Maintaining Continuing Bonds in Bereavement: A Participatory Design Process of Be.side

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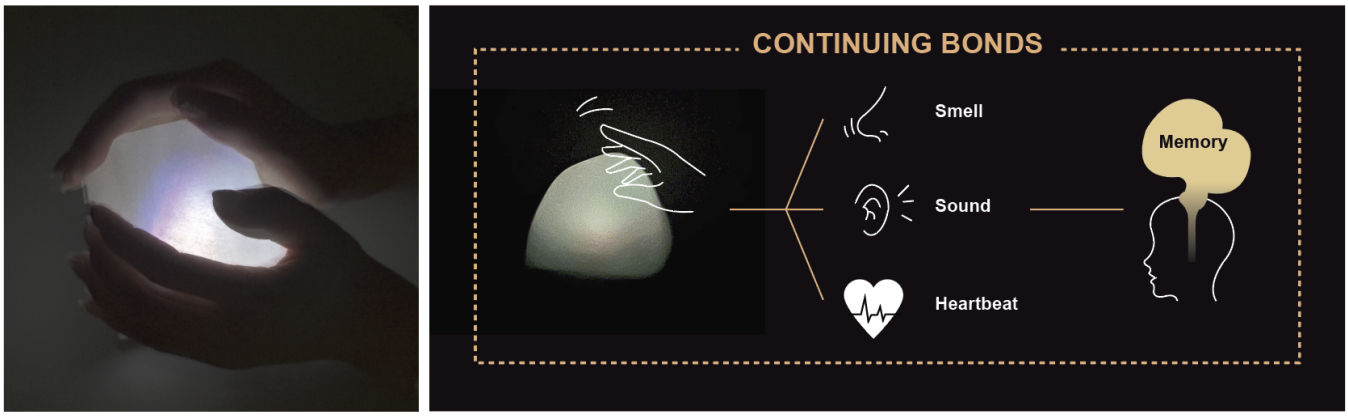

Figure 1: Be.side allows the bereaved to sustain bonds with their deceased loved ones by promoting remembrance through multi-modal stimuli.

ABSTRACT

During the grieving process, physical objects often serve as catalysts for remembering and honouring the relationship with departed loved ones. Leveraging a participatory design approach, we created Be.side, a fully customisable multi-modal artefact that incorporates scent, sound, and heartbeat stimulation and acts as a touch-point between the deceased and the bereaved. We conducted a four-week study with three participants to understand how the artefact, continuously attuned to each participant, helped to continue bonds with the deceased. Our results show that Be.side's bespoke elements helped participants to evoke memories of the deceased. Participants created personalised rituals for remembrance. They sustained bonds by not only interacting with Be.side but also participating in the research. Finally, highlighting that remembrance can both provide comfort and deepen sadness, we discuss future design considerations.

CCS CONCEPTS

• **Human-centred computing** → **Participatory design**.

KEYWORDS

continuing bonds, bereavement, participatory design, memory

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1 INTRODUCTION

Bereavement is a universal life event. However, each person's experience differs depending on individual characteristics and social

environment [70]. Psychology and psychiatry literatures define continuing bonds as *'ongoing inner-relationships'* between the deceased and bereaved [78], which are natural and adaptive mechanisms used to overcome loss and grief [18, 47]. Although the feeling of loss and the desire to preserve the memories of a deceased loved one are usually strong, one may intentionally avoid thinking of the deceased if they do not know how to manage their grief [45, 73, 79].

Continuing bonds take many forms depending on individual and societal beliefs. Some examples include creating and wearing jewellery with the hair of a deceased person [39], remembering their death anniversary, praying, or continuing one-sided conversations with a deceased individual [51]. To support the process of continuing bonds by cultivating memories to manage grief, we designed an artefact called Be.side (Fig. 1). This artefact acts as a touch-point between the deceased and bereaved. The name Be.side represents two concepts. Firstly, it refers to the commonly used preposition, beside, meaning next to someone or something. This indicates our goal to create an artefact that users can keep next to them. Secondly, it relates to the more abstract feeling of a deceased loved one's presence. This indicates our intention to craft a device that allows users to carry the memory of a lost one with them.

Be.side is a multi-modal translucent artefact designed for comfortable handheld use. It features three distinct elements: scent, sound, and heartbeat stimuli. Each element acts as a catalyst that supports a bereaved person in evoking memories of a deceased loved one. Users can customise the scent and sound according to their memories of the deceased. The heartbeat stimuli rate also depends on user preferences. Thus, Be.side is a bespoke artefact that our research participants could use in their houses to continue bonds over a prolonged period. We conducted a long-term four-week study with three participants from South Korea and Japan. We observed their interactions with Be.side and the artefact's effect on continuing bonds.

Our guiding design research questions were:

(1) How can we engage people undergoing bereavement in a prolonged participatory design process for a bespoke artefact?
(2) Can a personalised multi-modal artefact help the bereaved in continuing bonds with their deceased loved ones?
(3) How do participants interact with the different sensory aspects of the artefact over time?

In addressing our research questions, our study makes three significant contributions to human computer interaction (HCI) research. Firstly, we introduce an iterative participatory design approach that helps bereaved individuals design a remembrance artefact that fosters memory cultivation and a new relationship with the deceased. Secondly, we present Be.side, a fully bespoke artefact acting as a touch-point between bereaved individuals and their deceased loved ones, achieved through a combination of scent, sounds, and heartbeat stimulation. Finally, through a situated long-term study, we explore how the interactive artefact's different elements help evoke memories of the deceased and thus influence the emotions of bereaved individuals. Engaging with such a device over time, while developing unique rituals, contributes to continuing bonds and impacts the experience of grief.

2 BACKGROUND AND RELATED WORK

2.1 Continuing Bonds

According to Kübler's 'Five Stages of Grief', the journey of grief comprises the linear stages of denial, anger, bargaining, depression, and acceptance [48]. However, in practice, very few people experience a smooth and linear progression through these stages [53], and many remain trapped in cycles of grief and regret. Some even suffer from physical illness [80] or 'Complicated Grief Disorder (CGD)' [31]. Neimeyer et al. [62] noted that 506 young adults experienced complicated grief in the first two years of bereavement. This occurrence was higher when the reason of death was an unexpected accident, suicide, or early death [62]. Regardless of the reason, if one has difficulties in accepting the death of a loved one, their grief is generally more severe and lasts longer [20]. Further, after a loss, one can overcome distress and continue with their lives without the deceased person; however, moments of longing and grief are likely to reoccur even more than 10 years after the event [19, 47, 58]. Technology cannot, and arguably should not, attempt to 'solve' grief. However, technological artefacts and design processes can offer emotional support when facing death or coping with grief [1]. HCI research can provide support during the bereavement process by facilitating the continuity of bonds between the deceased and bereaved [33, 63].

Continuing a bond with a deceased loved one is a natural instinct and often represents a positive mechanism for remembrance and processing grief [46]. Depending on individual and cultural beliefs, individuals continue their bonds through a variety of practices including thinking of the deceased, praying, entertaining one-sided communication, commemorating the death anniversary, and preserving the deceased's room or possessions [50, 72].

However, continuing bonds with a deceased individual can also elicit feelings of loss, grief, and guilt, potentially causing additional distress [69]. This risk is particularly pronounced in situations where the pre-death relationship between the bereaved and deceased is problematic, which can lead to further negative feelings and deepening of trauma [18, 38]. As a result, early work on grief suggested that bereaved individuals would benefit from detaching themselves from their loss [79]. In contrast, contemporary studies take a more nuanced perspective that considers continuing bonds as a way to support meaning-making after the loss; moreover, although not universally viable, if adequately supported, continuing bonds can also help with conflict resolution and promote other benefits ranging from providing comfort to self-determination [38, 47]. Ultimately, continuing bonds is about not only remembering the deceased but also reframing the present. This can occur through a process that aids in finding meaning in loss [47] or reconsidering a new relationship with the deceased [78]. This study focuses on how design and technology can help to continue bonds between the deceased and bereaved to facilitate positive engagement with grief.

