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Technology Individuation: The Foibles of Augmented Everyday Objects

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ABSTRACT

This paper presents the concept of technology individuation and explores its role in design. Individuation expresses how, over time, a technology becomes personal and intimate, unique in purpose, orchestrated in place, and how people eventually come to rely on it to sustain connection with others. We articulate this concept as a critical vantage point for designing augmented everyday objects and the Internet of Things. Individuation foregrounds aspects of habituation, routines and arrangements that through everyday practices reveal unique meaning, reflect self-identity and support agency.

The concept is illustrated through three long term case studies of technology in use, involving tangible and embodied interaction with devices that afford communication, monitoring, and awareness in the home setting. The cases are analysed using Hornecker and Buur's Tangible Interaction Framework. We further extend upon this framework to better reveal the role played by personal values, history of use, and arrangements, as they develop over time in the home setting, in shaping tangible and embodied interaction with individuated technologies.

Author Keywords

Internet of Things; Individuation; Tangible; Embodied; Smart; Things; Objects; Design; Communication; Connection; Framework; Habituation; Situated.

ACM Classification Keywords

H.5.2 [User Interfaces and Presentation] User Interfaces - Theory and Methods.

INTRODUCTION

"You're beautiful, but you're empty... Of course, an ordinary passerby would think my rose looked just like you. But my rose, all on her own, is more important than all of you together, since she's the one I've watered... Since she's

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the one I listened to when she complained, or when she boasted, or even sometimes when she said nothing at all. Since she's my rose." — Antoine de Saint-Exupéry, The Little Prince

This paper contributes the concept of *technology individuation* to capture the phenomenon of how a person's use of a technology over time leads to development of unique meanings, emotional valence and significance, which is dependent upon how well the technology meshes with the person's self-identity, how fit it is for a given purpose, what arrangements have been made to accommodate it in the person's life, and the effort and time spent in sustaining its usage.

We draw an example of individuation using a well established technology, the car. People often personalize their cars [25], from the addition of simple bumper stickers to complex and expensive modifications to the engine, transmission, etc. These modifications cannot be easily explained in utilitarian terms, or even in terms of habituation (as attachments to routines and rituals). We argue that these modifications are part of a process that aims at shaping the technology to reflect one's self-identity (and, correspondingly, shape one's self-identity in response to the technology that one uses). Trips taken in the car further imbue memories in its occupants and reveal particular foibles of the car itself [44]. We describe this process as individuation, as it highlights identity, ownership and uniqueness.

Objects that incorporate information technologies have further capability for individuation through use, through amendments to both software and hardware, and through the gathering of data or content. We articulate the concept of individuation in order to unpack the complexities of designing Internet of Things (IoT) objects, which have communication, monitoring and awareness capabilities.

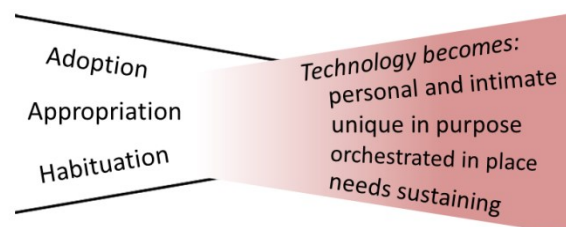


Figure 1. Technology individuation

Individuation extends related concepts of adoption, appropriation and habituation, by emphasising the differentiation that transforms an everyday object as it develops to be an extension of the self. *Technology individuation* is a continuous process through which technology is shaped in use over time, and shapes usage, arrangements and identity in return. Technology individuation makes the technology distinctly personal as it embodies personal history, emotional attachment, and time and effort spent in personalisation that reflects the owner's identity and relations (see Figure 1).

We illustrate the concept of individuation through two case studies from the literature and through one longitudinal case study of the usage of an augmented habituated object. We then frame our discussion based upon Hornecker and Buur's Tangible Interaction Framework [27]. This framework extended the understanding and analysis of tangible interfaces [28,57] to social and embodied aspects of interaction, by examining use of tangibles in public spaces in short term studies. We extend upon this work by examining continued usage of tangible technologies in a home setting. We emphasise the importance of habituation, routines and arrangements [6,23] that describe how people maintain and use objects to create and provide structure for their own lives and to sustain connection with others.

In exploring how tangible interaction with augmented everyday objects unfolds in a home setting, building on the emotional value that people sometimes place on cherished objects and routines, we aim to contribute to the area of tangible and embodied interaction and the design of the Internet of Things. The hope is to leverage design opportunities to enable greater specificity, agency and expression.

