounds impede health: A cognitive approach. *Int. J. Environ. Res. Public*

- Health* 10, 4 (April 2013), 1439–1461. DOI: <https://doi.org/10.3390/ijerph10041439>
- [4] Arlene J. Astell, Maggie P. Ellis, Norman Alm, Richard Dye, and Gary Gowans. 2010. Stimulating People with Dementia to Reminisce Using Personal and Generic Photographs. *Int. J. Comput. Heal.* 1, 2 (2010), 177–198. DOI: <https://doi.org/10.1504/IJCIH.2010.037461>
- [5] Ameer Baird and Séverine Samson. 2009. Memory for Music in Alzheimer’s Disease: Unforgettable? *Neuropsychol. Rev.* 19, 1 (May 2009), 85–101. DOI: <https://doi.org/10.1007/s11065-009-9085-2>
- [6] Ameer Baird and Séverine Samson. 2015. Music and dementia. In *Progress in Brain Research*, Eckart Altenmüller, Stanley Finger and François Boller (eds.). Elsevier, 207–235. DOI: <https://doi.org/10.1016/bs.pbr.2014.11.028>
- [7] Ameer Baird and William Forde Thompson. 2018. The Impact of Music on the Self in Dementia. *J. Alzheimers. Dis.* 61, 3 (May 2018), 827–841. DOI: <https://doi.org/10.3233/JAD-170737>
- [8] Saskia Bakker, Elise van den Hoven, and Berry Eggen. 2012. Knowing by ear: leveraging human attention abilities in interaction design. *J. Multimodal User Interfaces* 5, 3–4 (February 2012), 197–209. DOI: <https://doi.org/10.1007/s12193-011-0062-8>
- [9] Ashok J. Bharucha, Vivek Anand, Jodi Forlizzi, Mary Amanda Dew, Charles F. Reynolds, Scott Stevens, and Howard Wactlar. 2009. Intelligent Assistive Technology Applications to Dementia Care: Current Capabilities, Limitations, and Future Challenges. *Am. J. Geriatr. Psychiatry* 17, 2 (February 2009), 88–104. DOI: <https://doi.org/10.1097/JGP.0b013e318187d5e5>
- [10] Kirsten A. van den Bosch, Tjeerd C. Andringa, Deniz Başkent, and Carla Vlaskamp. 2016. The Role of Sound in Residential Facilities for People With Profound Intellectual and Multiple Disabilities. *J. Policy Pract. Intellect. Disabil.* 13, 1 (March 2016), 61–68. DOI: <https://doi.org/10.1111/jppi.12147>
- [11] Kirsten A. van den Bosch, Tjeerd C. Andringa, Wolter Peterson, Wied A. J. J. M. Ruijsenaars, and Carla Vlaskamp. 2017. A comparison of natural and non-natural soundscapes on people with severe or profound intellectual and multiple disabilities. *J. Intellect. Dev. Disabil.* 42, 3 (July 2017), 301–307. DOI: <https://doi.org/10.3109/13668250.2016.1250251>
- [12] Rita Maldonado Branco, Joana Quental, and Óscar Ribeiro. 2017. Personalised participation: an approach to involve people with dementia and their families in a participatory design project. *CoDesign* 13, 2 (2017), 127–143. DOI: <https://doi.org/10.1080/15710882.2017.1310903>
- [13] Virginia Braun and Victoria Clarke. 2006. Using thematic analysis in psychology. *Qual. Res. Psychol.* 3, 2 (January 2006), 77–101. DOI: <https://doi.org/10.1191/1478088706qp0630a>
- [14] D. Brooker and L. Duce. 2000. Wellbeing and activity in dementia: A comparison of group reminiscence therapy, structured goal-directed group activity and unstructured time. *Aging Ment. Health* 4, 4 (November 2000), 354–358. DOI: <https://doi.org/10.1080/713649967>
- [15] Dawn Brooker. 2003. What is person-centred care in dementia? *Rev. Clin. Gerontol.* 13, 03 (August 2003), 215–222. DOI: <https://doi.org/10.1017/S095925980400108X>
- [16] Caroline Bulsara, Karla Seaman, and Silke Steuxner. 2016. Using sound therapy to ease agitation amongst persons with dementia: a pilot study. *Aust. Nurs. Midwifery J.* 23, 7 (2016), 38–39.