2.2 HCI and Bereavement

In 2009, Massimi & Charise [57] were amongst the first to urge the HCI community to consider how mortality, dying, and death should affect our research and practice. They coined the specific term *'thanatosensitivity'* to indicate HCI technologies and approaches

that actively integrate the idea of death in the way we design and study how humans interact with physical and digital devices. While some questions around *thanatosensitivity* pertain to digital legacies after death, specifically, who should be able to access them and how [21, 54, 59], others focus on establishing guidelines for research and designing with bereaved participants, including understanding the role, risks, and limitations of technology and adapting timelines and methods to suit individual needs [1, 56].

In 2011, Massimi & Baecker [56] noted that grief is not a problem to be solved but a process that we experience and radically changes our worldviews. Moreover, a bereaved person's relationship with their deceased loved one changes after their death but does not die. They also identified key processes to support bereaved participants in their grieving process and continuing their relationships with the deceased as 'meaning-making' and 'storytelling'. How can we create thoughtful designs with the participation of bereaved individuals and help them continue their bonds?

The systematic review published at CHI 2023 by Albers et al. [1] analysed 107 relevant papers on death and bereavement and identified three major contribution areas: *digital remains*, *remembrance*, and *coping*. For the bereaved, *digital remains* represent both an inheritance and a legacy which embodies not only their deceased loved one but also the relationship. On the other hand, *remembrance* encompasses not only looking back on the past to honour the deceased and the bond but also grieving for the loss. Finally, *coping* involves the practices of facing death and moving on, including social support, sense-making, and letting go.

Although HCI research has explored emerging technologies and design related to death, bereavement, and grief, few studies focus on sustaining bonds with the deceased from a design perspective [1]. For example, in 2010, Uriu & Okude [84] presented *ThanatoFenestra*, a small installation featuring a round case that detects the flame of a candle fire and displays photos of the deceased on a screen. This installation aimed to adapt and enhance traditional remembrance practices based on Buddhist altars by incorporating digital technologies, thereby offering the opportunity to create new rituals.

In 2015, Moncur et al. [60] designed *Storyshell*, a bespoke tangible and digital photo memorial intended for bereaved parents. It allowed them to curate photos of a deceased child and input stories in a delicate social context. By employing an iterative participatory design approach, the authors extensively collaborated with a bereaved mother. They captured her sense of loss, comprehended her context, and created a unique and bespoke design. The technology aimed to provide an avenue for sharing detailed memories of the deceased child with family and friends, thereby honouring and continuing their relationship.

Building on the previous concept [84], Uriu & Odom [81] developed *Fenestra* as a research product in 2016 specifically for domestic environments [64]. Their investigation involved three participants and centred on understanding how Fenestra could generate new memorialisation rituals within households.

In 2020, Wallace et al. [89] introduced *ReFind*, a handheld artefact enabling bereaved individuals to curate and create digital photos for continuing bonds with the deceased. It centred around the idea of 'ongoingness' and redefining the relationship. The research involved a 10-week auto-ethnographic design account by the first author, living with the product and observing its expectations and limitations.

Focusing on technical developments, several researchers have emphasised the potential of engaging with bodily aspects to evoke a sense of physical closeness that transcends death [4, 16, 37]. For example, Eriksson et al. [16] proposed *HeartBeats*, a haptic device that recreates a deceased person's heartbeat based on heart-rate data obtained from health applications. The device is put inside a pillow for activation. When a person hugs the pillow, they can listen to their loved one's heartbeat, which creates a private, intimate feeling. Most recently, Jørgensen et al. developed *Anekdota*, a handheld metadata detector that a bereaved person can use to explore a deceased person's location data. The authors also used research through design (RtD) to understand how these daily-life traces produced via technological interactions can be used in the context of design [42].

Beyond exploring and designing physical artefacts, several researchers have explored the use of emerging technologies in the context of bereavement, focusing on digital remains [26, 34], memorialisation [32], and coping [94]. For example, Anna et al. [94] focused on the potential of artificial intelligence (AI) to support coping. Through semi-structured interviews with 10 bereaved participants, they explored how ongoing connections with chatbots affect the grieving process. Participants reported how, depending on their individual needs and the characteristics of the technology, the chatbot could be used as a listener, as a representation of the deceased, and as emotional support. Despite their shortcomings, chatbots are considered to supplement connections with others and oneself [94]. On the other hand, Getty et al.'s study analysed the role of the popular SNS Facebook as a memorial and a place to sustain bonds [25]. Moreover, Häkkilä et al. developed an interactive gravestone that acts as a physical memorial which can display different contents, based on RFID [35].

Overall, existing studies privilege the visual communication channel to evoke a sense of connection and remembrance amongst bereaved individuals. To address the gap, in the following section, we look at how memory evocation involves more complex multi-sensory aspects that should be accounted for in the design of thanatosensitive artefacts.

2.3 Multi-sensory Aspects of Memory Evocation

Numerous HCI researchers have explored ways to facilitate memory evocation to support connections between individuals, using different sensory channels [12, 28, 66, 82]. Recently, Gibson et al. [28] investigated the use of a Memory Machine as a technological probe through which participants could exchange digital gifts in the form of autobiographic image collages and other visual media. Storytelling, legacy building, and preservation generated opportunities for reflection, nostalgia, and reminiscence for both gift-givers and receivers. In a similar study, Gibson et al. [29] expanded the concept of gift-giving rituals to evoke nostalgia by leveraging hybrid gifts which incorporate both physical and digital triggers. Chocolate was used as a traditional gift and accompanied by a QR code that receivers could scan to visualise uploaded nostalgic photos and text messages. The study participants included friends, partners, children, and parents who wanted to find new ways to share important

memories with each other [28, 29]. Although these studies did not specifically focus on bereaved individuals, they helped to understand how visual images and ordinary objects can be combined to support memory evocation and nostalgia.

The sense of smell is one of the most easily connected to our memories and the process of remembrance [8, 14, 83]. The famous *Proust phenomenon* notes that smells can spontaneously evoke highly vivid autobiographical memories. Further, olfactory memories are more strongly associated with emotional responses and nostalgic feelings [11]. In the novel *Involuntary Memory*, Proust vividly recalls childhood memories triggered by the smell of a tea-soaked pastry [17]. The 2016 study by Garcia-Hernandez [22] explored which object could evoke stronger memories amongst 50 parents who had lost their children. Parents could vividly recall specific memories when smelling their children's favourite foods or scents from places associated with them. More recently, Brianza et al. [8] examined the emotional effect on memories and body images through a probe package called *QuintEssence* containing three different scents: lemon, peppermint, and cinnamon. The study results showed that lemon and peppermint were associated with more concrete memories and with personal memory associations in the case of peppermint. On the other hand, cinnamon was associated with more blurred memories [8].

Moreover, numerous studies have shown how both positive and negative emotions could be elicited by leveraging sounds in different contexts [9]. In particular, music connected with the autobiographical memory of an event can be used to trigger nostalgia [44]. Twenty-nine percent of the 41 respondents who took part in the survey by Massimi & Baecker in 2011 [56] cited both musical and non-musical sounds as valuable when reminiscing about a deceased individual. Similarly, participants evaluating the *Memory Tree* developed by Jayarante in 2016 [41] highlighted how specific sounds could trigger more personalised memories compared to visual images. Furthermore, sounds were described as a more creative and subtle way to engage in reminiscing and evoking more familiar memories [13].