RELATED WORKS

As sensing and computing devices become smaller, cheaper, and more power efficient, a range of new possible applications become feasible, by augmenting and interconnecting all sorts of objects to form an Internet of Things (IoT) [33]. Originally conceived with the goal of optimizing manufacturing by making products aware of their position in the supply chain [1] IoT research initially focussed on technical challenges of connecting things across the internet, typically for remote monitoring or control [2].

More recently however scholars are reflecting on the human side of the IoT, and advocating for a more 'social' vision to be pursued [31,32,40,52]. In particular, there is an emergent call for finding 'the people' in the IoT [52]. Our Things [18], the rituals that they enable and the value that we project on them, may be the key to build and help sustain enduring connections to distant loved ones, enable and support agency and creatively express ones identity.

The relations between people and their objects can be unpacked in many ways. Theories of socio-material

relations articulated in the Social Studies of Science [34,43,55] have demonstrated how social relations and objects are mutually constituted. Scholars have articulated specific nuances of such relations, focusing on objects as integral part of the everyday and our social actions [42], considering how ordinary objects shape and are shaped in turn by their users' preferences and circumstances [13], and even taking the perspective of the objects themselves as a vantage point to understand interaction [12,20–22].

Objects are important to us for what they enable, including the routines, the rituals, and the social and emotional context in which they take place. Our things give us illusion of *power*, give permanence to meaningful *relationships* and serve as an extension of the *self* [14]. Our houses, offices, coffee pots, guns etc. materialize the relations between us. We inhabit and use them and they in turn shape our interactions and agency.

The more an object is personalised and used to express the self, the more the emotional bond with that object strengthens [38]. The emotional investment in an object is heightened when relationships are attached to it. Vaisutis et al [58] have discussed the role of personal things and how they may over time come to represent the relationship with loved ones, become a symbol of independence, or otherwise be charged with an emotional valence. Furthermore, social actions and everyday practices embed mundane arrangements, routines, and habits [37] that over time people come to rely upon. Routines and habits highlight the importance of particular objects used within them that support independence, agency, and connection to friends and services [6]. These practices give meaning to our lives, keep us functional [23] and they are cues that everything is in order [5].

This body of previous research shows that rituals, and habituated objects [6] offer an invaluable opportunity for imagining new scenarios for the IoT, beyond sensing and monitoring. Augmented everyday objects could be designed to foster mindfulness and engagement in the interaction [49] and stimulate connectedness and participation with one's family and the broader community. Routines and cherished objects have been the inspiration of several projects that have augmented everyday objects with communication capability to foster connection between people (e.g. [4,7,11,39,51,59]) Other studies explored the opportunities for interaction offered by everyday objects, e.g. DataSpoon [62] to monitor movements while eating, MugShot [29] to facilitate communication between office workers through their drinking mugs and BreathingFrame [30] photo frames that enable communication through breathing.

However, how people will interact with and accept augmented everyday objects that sense and gather data is much less well understood, and there are fewer studies examining how augmented everyday objects and the IoT can be (or will be) blended into the home environment in

the long run. The process through which people move from inspecting a novel technology to embracing it and making it an integral part of their own routines is the focus of studies on technology adoption, appropriation, and habituation.

Adoption is the process through which users first become aware of a novel technology, and later embrace and start to use it [48]; appropriation also involves the adaptations that users come up with, of the practices, skills, and the place itself where the novel technology will be placed [50]; habituation extends these concepts into development of rituals and routines, as well as the attachment that people form to those routines and the objects that make them possible [6]. It is apparent that design continues in use [18,56] as new skills are developed, workarounds are practiced and new uses are discovered [53]. Designers envision the use of the technology but the users mould it differently [16] based on their personal history, experiences and needs [53]. Soro and colleagues have combined these concepts in a *technology habituation framework* [53] that offers an analytic lens to understand interaction with objects that are endowed with emotional and symbolic meaning.

Yet, these constructs have limited reach in that they focus on the relationship between individuals and technology, and do not attempt to capture the more complex aspects that relate to the social and emotional context. Questions arise such as: how does the technology come to reflect (and shape) its user's self-identity? How does the technology become part of its user's rituals, and how are these rituals adapted to accommodate the new devices and what they afford? Crucially, considering people as social groups and emotional beings, rather than as utilitarian individuals, how do peoples' mutual relationships shape (and accommodate) novel technology in general, and augmented objects and the IoT in particular?