- [17] Bree Chancellor, Angel Duncan, and Anjan Chatterjee. 2014. Art Therapy for Alzheimer’s Disease and Other Dementias. *J. Alzheimer’s Dis.* 39, 1 (January 2014), 1–11. DOI: <https://doi.org/10.3233/JAD-131295>
- [18] Tim Coughlan, Kerstin Leder Mackley, Michael Brown, Sarah Martindale, Stephan Schlögl, Becky Mallaband, John Arnott, Jettie Hoonhout, Dalila Szostak, Robin Brewer, Erika Poole, Antti Pirhonen, Val Mitchell, Sarah Pink, and Nicolas Hine. 2013. Current issues and future directions in methods for studying technology in the home. *PsychNology J.* 11, 2 (2013), 159–184.
- [19] Paul Devos, Francesco Aletta, Pieter Thomas, Karlo Filipan, Mirko Petrovic, Dick Botteldooren, Tara Vander Mynsbrugge, Dominique Van de Velde, and Patricia De Vriendt. 2018. Soundscape design for management of behavioral disorders : a pilot study among nursing home residents with dementia. In *Impact of noise control engineering : proceedings of Inter-Noise 2018*, 8.
- [20] Jan Dewing. 2007. Participatory research: A method for process consent with persons who have dementia. *Dementia* 6, 1 (February 2007), 11–25. DOI: <https://doi.org/10.1177/1471301207075625>
- [21] Berry Eggen. 2016. Interactive Soundscapes of the Future Everyday Life. In *Peripheral interaction: challenges and opportunities for HCI in the periphery of attention*. 239–251. DOI: [https://doi.org/10.1007/978-3-319-29523-7\\_11](https://doi.org/10.1007/978-3-319-29523-7_11)
- [22] Daniel Fallman. 2007. Why Research-Oriented Design Isn’t Design-Oriented Research: On the Tensions Between Design and Research in an Implicit Design Discipline. *Knowledge, Technol. Policy* 20, 3 (October 2007), 193–200. DOI: <https://doi.org/10.1007/s12130-007-9022-8>
- [23] Stu Favilla and Sonja Pedell. 2013. Touch Screen Ensemble Music: Collaborative Interaction for Older People with Dementia. In *Proceedings of the 25th Australian Computer-Human Interaction Conference on Augmentation, Application, Innovation, Collaboration -*



- OzCHI '13*, 481–484. DOI: <https://doi.org/10.1145/2541016.2541088>
- [24] Sam Fazio, Douglas Pace, Janice Flinner, and Beth Kallmyer. 2018. The Fundamentals of Person-Centered Care for Individuals With Dementia. *Gerontologist* 58, suppl\_1 (January 2018), S10–S19. DOI: <https://doi.org/10.1093/geront/gnx122>
- [25] Bill Gaver, Tony Dunne, and Elena Pacenti. 1999. Design: Cultural probes. *interactions* 6, 1 (January 1999), 21–29. DOI: <https://doi.org/10.1145/291224.291235>
- [26] Karen Gold. 2014. But does it do any good? Measuring the impact of music therapy on people with advanced dementia: (Innovative practice). *Dementia* 13, 2 (2014), 258–264. DOI: <https://doi.org/10.1177/1471301213494512>
- [27] Gary Gowans, Jim Campbell, Norm Alm, Richard Dye, Arlene Astell, and Maggie Ellis. 2004. Designing a multimedia conversation aid for reminiscence therapy in dementia care environments. In *Extended abstracts of the 2004 conference on Human factors and computing systems - CHI '04*, 825–836. DOI: <https://doi.org/10.1145/985921.985943>
- [28] Megan E. Graham. 2018. Re-socialising sound: investigating sound, selfhood and intersubjectivity among people living with dementia in long-term care. *Sound Stud.* (December 2018), 1–16. DOI: <https://doi.org/10.1080/20551940.2018.1551051>
- [29] Mark Grimshaw. 2009. The audio Uncanny Valley: Sound, fear and the horror game. In *Games Computing and Creative Technologies: Conference Papers (Peer-Reviewed). Paper 9.* (2009)., 21–26.
- [30] Michael James Hayne and Richard Fleming. 2014. Acoustic design guidelines for dementia care facilities. In *Proceedings of 43rd International Congress on Noise Control Engineering: Internoise 2014*, 1–10.