We commonly associate the sound and feeling of a heartbeat with love and emotional connection. Several researchers have worked on the potential of sharing it between individuals in a variety of contexts [52, 75, 90]. *Intimate Heartbeats* showed that the perception of heartbeat in an immersive virtual reality (VR) environment influenced social behaviours, creating a sense of connection with the other; however, this was only valid when people could link the heartbeat to a particular person [40]. Interestingly, although hearing someone's heartbeat can foster empathy and connection [91], previous research has also shown how people cannot necessarily discern between different heartbeats and attribute a heartbeat to a particular individual [2]. Hearing a heartbeat and connecting it to a specific person in our mind is sufficient to trigger a feeling of empathy with others around us. Hearing and feeling the amplified beating of a heart not only allow us to feel connected to others but also to ourselves, facilitating a self-reflective state [86]. Moreover, Xu et al. [93] showed that altering the frequency of a heartbeat stimulation further supports this; when participants received an artificially slowed-down haptic stimulation simulating their own heartbeats, they believed it to be accurate and were likely to feel less anxiety and distress.

3 METHODOLOGY

Our study was exploratory and required multiple iterations and a deep collaborative approach that involved participants to ensure that the artefact we created could support users in their personal experiences of bereavement. Therefore, we followed a RtD approach [24, 95, 96]. We structured our research through two phases: an initial design process followed by a situated long-term study. However, in line with previous work on the development of bespoke artefacts for bereavement [89], our design attunement process did not end at the beginning of our deployment study but continued throughout it.

From a methodological point of view, during the initial design phase, our RtD process focused on the conceptualisation and development of Be.side through testing and iterations. We defined the broader characteristics of the device including its size and shape, selected the sensory elements, and developed supporting materials to facilitate engagement with the device. During the long-term study, our RtD targeted identifying how participants' engagement with the different elements would change over time and uncovering needs for additional attunement.

Our goal was to understand how participants wanted to maintain a connection with their deceased loved ones, how a personalised artefact could act as a touch-point in the process of remembrance, how different sensory aspects would affect user experience while supporting reminiscing activities, and how leveraging the artefact to continue bonds would affect participants' grief process. This focus required a sustained participatory design approach [74] to ensure that not only the outcomes but also our actions were always aligned with user needs [36] and that the resulting designed artefact is contextually appropriate to users' personal experiences of bereavement and desire for connection [43, 55]. The authors of this paper have diverse expertise ranging from design and HCI to clinical practice. Our intersectional identities encompass multiple countries, including Japan and Korea where we conducted this research. As bereavement is a universal experience, we shared some common ground with our participants. However, bereavement and grief are also deeply personal and unique. Therefore, we remained mindful of the need to cultivate trust to ensure that participants could comfortably express themselves in their own ways. We adapted our methods to suit their individual needs rather than asking them to adhere to specific protocols or timelines.

Our research process comprised two phases as illustrated in Figure 2.

In phase 1, we conducted two exploratory rounds of semi-structured interviews and watched a series of documentaries to gain a better understanding of bereavement experiences (1.1) [87]. Based on the insights gained, we created an artefact to serve as a touch-point between the deceased and bereaved (1.2). Through a series of iterative design sessions, we developed and integrated multi-sensory elements that would be meaningful to each individual (1.3) [12]. To finalise the prototype, we carried out a two-week study to gather feedback on longer-term use (1.4) and to develop appropriate tools for data collection for our final study.

In Phase 2, the first author met each participant on multiple occasions to build rapport before the start of the research (2.1) and customise the elements of the artefact for each individual to help

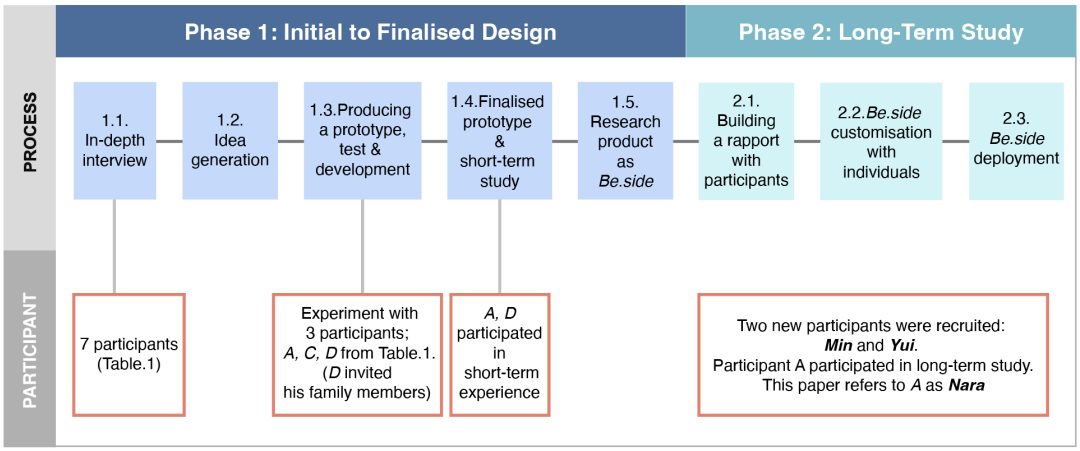


Figure 2: Research process.

foster a sense of connection with the deceased (2.2). Next, we deployed Be.side (2.3) and conducted a four-week study to understand how bereaved participants continued bonds with deceased loved ones and how our artefact affected their experiences.

Throughout the four-week period, the first author conducted weekly interviews to explore the participants' experiences and to ensure they were happy to continue. Be.side was continuously attuned according to their suggestions. Participants were not asked to return the artefact after the study.

A total of nine participants contributed to our research. Seven participants took part in the two initial rounds of interviews; and three amongst them supported the iterative development of the prototype in the subsequent stages of phase 1. Finally, we recruited three participants for the long-term study, *Min, Yui*, and *Nara. Nara* had taken part in phase 1.

During each phase, we collected data in the form of researcher notes, transcripts from audio recordings, and written notes and photos from participants. Our approach to data analysis across these multiple studies remained consistent throughout the research. We applied reflective thematic analysis using an inductive approach and a narrative focus that aimed to map the experiences of participants and their interactions with the prototype over time [5–7, 49].

The first author developed the initial codes for each participant. Once these codes were developed, we looked for commonalities and divergences that could be categorised and aggregated into broader themes. We decided to use a narrative style to present individual experiences, rather than aggregating them, to preserve the complexity of each experience and highlight the similarities and differences among them. This approach honours the relationship developed over prolonged engagement with participants, preserves the details of individual nuances, and acknowledges that claiming generalisation might be inappropriate considering our limited number of participants.

4 DESIGN PROCESS

4.1 Interview

To gain a deeper understanding of individual bereavement experiences including remembrance and mourning practices, we begun our research by carrying out two rounds of in-depth interviews with seven participants (Table 1).

4.1.1 Method. We limited recruitment to participants who identified as Korean and Japanese, as we had a greater degree of familiarity with these cultures. Moreover, since most research in bereavement focuses on Western culture, we wanted to explore East Asia's death and mourning rituals. All seven participants reported that they did not have strong religious beliefs or records of mental health conditions after bereavement. Interviews were organised in two subsequent rounds to build continuous relationships and minimise the emotional burden of each encounter [68]. In the first round, we focused on exploring the factors affecting the bereaved individuals' emotions, circumstances, triggers for remembrance and reminiscing, and views on analogy and digital mediated practices including symbolic objects and immersive experiences. The second round of interviews focused on the grief journey of each participant and their perception of continuing bonds. The first author audio recorded and transcribed the interviews and analysed the data using reflexive thematic analysis [6, 7]. Through an iterative process that integrated multiple rounds of discussions, all authors contributed to final theme conceptualisation. To understand the diverse situation of bereavement in Japan and Korea, we also analysed disaster documentaries [87] including ones that focus on the 2011 Tohoku earthquake [30] in Japan and the 2014 Sewol ferry incident [10] in Korea.