Several design approaches touch on these aspects but have not emphasised the user's self-identification. The approach of Slow design [54] builds upon principles such as reveal, expand, reflect, engage, evolve and routines [24] to highlight overlooked everyday practices and capitalise on attachments and the daily routines for sustainable design. Chapman's Experiential Framework banks on this emotional attachment in the hope of creating products that are more enduring to lessen waste [10]. Similar arguments were articulated within the domain of aesthetic interactions [35,45–47]; to bring emotions and experience to the foreground, and particularly before efficiency. Routines, emotions and experiences need to be understood for the design to uniquely take shape – coupled tightly with the object's instrumentality and context of use in the everyday [45]. One example of “expressive interaction” is Interactive Pillows [46], where one of a pair of pillows lights up when the other is hugged. This and other analogous studies (e.g. [3]) redesign an existing everyday object to create a communication device.

The proposed construct of Individuation aims at capturing these concepts by describing how a novel technology can eventually become endowed with unique meanings, emotional valence and significance because it comes to represent one person, as part of his/her self-identity, and in relation to others.

Analytic lens

Different analytic positions may help to deconstruct the idea of technology individuation. Notably, McCarthy and Wright ‘threads of experience’ framework [36] offers a sense-making process to help understand the relationship between people and technology by focusing on emotion and experience. The framework deconstructs technology experience in terms of (1) the sensual thread, which involves the body's senses in experiencing the technology – its look, feel, sound, etc.; (2) the emotional thread, which is the worth we associate to other people and things in relation to our needs; (3) the compositional thread, which is being conscious of the connection between the part and the whole of the experience, seeing the big picture while being mindful of the details of the experience; and (4) spatio-temporal thread of experience, which involves an intense emotion that the users sense of time is altered.

Augmented objects however build on the physicality of ordinary objects, their original purpose, and their aesthetics, to anchor the interaction with digital data and the computer-mediated communication to the real world. Because their purpose is to make the interaction tangible and situated we refer to the body of literature on tangible interaction as the most suitable analytic lens to unpack the complexities of designing IoT objects for individuation. We acknowledge, however, that this is not the only possible approach.

Tangible and embodied interaction is rooted historically in the works of Ishii and Ulmer on tangible interfaces [28]. Tangible interfaces allow the user to manipulate objects in the physical world, thereby also changing information in the digital world. Graspable interfaces [19] are tangibles that express in more detail the nature of the physical manipulation with the hand.

While objects are often manipulated with the hand, they are experienced by the entire body. Embodied interaction [17] centres on the role of the body and bodily interaction in human understanding. For human sense-making, the body is central in technology design [15]. To make sense of the world, the body is the structure between the social and physical environment and the brain [15]. Each person's body is unique and different, as is the environment in which the body functions, thus there is value in understanding social activities in the real world in order to enhance the overall experience in using a designed artefact [26].

A canonical framework that encompasses many aspects of tangible and social interaction that is meant to guide in investigation, reflection, support and organisation of ideas on tangible interaction is that of Hornecker and Buur [27].

Their Tangible Interaction Framework focuses on the importance of the social aspects of interaction explained in four themes with underlying concepts in each theme: (1) Tangible Manipulation refers to the actual physical object or material that is directly manipulated through bodily interaction, (2) Spatial Interaction is the movement in space in order to interact with the object embedded in real space, (3) Embodied Facilitation signifies the structure and arrangements (allows or prohibits actions) around the objects and space and how it directly affects behaviour, and (4) Expressive Representation captures the emulated digital representation of the tangible and its quality (expressiveness, legibility). The themes present different perspectives on understanding the social user experience and the interweaving of the physical and the social [27].

Hornecker and Buur's [27] Tangible Interaction framework offers an analysis vantage point to understand collaboration supported by the IoT, and we will adopt it to unpack the aspects of tangibility, spatial interaction, embodiment and expressive representation of the three case studies in the following sections. We also extend upon it to capture aspects of tangible interaction with individuated technology that occur over a sustained period in domestic settings.

CASE STUDIES OF AUGMENTED EVERYDAY OBJECTS

We illustrate the idea of technology individuation through three case studies of augmented everyday objects; two from the literature and one from a longitudinal on-going study. We selected these cases because they offer different ways to reflect on tangibility, spatial interaction, embodiment and expressive representation in a home setting.

The first case is Brown et al's Whereabouts Clock [8]. It is a situated alternative to ubiquitous mobile devices, a mantel-clock like device that visualises the real-time location of family members based on their mobile phone location. When a family member moves location, the Clock chimes. They may also send short messages to the Clock.