- [31] Niels Hendriks, Liesbeth Huybrechts, Karin Slegers, and Andrea Wilkinson. 2018. Valuing implicit decision-making in participatory design: A relational approach in design with people with dementia. *Design Studies* 59, 58–76. DOI: <https://doi.org/10.1016/j.destud.2018.06.001>
- [32] Niels Hendriks, Liesbeth Huybrechts, Andrea Wilkinson, and Karin Slegers. 2014. Challenges in doing participatory design with people with dementia. In *Proceedings of the 13th Participatory Design Conference on Short Papers, Industry Cases, Workshop Descriptions, Doctoral Consortium papers, and Keynote abstracts - PDC '14 - volume 2* (PDC '14), 33–36. DOI: <https://doi.org/10.1145/2662155.2662196>
- [33] Niels Hendriks, Karin Slegers, and Pieter Duysburgh. 2015. Codesign with people living with cognitive or sensory impairments: a case for method stories and uniqueness. *CoDesign* 11, 1 (January 2015), 70–82. DOI: <https://doi.org/10.1080/15710882.2015.1020316>
- [34] James Hodge, Madeline Balaam, Sandra Hastings, and Kellie Morrissey. 2018. Exploring the Design of Tailored Virtual Reality Experiences for People with Dementia. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems* (CHI '18), Paper 514, 1–13. DOI: <https://doi.org/10.1145/3173574.3174088>
- [35] Maarten Houben, Benjamin Deneff, Matthias Mattelaer, Sandy Claes, and Andrew Vande Moere. 2017. The Meaningful Integration of Interactive Media in Architecture. In *Proceedings of the 2017 ACM Conference Companion Publication on Designing Interactive Systems (DIS '17 Companion)*, 187–191. DOI: <https://doi.org/10.1145/3064857.3079143>
- [36] Emily S. Ihara, Catherine J. Tompkins, Megumi Inoue, and Sonya Sonneman. 2019. Results from a person-centered music intervention for individuals living with dementia. *Geriatr. Gerontol. Int.* 19, 1 (January 2019), 30–34. DOI: <https://doi.org/10.1111/ggi.13563>
- [37] Gail Kenning. 2018. Reciprocal design: inclusive design approaches for people with late stage dementia. *Des. Heal.* 2, 1 (January 2018), 142–162. DOI: <https://doi.org/10.1080/24735132.2018.1453638>
- [38] Tom Kitwood. 1997. The experience of dementia. *Aging Ment. Heal.* 1, 1 (1997), 13–22. DOI: <https://doi.org/10.1080/13607869757344>
- [39] Tom Kitwood. 1997. *Dementia reconsidered: The person comes first*. Open University Press, London.
- [40] Noriaki Kuwahara, Shinji Abe, Kiyoshi Yasuda, and Kazuhiro Kuwabara. 2006. Networked reminiscence therapy for individuals with dementia by using photo and video sharing. In *Proceedings of the 8th international ACM SIGACCESS conference on Computers and accessibility - Assets '06*, 125–132. DOI: <https://doi.org/10.1145/1168987.1169010>
- [41] Amanda Lazar, Raymundo Cornejo, Caroline Edasis, and Anne Marie Piper. 2016. Designing for the Third Hand. In *Proceedings of the 2016 ACM Conference on Designing Interactive Systems - DIS '16*, 1047–1058. DOI: <https://doi.org/10.1145/2901790.2901854>
- [42] Amanda Lazar, Caroline Edasis, and Anne Marie Piper. 2017. A Critical Lens on Dementia and Design in HCI. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems* (CHI '17), 2175–2188. DOI: <https://doi.org/10.1145/3025453.3025522>
- [43] Amanda Lazar, Jessica L. Feuston, Caroline Edasis, and Anne Marie Piper. 2018. Making as Expression: Informing Design with People with Complex Communication Needs through Art Therapy. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems - CHI '18*, Paper 351, 1–16. DOI: <https://doi.org/10.1145/3173574.3173925>
- [44] Amanda Lazar, Hilaire Thompson, and George Demiris. 2014. A systematic review of the use of technology for

- reminiscence therapy. *Health Educ. Behav.* 41, 1 Suppl (October 2014), 51S–61S. DOI: <https://doi.org/10.1177/1090198114537067>
- [45] Micheline Lesaffre, Bart Moens, and Frank Desmet. 2017. Monitoring music and movement interaction in people with dementia. In *The Routledge Companion to embodied music interaction*. Routledge, 294–303.
- [46] Tom Luyten, Susy Braun, Gaston Jamin, Susan van Hooren, and Luc de Witte. 2017. How nursing home residents with dementia respond to the interactive art installation ‘VENSTER’: a pilot study. *Disabil. Rehabil. Assist. Technol.* (August 2017), 1–8. DOI: <https://doi.org/10.1080/17483107.2017.1290701>
- [47] Kellie Morrissey, John McCarthy, and Nadia Pantidi. 2017. The Value of Experience-Centred Design Approaches in Dementia Research Contexts. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems (CHI '17)*, 1326–1338. DOI: <https://doi.org/10.1145/3025453.3025527>
- [48] Kellie Morrissey, Gavin Wood, David Green, Nadia Pantidi, and John McCarthy. 2016. “I’m a rambler, I’m a gambler, I’m a long way from home.” In *Proceedings of the 2016 ACM Conference on Designing Interactive Systems - DIS '16*, 1008–1020. DOI: <https://doi.org/10.1145/2901790.2901798>
- [49] Raymond Murray Schafer. 1977. The soundscape: Our sonic environment and the tuning of the world. *Vancouver Destin. Books* (1977).