4.1.2 Results. The emotions and perspectives of bereaved participants varied depending on their circumstances and the length of time passed since the death of their loved ones. Participants who lost their loved ones more than 10 years ago reported a more stable emotional state. Regardless, they still experienced moments of longing. Although some were still grieving, they reported that they could not express their feelings in front of family members.

Table 1: In-depth Interview Participants' Information

Participant	Age	Nationality	Deceased individual	Reason	Age of death	Bereavement period
A	late 30s	Korean	Father	Chronic disease	50s	12 years
B	late 30s	Korean	Father	Heart attack	40s	21 years
C	early 60s	Korean	Mother	Chronic disease	80s	5 years
D	late 20s	Japanese	Grandfather	Chronic disease	70s	7 years
E	early 60s	Japanese	Father	Chronic disease	70s	20 years
F	early 40s	Japanese	Grandmother	Heart attack	90s	2 years
G	late 20s	Japanese	Grandfather	Accident	40s	40 years

The loved one's death anniversaries had become a formal occasion, which created less opportunities for genuine connection. None of the participants had positive views concerning the recreation of a deceased individual using immersive visualisation; however, all had positive opinions towards the use of symbolic objects. The Korean participants wanted to keep the deceased's possessions, even though these are traditionally burnt after death in Korea [76]. The Japanese participants wanted a new way of communication with the deceased rather than through a traditional Buddhist altar due to different religious beliefs.

In the second round of interviews, all participants stated that the most difficult period was immediately after the death of their relatives. They strongly clung to the deceased individual's belongings such as hugging their clothes, smelling their favourite fragrances, and looking for photos or letters. These objects acted as a catalyst for connection which helped them to feel close to the deceased. The length of such intense grief varied among the participants. Some reported six months, while others reported more than three years. During this time, their emotions such as anger, depression, and guilt were not consistent but cyclical. However, some explained how, after these periods, they tried not to recall the person they lost and purposefully avoided to talk about them. As participants' emotions dulled and memories blurred, they were more capable of accepting the loss yet feared the fading of their memories of the deceased.

4.2 Idea Generation

After conducting interviews, contextual research, and reviewing the bereavement literature, we analysed our data to form initial insights. We recognised that grief is a complex, non-linear process. Due to ethical considerations, we aimed to focus on participants who experienced bereavement without exacerbating sensitive circumstances such as unexpected accidents or suicides. Our goal was to design a personal yet bespoke artefact, understanding the unique nature of grief and memory for each individual. Additionally, although participants expressed a strong desire to preserve memories and continue their bonds through tangible objects, we avoided potential triggers, such as VR encounters that could cause uncanny valley effects [61]. These are inappropriate and counterproductive according to the literature [67, 77]. During this process, we drew on Massimi et al.'s study [56] that notes how creating a personal and meaningful artefact can support a new relationship between the deceased and bereaved [56]. Moreover, from the psychotherapy perspective, symbolic objects such as photos, perfumes, and audiotapes allow the bereaved to create a sense of intimacy with the deceased, which, in turn, helps them express themselves [92]. Therefore, we decided that a physical artefact that embodies multisensory experiences would be the most efficient touch-point for evoking memories of the deceased.

The first element we chose to integrate was a heartbeat. We were inspired by its multifaceted potential as a symbolic representation of life and connection between individuals, which could help users feel close to their loved ones and recall the memories of their shared lives [16, 65, 75, 85]. Moreover, previous research has shown the potential of heartbeat simulation to create a mindset of calm and reflection, which we believed could support the process of remembrance [93].

4.3 Prototype Testing and Development with Participants

The initial prototype consisted of a wooden box featuring the following elements: M5 stick C plus, SW2812B NeoPixel lighting, 639867 vibration actuator (Foster Electric Company), Mylar speaker, ESP32-WROOM-32E Bluetooth receiver (Espressif), and NS4168 Power Amp (Shenzhenshi Yongfukang Technology). Then, we created a translucent 3D-printed (Stratasys J55 3D printer) surface as a cover and light diffuser (Figure 3).

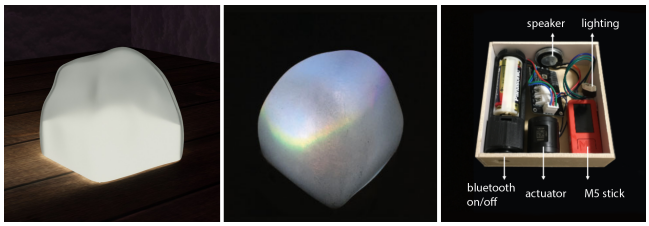


Figure 3: Prototype Development (Left: Render. Middle: Prototype with lighting, the surface for covering the base part, and subtle illumination. Right: Wooden-box base that holds operated elements.)

4.3.1 Method. The first author recorded her own heartbeat using a stethoscope. The initial prototype played the recorded heartbeat sound via the speaker, provided visual stimuli using pulsating light and haptic vibration through the actuator. This initial design was proposed as a probe to three participants *C*, *A*, and *D* from the previous interviews. Using the lean user experience method, we

performed two iterative tests to gather feedback. The new proposed elements in the form of sounds and scents were progressively integrated. The Korean Participant, *C*, only provided feedback on the prototype featuring the heartbeat stimulation. We added the olfactory component based on the Korean participant *A*'s suggestion, who described a specific scent associated with her deceased father during the interview. Then, we added the auditory component upon the request of the Japanese participant *D*, who involved his family in this phase.

4.3.2 Result. Participant *C* stated that the heartbeat sound triggered memories of the hospital and the final moments of her father's life. Therefore, we decided that focusing on the heartbeat could trigger negative memories associated with beeping hospital monitors. Upon participant *A*'s suggestion, our second iteration integrated an olfactory experience. In the previous interview, participant *A* had indicated that she could vividly evoke her father when she smelt the scent of a lotion called Aramis that her father used for about 10 years during her childhood. We applied the scented lotion on the prototype's surface. As the participant entered the room, she instantly noticed the scent and smiled. She expressed that combining the scent with the repeated heartbeat stimuli calmed and comforted her. During the session, she recalled a specific memory of her father humming the song 'Heal the World' by Micheal Jackson during a family trip to Europe when she was fifteen. After the session, she shared that our research felt like a journey of collecting scattered memories of her father.

After this second session, we integrated an auditory element to create a richer trigger, as suggested during the interview by Participant *D*. Participant *D* invited his family to join the session. Ahead of the in-person session, we asked for a representative scent and sound that they associated with the deceased, and they chose the smell of Japanese mint candy and Argentine tango. We integrated these into the artefact. The family reported that interacting with the prototype helped them to evoke the memory of the deceased. In particular, the wife of the deceased explained how a Buddhist altar is not focused on her deceased husband but more of a reminder to pray for the ancestors, including her husband. However, this artefact made her feel especially connected to him thanks to the specific music and scent, and the heartbeat stimuli created a calm and comforting atmosphere.

4.4 Final Prototype

4.4.1 Method. For our final iteration, we asked two participants, *A* and *D*, to keep and interact with the prototype for two weeks whenever they wanted. Our goal was to understand, ahead of the four-week study, the potential for longer term engagement with the artefact as well as its durability. Participants were asked to keep a diary for the two weeks. The first author held exit interviews with the participants.