- [50] Bryan C. Pijanowski, Almo Farina, Stuart H. Gage, Sarah L Dumyahn, and Bernie L Krause. 2011. What is soundscape ecology? An introduction and overview of an emerging new science. *Landsc. Ecol.* 26, 9 (May 2011), 1213–1232. DOI: <https://doi.org/10.1007/s10980-011-9600-8>
- [51] Bryan C. Pijanowski, Luis J. Villanueva-Rivera, Sarah L. Dumyahn, Almo Farina, Bernie L. Krause, Brian M. Napoletano, Stuart H. Gage, and Nadia Pieretti. 2011. Soundscape Ecology: The Science of Sound in the Landscape. *Bioscience* 61, 3 (May 2011), 203–216. DOI: <https://doi.org/10.1525/bio.2011.61.3.6>
- [52] Alfredo Raglio, Stefania Filippi, Daniele Bellandi, and Marco Stramba-Badiale. 2014. Global music approach to persons with dementia: evidence and practice. *Clin. Interv. Aging* 9, (2014), 1669–1676. DOI: <https://doi.org/10.2147/CIA.S71388>
- [53] Kimberly Johanna Schelle, Carolina Gomez Naranjo, Martijn ten Bhömer, Oscar Tomico, and Stephan Wensveen. 2015. Tactile Dialogues: Personalization of Vibrotactile Behavior to Trigger Interpersonal Communication. In *Proceedings of the Ninth International Conference on Tangible, Embedded, and Embodied Interaction - TEI '14*, 637–642. DOI: <https://doi.org/10.1145/2677199.2687894>
- [54] Jennifer Schine. 2010. Movement, Memory & the Senses in Soundscape Studies. *Can. Acoust.* 38, 3 (May 2010), 100–101.
- [55] Sandra Suijkerbuijk, Rens Brankaert, Yvonne A.W. De Kort, Liselore J.A.E. Snaphaan, and Elke Den Ouden. 2015. Seeing the first-person perspective in dementia: A qualitative personal evaluation game to evaluate assistive technology for people affected by dementia in the home context. *Interacting with Computers* 27, 47–59. DOI: <https://doi.org/10.1093/iwc/iwu038>
- [56] Cathy Treadaway and Gail Kenning. 2016. Sensor e-textiles: person centered co-design for people with late stage dementia. *Work. with Older People* 20, 2 (June 2016), 76–85. DOI: <https://doi.org/10.1108/WWOP-09-2015-0022>
- [57] Cathy Treadaway, Gail Kenning, and Steve Coleman. 2014. Designing for positive emotions: Ludic artifacts to support wellbeing for people with dementia. In *Colours of care: 9th Design and emotion conference*.
- [58] Cathy Treadaway, Gail Kenning, David Prytherch, and Jac Fennell. 2016. LAUGH: Designing to enhance positive emotion for people living with dementia. In *Celebration and Contemplation (Proceedings of Design and Emotion International Conference 2016, 27-30 September)*, 37–44.
- [59] Barry Truax. 2001. *Acoustic communication*. Greenwood Publishing Group.
- [60] Carlijn Valk, Xu Lin, Loe Fijes, Matthias Rauterberg, and Jun Hu. 2017. Closer to Nature - Interactive Installation Design for Elderly with Dementia. In *Proceedings of the 3rd International Conference on Information and Communication Technologies for Ageing Well and e-Health*, 228–235. DOI: <https://doi.org/10.5220/0006378502280235>
- [61] Jayne Wallace, Peter C. Wright, John McCarthy, David Philip Green, James Thomas, and Patrick Olivier. 2013. A design-led inquiry into personhood in dementia. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems - CHI '13*, 2617–2626. DOI: <https://doi.org/10.1145/2470654.2481363>
- [62] Bob Woods, Laura O’Philbin, Emma M. Farrell, Aimee E. Spector, and Martin Orrell. 2018. Reminiscence therapy for dementia. *Cochrane Database Syst. Rev.* 3 (March 2018). DOI: <https://doi.org/10.1002/14651858.CD001120.pub3>
- [63] BBC Sound Effects - Research & Education Space. Retrieved January 9, 2019 from <http://bbcsfx.acropolis.org.uk/>