4.4.2 Result. Initially, the prototype had issues related to the noise caused by internal components, confusion caused by multiple switches, and lack of clear instructions for interaction. We addressed these by redesigning the shape with a softer, touch-friendly Elastomer cover and adjusted the lighting for better immersion. We also increased the internal space to prevent component noise and integrated a single on/off switch. Moreover, we slowed down the heartbeat rate upon user feedback to enhance comfort. Finally, we provided an instruction manual and an optional question book to guide the process of connecting with the deceased loved one. The questions aimed to prompt users to start one-sided conversations, allowing them to recall memories and share recent happy moments or concerns with their loved ones (Figure 4).

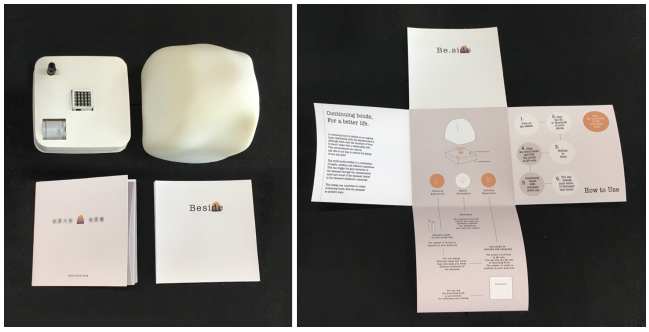


Figure 4: Final prototype with supplements for the long-term study.

5 DEPLOYMENT OF THE LONG-TERM STUDY

Our design process demonstrated the importance of directly involving participants in creating their bespoke version of Be.side. Thus, for our four-week study, we decided to focus on a smaller group of participants and work with them to identify representative scents and sounds, as we believed that the journey of designing individual elements could represent the starting point for creating continuing bonds as well as gaining more comprehensive results.

5.1 Participants and Procedure

To recruit participants for the long-term study, we distributed flyers among communities on death and bereavement and a Japanese community living in Korea. Word-of-mouth from past interviewees, between the start of February and the end of March 2023, was also helpful. To meet the recruitment criteria, potential participants were required to have experienced the loss of a significant loved one at least six months ago. After an initial meeting with volunteers, we identified three participants who met the inclusion criteria and wanted to actively engage in the long-term experience. Hereafter, we will use pseudonyms for the participants.

Min (P1) is a Korean man in his early 40s, who lost his grandfather 11 years ago. He had been closer to his grandfather than his own father, and the grandfather had greatly influenced his life. He sometimes recalled his grandfather and missed him. However, he had only one picture to remember him by. He regretted that he never got the chance to take a video or record his voice. He hoped to evoke memories of his grandfather in new ways by participating in this research.

Yui (P2) is a Japanese woman in her early 30s, whose father passed away a year ago. Remembering her father still caused her sadness. Although she often tried not to think of him, she could not help it, because she still missed him. She did not know how

to navigate her emotions and thought that participating in the research could help her develop a new relationship with him.

Nara (P3) is a Korean woman in her late 30s, whose father passed away 12 years ago. She had taken part in the previous research stages (participant *A*) and was interested in being involved in a longer-term study with the Be.side artefact.

The procedure of the long-term study was as follows:

(1) We provided a preliminary questionnaire to participants to gather information about their relationship with the deceased individual.
(2) The authors conducted several semi-structured interviews with the participants to explore the preliminary questionnaire responses and build rapport.
(3) Based on the interview insights, we discussed and adjusted the scent, sound, heartbeat rate, and brightness associated with the deceased individual for each participant's Be.side.
(4) We delivered Be.side to the participants including the instruction manual and question book.
(5) Over a four-week period, we requested the participants to live and engage with the artefact at their discretion by simply activating its switch that triggers the multi-sensory elements. Participants could also utilise the question book to aid in remembrance if desired.
(6) We conducted weekly semi-structured interviews with all participants throughout the study.
(7) Upon completion of the four-week study, participants were free to keep their Be.side.

5.2 Ethical Considerations and Rigorousness

Our study prioritised building rapport between researchers and participants to ensure an environment where individuals felt comfortable expressing themselves and raising concerns. To ensure safety and prevent negative experiences, three experts reviewed the final prototype: two psychiatrists from Korea and Japan, and a psychology professor. They confirmed Be.side's non-invasiveness and its potential to help recall memories without triggering negative emotions. Additionally, we regularly checked participants' emotional responses during interviews, offering them the option to withdraw if uncomfortable. Ethics committees approved the research, and participants provided informed consent, understanding that their personal details would remain confidential while interview recordings would be used for transcription and analysis.

5.3 Prototype Customisation via Participatory Design

Throughout several trials and conversations, we worked with the participants to finalise the scent, sound, and speed of the heartbeat for their bespoke version of Be.side. We provide the details and motivation for each below.

Min's grandfather ran a pharmacy near his house. According to *Min*'s memory, his grandfather always kept the television on in the background on the NHK news channel. He remembered that, as a child, when he opened the door to his grandfather's room, he could smell the scent of a typical Korean medicine from the pharmacy and hear Japanese words that he could not understand. Therefore, we decided to use the sound of the news channel and found broadcasts from 1985 when he was a child. For smell, we conducted several experiments. First, the first author prepared an ethanol and iodine mixture; however, *Min* said it did not match his memories. Later, we identified that the smell was associated to a medicine called Jung-ro-hwan, a typical Korean medicine with a unique smoky smell due to the presence of wood-tar creosote (a substance created by the distillation of wood tar). We placed some tablets inside the device to release the scent. The heartbeat rate was adjusted to 42 beats per minute, which he described as serene and comfortable. The blinking of light was also adjusted to match the heartbeat rate. As *Min* had poor eyesight and his eyes were easily tired by bright lights, we adjusted the colour and brightness of his Be.side and limited the duration of the experience to a maximum of five minutes. He also shared his family's photos which we included in the question book to support reminiscing activities.

Yui's Be.side could reproduce the tune of the baseball team Yomiuri Giants and smelled of barley tea. Her father loved baseball and was a fan of the Yomiuri Giants. She recalled that he always watched baseball games on television. Moreover, he loved Japanese alcohol and had the peculiar habit of drinking it mixed with barley tea. While he enjoyed a drink watching the baseball game, her mother used to cook some snacks, and afterwards, the family would go out together for an evening stroll. Embedding the cheerful Yomiuri Giants tune was a straightforward task; however, replicating the scent of barley tea proved to be challenging. Initially, the first author tried to replicate the scent with a perfumer; however, the participant considered it to be artificial. Finally, we placed a barley tea bag inside the prototype. Moreover, we soaked the surface in brewed water of barley tea overnight, letting the smell of barley tea permeate it. The heartbeat rate was adjusted to 48 beats per minute with which the participant felt comfortable. We also reduced the vibration intensity due to the overlapping of the cheering sound of the baseball team's jingle. Finally, we adjusted the colour and brightness of the light to match that of sunset and set the length of the experience to five minutes.

Nara chose the same sound and scent from the previous study phase: the perfume Aramis and the song 'Heal the World' by Michael Jackson. We set the heartbeat rate to 45 beats per minute, which felt comfortable to her, and the light matched the same rate. The colour and brightness of the light were the same as the ones described for *Yui*.

After completing these adjustments, we delivered a bespoke artefact and the supplementary materials to each individual (Figure 5).

5.4 Data Collection and Analysis

We conducted weekly, in-person, semi-structured interviews with participants at their houses, places of work, or online depending on preference and availability. Each interview lasted between 40 and 60 minutes. Participants answered in writing the preliminary questionnaire about their general details and relationship with the deceased individual with whom they wanted to connect using Be.side. First author Jieun Kim, who is a native Korean speaker,

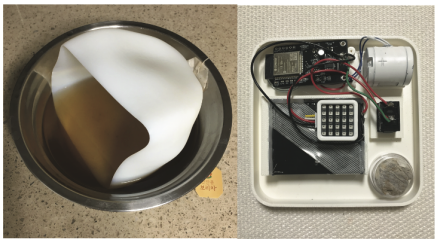
	Min (P1)	Yui (P2)	Nara (P3)
Scent	Cheongrohwan which is a strong-smell of Korean medicine.	Smell of barley tea.	"Aramis" perfume.
Sound	NHK News which broadcasted in 1985 when he was a child.	Cheering song of Yomiuri Giant's baseball game.	Song of "Heal the world" from Michael Jackson.
Speed of Heartbeat	42 beats per a min which makes him serenity and comfortable.	48 beats per a min, weaker intensity due to overlapping the cheering song.	45 beats per a min.
Process of Making a Bespoke			

Figure 5: Individuals' bespoke artefacts.

orally conducted the interviews. Although *Yui* could fluently speak in Korean, her native language was Japanese. While the interviews were conducted in Korean, we asked her to respond to the initial questionnaire in Japanese and supplement interviews with written notes in Japanese when she wanted to express her feelings in a more complete manner. We chose this approach to support participants to articulate their experiences in the most comfortable and appropriate way [15]. We audio recorded the interviews, and the first author took notes as appropriate. Then, the first author manually transcribed the recordings in Korean, translated them into English, and shared them with the other authors. We followed an inductive thematic narrative analysis approach [5, 7, 49]. Author Jieun Kim conducted and discussed the initial coding with author Giulia Barbareschi. As codes were progressively defined, the authors held discussions to formulate the final themes.

5.5 Results

5.5.1 Different Experiences of Grief. The meeting and interview results revealed that participants' personal stories and grief influenced their desire to feel connected to the deceased person.

Min had a strong bond with his grandfather who had been a role model for him. His family lived with his grandparents in the Korean countryside. He had rich childhood memories immersed in nature rather than an urban environment. As a child, he played outside and went on mountain hikes with his grandfather. *Min* admired his grandfather's participation as a pharmacist in the Korean War and his studies in Sweden after the war. His grandfather had inspired *Min* to study overseas. When he was studying abroad in Europe, his grandfather passed away. He regretted that he could not be with his grandfather in his last moments. *Min*'s father had told him that the grandfather was developing dementia. When *Min*'s father asked the grandfather if he would move to a nursing home, as they could not look after him anymore, the grandfather refused to respond. He passed away a month after that conversation. *Min*'s father regretted this conversation and often stated *'He left fast, because I told him about the nursing home'*. While *Min* shared this story with us, he was overwhelmed by sadness. His family holds a traditional memorial service for the deceased grandfather on his death anniversary. Yet, for *Min*, this feels like just a formal ritual, and he wanted a more intimate bonding experience with his grandfather.

Yui was more recently bereaved, and her grief was more prominent, even though she accepted the reality of her father's death. During our initial meeting, she shared some personal stories. When she graduated from university in Japan, her parents were divorced. Yet, she was already grown up and felt no resentment for the divorce and thus wanted to remain close to both parents. Although she could not see her father often, they had a good close relationship. As her husband is Korean, they had planned to move from Japan to Korea. Her father was sick at the time. After the move, she received a call one day and learned that his condition had deteriorated. She quickly travelled back to Japan to see her father who passed away a few days later. *'My father did not want me to live in another country, he worried about me. I think he was waiting for me before he passed away' – Yui (P2)* Although her parents were divorced, her mother experienced strong grief following the loss, and *Yui* worried about her. Overall, *Yui* felt guilty for not being able to nurse her father and spend much time with him, as she was living in Korea at the time. Her desire to sustain their bond in a positive way drove her to participate in our research.

Nara was closer with her father than her mother. Her father passed away when she was in her early 20s, while she was studying in Japan. Her mother did not tell her that her father was sick, because she was concerned that this would upset her while she was overseas. When she heard about her father's imminent death, she was shocked. However, over time, she was able to process it. *'My father's death was a long time ago, I suffered when he died, but I am fine now. I feel sorry for his death more than missing his presence. I could understand him better when I became older in my 30s. His life*

was quite short, he only focused on his responsibility as a father and a husband for our family' – Nara (P3) When asked if she used anything to help her evoke the memory of her father, she mentioned that her family did not keep any of his belongings at home since he passed away. All were burnt except some photos and letters; however, she did not look at them much and wanted a more consistent and subtle way to remember him.

5.5.2 Continuing Bonds Over Time. All participants reported using Be.side in the evenings before going to bed. *Min* had a ritual of praying to the Holy Mary before going to bed. Since starting the study, he began to keep Be.side next to the image of the Holy Mary on his bedside table (Figure 6), using it to feel connected to his grandfather before praying. *Yui* also kept Be.side on her bedside table and used it while sitting in bed. In the initial meeting, she explained how she often struggled to sleep well due to thoughts of her father. She noted how she frequently evoked memories of him before going to bed and found it natural to use Be.side to more actively explore those memories. This motivated her to keep the artefact beside her bed. Additionally, she mentioned that she found the shape and size of Be.side aesthetically pleasing and was not concerned about other people seeing it there. *Nara* kept Be.side on a bookshelf in her room and used it while sitting at her desk before going to bed. She put the letter from her father inside, underneath the *Elastomer* cover.

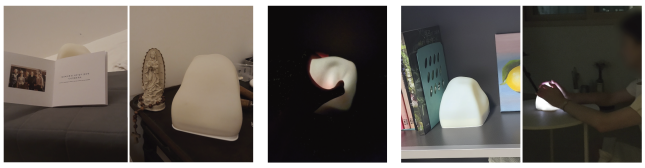


Figure 6: Photos of places where participants kept Be.side. Left: Min kept it next to the Holy Mary, used Be.side first and prayed. Middle: Yui kept it on the bedside table and used it in bed. Right: Nara kept it on a bookshelf in her room and used it while sitting at her desk.

Participants found that living and interacting with Be.side every day had a gradual effect on their thoughts and emotions which evolved over time.

Min's first impression was one of a *'surprising and new experience'*. He noted that he closed his eyes when activating the artefact and that the combined smell of medicine and the NHK news channel sound were strongly reminiscent of his grandfather's room. The heartbeat stimuli made him recall the memory of laying his head on his grandfather's stomach when he was a child. In the second interview, *Min* used the question book as a guide to express his feelings and memories. He did not feel the need to use the book in the first week, because he could focus on the artefact alone and naturally reminisce about his grandfather. However, after using Be.side several times, he got used to its multi-sensory stimuli and decided to open the question book. Some questions there led him to want to talk to his grandfather. At first, he felt quite awkward to the idea of speaking to an artefact; however, he tried to concentrate on the atmosphere and simply talk to his grandfather. *'When I answered the question "if there is something you have not been able to say yet, please tell your deceased grandfather", I felt sad. I accomplished many things after grandfather passed away. If he were alive, he would definitely be proud of me. So, I said that'–Min (P1)*

Regularly interacting with Be.side made it easier for him to keep his grandfather's memory alive in his mind. Sometimes he shared memories with his mother, which further helped him to continue the bond with his grandfather. His bedtime routine changed. He started to first pray to his grandfather for his family's well-being and then the Holy Mary.

The day of her first interview after the start of the study *Yui* told us that she had a dream about her father the previous night. Her first impression of Be.side was positive, and she was curious about using it more. However, *Yui* found the scent of barley tea too weak; therefore, she decided to use the artefact while drinking barley tea, which calmed and relaxed her as she reviewed her day and listened to the sounds and vibrations from Be.side. She noted that during first-week use, thinking about her father saddened her; however, by the second week, the sadness was less pronounced. She tried to recollect their happy and funny memories from her childhood, and the music and smell from the artefact helped her. She laughed and told us that she had a memory of her father always drinking all the soup when having ramen. As ramen soup can be remarkably salty, she often teased him for it. During the long-term study, *Yui* visited Japan for four days. Although she did not bring Be.side with her, the memories that she recalled helped her continue her bond with her deceased father when she travelled back to Japan. At her old house, she took out an old family album and talked to her sister about their father. Together, they visited his favourite ramen restaurant that she had mentioned in our previous interview. She also prayed everyday in front of his Buddhist altar in her family home. In the last interview, *Yui* expressed her gratitude to us for having given her the opportunity to process her grief and recall happy memories from her childhood.

Nara had a strong desire to engage with Be.side from the very beginning. On her first day, she recalled using the prototype for 15 minutes in a row, activating the trigger three times. *'I put my ear on this artefact on the desk. I thought, does a fetus in the mother's womb feel the same? I immersed myself in the heartbeat and song in a lying position for quite a long time. It was therapeutic, and I thought about my father's memories'–Nara (P3).* She used the artefact to share her daily concerns or when she wanted to be comforted. For example, after having some troubles with her co-worker one day, she used Be.side to complain to her father about the argument. Simultaneously, she felt sad that he could not be there to listen to her in person. As she engaged in continuing their bond, she felt bittersweet especially on the day of the third interview, which was the day after *Parent's day* in Korea. Recently, her brother's family had a baby, and they gathered in the family home where her mother lives. She thought about her father and felt that he would have been happy to have this grandchild, and she missed him. When she used the question-book prompts around the date of Parent's Day, she wished that he could be beside her, which made her sad and caused her to cry. This shows how, depending on individual situations, the same question could lead to very different feelings. Concerned

about her well-being, we suggested that she might want to limit or avoid engaging with the Be.side for the following week if it intensifies her grief. However, in her final interview, she explained that she kept interacting with the artefact to continue their bond and that she was able to share with her partner some memories of him. She mentioned that, before the start of the study, she rarely thought about her father and forgot the feeling of loss and sadness. The study was a good opportunity for her to evoke memories of her father, while the experience was bittersweet.

5.5.3 Evolving Multi-sensory Difference. At each interview, participants shared newly evoked vivid memories that they did not recall before the long-term study. The most effective sensory element varied among participants and was likely to change over time.

Min felt that he was almost meditating during the first week. The combination of various sensory elements calmed and comforted him. Listening to the cheers from the baseball stadium from the NHK news broadcast made him recall the Sundays of that time in his life. He noted that when he was recollecting memories of his grandfather, he felt a sense of grief. However, the heartbeat stimuli helped to mitigate his sadness. Each element seemed to trigger multiple senses; thus, he could vividly imagine specific moments, although Be.side had no visual element. After the experience, the sense of connection and comfort remained.

Yui could not define which elements was the most effective for her. As she is currently living in Korea and not Japan, the Yomiuri Giant's cheer song evoked nostalgia. She could imagine her old house, the street, and the scene of her father lying down and watching the baseball game on Sunday. *'I am still sad when I think of my father, but this whole experience including sound, smell, haptic stimulation, and taste of tea lead me focus on this atmosphere and not to think about other things such as regret or sorrow'–Yui (P2). Nara* noted that, compared with the initial prototype, this final prototype was easier to use with just one switch and that the noise of rattling components did not distract her from immersing herself in the atmosphere. She liked the combination of various elements and felt a general sense of calm and comfort. However, her experience with Be.side was affected by her own mental state.

As the process of continuing bonds evolved over time, the participants' relationship with Be.side changed. Some participants requested new scents and sounds and wanted the capability to add a photo of the deceased person. *Min* started to recall the memories of his deceased grandmother, especially the moments of her cooking his grandfather's breakfast. He requested a chopping-board sound and bread smell. We sourced the sound recording from a royalty-free sound portal, and the first author replicated the bread scent with a perfumer. *Yui* requested two additional changes after the study ended. One was to create a copy of the question book for her sister, and the other was to incorporate her father's photo on the artefact. She sent us a photo of him and herself when she was a baby. We printed this photo on film paper and placed it on the prototype's surface so that it can only be seen when Be.side is on (Figure 7). We delivered the second question book and upgraded product before she returned to Japan for another visit. She was very satisfied with the new product and said that it helped her to vividly think of her father. In our last encounter with her, we asked her why she chose this specific photo. She said that she preferred older, more nostalgic photos. This photo was her favourite, because her father looked happy hugging her, and when she looks at it, she feels connected to him.

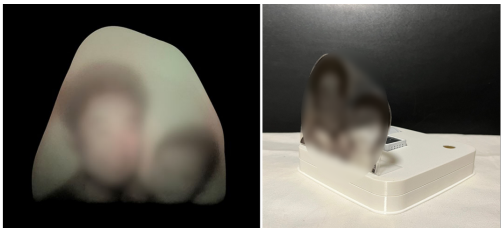


Figure 7: Development of Yui's Be.side. This image is blurred for privacy concerns.

6 DISCUSSION

6.1 Personalised Rituals and Bonds

Throughout the study, we observed how each participant created rituals for when and how they interacted with Be.side. All participants used the artefact at night before bed, as the soft lighting helped to create the ritual of recalling memories of their deceased loved one before sleep. *Min* incorporated his ritual in his usual religious practice; using Be.side helped *Nara* wrap up her day with her deceased father before bedtime. Since *Yui* had considered Be.side's smell of barley tea weak, we gave her barley tea together with the artefact at the start of the study. Unintentionally, we helped her to create her own ritual of interacting with Be.side. She used it after shower; she steeped her tea and recalled her father as she waited for the tea to be ready. All participants gradually found ways to integrate their use of Be.side as part of their own daily rituals, which facilitated the process of continuing bonds with the deceased.

Prior works have explored rituals in death and mourning. For instance, *Fenestra* [81] randomly showed digital pictures of a deceased person by flickering candlelight; this encouraged the bereaved to focus on the interaction with the object and created a new way of mourning the deceased compared to a traditional Buddhist altar common in Japan. In contrast, Corina et al.'s [71] research explored the therapeutic value of rituals as disposal practices. Interestingly, these disposal practices were similar to traditional Korean bereavement rituals. Family members burn the deceased's belongings in Korea as a means to move on from grief towards the next steps in their lives [76]. However, in our initial meeting, *Min* and *Nara*, who are both Korean, mentioned that they felt sorry for not having any of their loved one's belongings because of this traditional ritual. In addition, our initial rounds of interviews showed us that the young generations in Japan and Korea wanted to mourn in their own ways rather than follow the traditional rituals.

Many HCI researchers have used digital remains including metadata, photos, location, and heartrate data to create thanatosensitive artefacts for remembrance and bereavement support; yet few have focused on the creating objects that are not based on digital remains [16, 25, 35, 42, 60, 81, 89]. In this regard, Be.side represents a meaningful example of manifesting intangible memories as tangible

objects, designed with a participatory approach. Engaging with the researchers in the quest for specific scents and sounds from their childhood memories gave participants an opportunity to engage in continuing bonds via meaningful personal experiences.

Be.side presents a new way to privately mourn. Although sharing a similar context with *Fenestra*, Be.side is intended to create personal ways of continuing bonds, which is different from the goal of memorialisation by an altar or a monument. In the last interviews, the three participants noted that while they were happy to share the memories triggered by Be.side with their family members, they did not want to share the artefact with them, because the key memories of the deceased would be different for each individual. Therefore, the elements of the artefact should be different. This suggest that future designs of artefacts to foster continuing bonds should incorporate features that support the creation of personalised rituals which can be meaningful based on an individual's preferences, beliefs, and relationship with the deceased. To achieve long-term use, it is also important to consider how such relationships and rituals might change over time, requiring adaptations of the artefact, such as when we introduced new scents and sounds upon participant requests, or allowing for a process of appropriation, such as when *Nara* inserted her father's letters inside the prototype.

The novelty of Be.side lies in its duality as an object that is both generic and bespoke. While its basic shape and core components remain consistent across users, it offers a unique and personalised experience. This approach aligns with the concept of grief, which is both universal and deeply individual. Therefore, designers and HCI researchers in this domain must consider this duality. Grief also evolves over time, as the bereaved person redefines their relationship with the deceased. Therefore, artefacts supporting this process should be adaptable to these changes. Although the design specifics of thanatosensitive objects may vary across cultures, the general principles remain applicable, even in cultures emphasising different aspects of materiality which focus on retaining belongings of the deceased [27].

6.2 More Than Just an Artefact

All three participants noted that their process of sustaining bonds with the deceased started from the initial interview with the first author, before they received and interacted with Be.side. Further, they appreciated the regularity of the weekly interviews, as this gave them opportunities to freely talk about the memories of the deceased, share their feelings, and process their grief. This finding is similar to that of the *Storyshell* study [60] where a participant highlighted how not only the interaction with the artefact but creating a safe space for the bereaved participants to express their feelings and feel listened to by the researcher is crucial in the context of design for bereavement.

Engaging with participants to explore how design processes and resulting artefacts have a compounding effect that expands existing practices. It allows for better accommodation of individual needs and experiences and increases the impact of devices when in use. The goal of Be.side is to facilitate continuing bonds through remembrance at an individual level. Therefore, our research approach offered a safe space to truly and meaningfully participate in these processes.

Min and *Nara*, who had lost their loved ones quite some time ago, considered this study as a chance to reminisce starting from the initial sessions. As the interviews progressed, they recounted new, more vivid memories evoked through interactions with Be.side. In contrast, *Yui* who had recently lost her father, expressed intense grief during the initial meeting. However, throughout the four-week study and beyond, she began focusing on happier memories of her father. Interestingly, the shared experience of losing a loved one to the same disease as the first author's father created a sense of connection between *Yui* and the author.

Throughout the research, we realised the necessity of deeply engaging with bereavement theory and evidence from grief care that highlights the importance of enabling bereaved participants to express their feelings and ensuring that they feel listened to. We constantly adapted our approach to their needs rather then expecting them to adhere to a research schedule. We hope that sharing our experience in detail will support future research in this area. Overall, HCI researchers should apply participatory research practices throughout the design process, which match the artefact's goal as closely as possible. This way, the design process in itself represents a benchmark of its effectiveness in future deployment. As argued by Zimmerman et al. [96], this provides an avenue for creating devices that embody relevant theoretical aspects, in this case, bereavement theory, with technological opportunities in the domain of multi-sensory interactions.

Additionally, *Min* and *Nara*, who are both from South Korea, mentioned that burning their deceased loved one's belongings is typical within their culture of mourning. They considered Be.side a channel to meet the deceased through a more material aspect which was not otherwise available. On the other hand, *Yui*, who is from Japan, wanted to incorporate the deceased's photo on the cover of Be.side which she placed on her bedside table alongside flowers. She tended to the flowers in a similar fashion in which one maintains a Buddhist altar within traditional Japanese culture. These differences highlight how the device is adaptable to the different cultural practices of mourning present in the two countries.

6.3 Pros and Cons of Continuing Bonds

Recalling memories of a deceased loved one is a bittersweet experience incorporating delight, longing, and sorrow. Although individual participants had their favourite sensory elements, their combination allowed for deep engagement in remembrance. All participants mentioned that they could feel a sense of calm and comfort using Be.side, akin to that experienced in meditation. The consistent rhythmic nature of the heartbeat stimuli might have helped to remain focused in the present moment and not be overwhelmed by the feeling of grief, along with the combination of other elements creating the immersive atmosphere. Interacting with Be.side allowed participants to preserve their memories of and continue their bonds with the deceased. However, this engagement had both positive and negative connotations. *Min* and *Yui* enjoyed reconnecting with their lost ones and were grateful for the opportunities of remembrance that Be.side created; however, for *Nara*, reminiscing caused a resurgence of grief. Throughout the weekly

interviews, *Nara* often spoke about her regret. One of the most common expressions she used when talking about her father was 'what if...'. Continuing bonds involves engaging with our memories of a deceased individual; however, not all of these will necessarily be positive. *Min* and *Yui* also spoke about sad memories, creating a sense of longing; yet, they were able to accept and move forward. Whereas, for *Nara*, this did not happen. According to the Continuing Bonds Theory [47], the reasons might lay in *Nara*'s pre-death relationship with her father. As her mother did not share the news of her father's sickness while she was studying abroad, his death came as a sudden shock. She could not prepare herself to let him go. In her final interview, she stated that her grief had lessened, and her feelings were more positive. However, the relatively short time of the study makes it challenging to understand whether the experience of engaging with Be.side has been beneficial to her.

Promoting engagement with both negative and positive memories and reflections offers specific benefits in the design of technological artefacts that seek to support the exploration of complex experiences [3, 23]. Designers and researchers should strive for a balance between allowing participants to acknowledge their own pain while offering resources to process it. Combining our designed artefacts with other forms of interventions led by expert mental health professionals can also help navigate these complexities. This would ensure against accidental harm in the quest to develop technology that affects intimate and vulnerable aspects of an individual's life. Examining Be.side's varying impacts on our participants, we invite researchers working on thanatosensitive artefacts to consider the possibility of integration with grief and bereavement therapy with a role similar to that of transitional objects [88]. This approach would leverage the strengths of artefacts such as Be.side that can be used to engage in remembrance and conversation, favouring the development of a new relationship with the deceased. Simultaneously, therapeutic process support can help individuals to process their feelings of grief which might be evoked by the use of these objects.

6.4 Limitations and Future Studies

This research could be extended or supported further with more clinically-relevant evaluations of the technology's impact. In addition, future research can explore real-world applications for aiding the bereaved, potentially integrating grief therapy or establishing channels for discussing a deceased loved one in clinical settings. There is also scope for discussion regarding the potential scalability of our solution and what might be required for a feasible deployment as a product or service. We made significant adjustments and substantial intervention while conducting the long-term study with each participant. Further, the artefact was developed and personalised for the bereaved through participatory design approach. However, although unique, this is evidently a limitation. Hence, we plan to reflect on how to address this aspect in future studies.

7 CONCLUSION

Our research focused on the design and deployment of Be.side, a personalised multi-sensory artefact that helps bereaved users to continue bonds with a deceased loved one by leveraging meaningful memories. Our results show how participants could feel a sense of connection with the deceased not only through their engagement with the artefact but also as a result of engaging in the research process that included interviews and participatory design of multi-sensory elements such as smell, sound, and heartbeat simulation. The design and attunement of these bespoke elements was used to symbolise the deceased in a unique way that helped the bereaved to reconnect to them using their childhood memories.

Existing HCI studies in this field focus on the use of digital remains of the deceased. This study offers a slightly different approach by leveraging the memories of a bereaved person to create a unique multi-modal artefact representing the deceased. Moreover, the process of designing specific scents and sounds for each individual through a participatory approach is a meaningful example of engagement in research through design.

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