The second case study is the emergency pendant: an alarm system in a form of pendant and terminal device connected to the home telephone line. This system lets independently living older adults send an emergency alarm signal by pressing the button in their pendant or the button in the terminal. Gómez [23] discussed the 'little arrangements' that people made in the way they "use" this wearable device in relation to their character, beliefs and outlook in life.

The last case is the Messaging Kettle [7,52] presented by Brereton and colleagues, an ambient device designed to connect two distant persons over the routine of boiling the kettle to make tea. The Messaging Kettle augments the users' existing kettle through a Kettle Mate, that senses the kettle temperature and a Smart Tea Box, that embeds messaging and networking. They come in connected pairs of two Kettle Mates and two Tea Boxes. When one kettle is hot, the remote Kettle Mate glows, and hand-written messages can be exchanged through the smart Tea Boxes.

Each case study offers an interesting vantage point to explore tangible interaction for communication in the home over a period of weeks to years. The Whereabouts Clock [8] involved five households with 26 participants in total and ran for one to two months. The interviews and observations of the use of the emergency pendants involved five users of telecare systems, spanning over a period of 1 to 3 years [23]. The Messaging Kettle study is still ongoing; and has been running for almost two years [7,52].

The case studies suggest relationships between use and identity that can only in part be understood in terms of the arrangements that occur after design, such as appropriation [9], design after design [18], and technology habituation [53]. These frameworks capture design in use and to some extent the emotional value of particular technologies, but do not fully explain how technology comes to reflect, and reshape in turn, the self-identity of individual users.

At the same time, the case studies offer in different ways material for reflection on tangible and embodied interaction, when considering the specificity of home settings, and a longer timeframe. The Whereabouts Clock is a calm ambient device, situated in a place that is easy to see, that depicts broadly where family members are; the pendant is designed to be worn at all times and somehow become an extension of the body to be effective; the Messaging Kettle occupies physical space in the kitchen, involves many different tangible manipulations, and comes to represent a distant loved one.

Case 1: The Whereabouts Clock: not one universal but many unique interpretations of the same technology.

The Whereabouts Clock [8], is a mantelpiece clock-like device that depicts each family members' current location (based on their smartphone GPS position). Each family member initially registers different locations in their smartphone to refer to home, work or school (the Clock's regions). The Clock's interface displays in which region each family member is currently located. When a family member is in an unregistered location, their icon displays in the middle region of the Clock indicating the family member is "somewhere else". When a family member's phone GPS location changes, their icon location updates as it floats from one region to the next, also indicated by a chime sound. Users can also address messages to the clock, that everyone will be able to read on the main clock interface. The designers purposely made the regions generic so as to preserve privacy.

The Clock [8] was installed in the homes of five families who have four to six members; Brown and colleagues gave a detailed account of specific usages, for example one user, a wife, sees the movement of her husband's icon around six in the evening as an indication that he is on his way home and that it is a good time to prepare his tea. Another user, a father, looks at the Clock [8] as a form of reassurance that everyone is in the right place when he gets home in the evening. Even when their daughter lives far away, and she

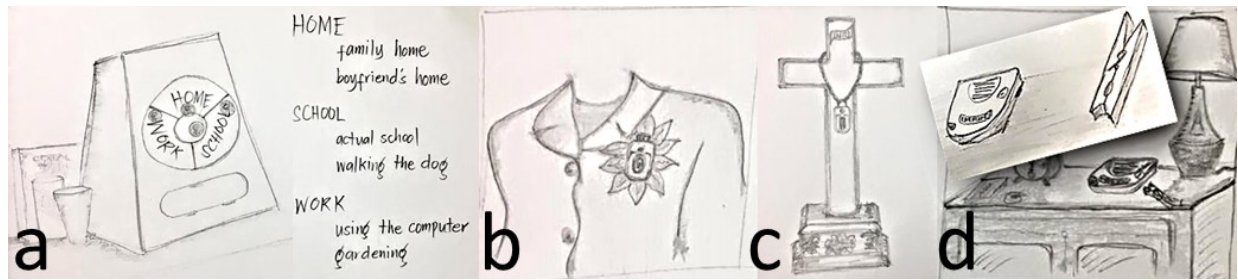


Figure 2. An artist's impression of (a) one family's use of the Whereabouts Clock, (b) emergency care pendant worn as a brooch, (c) hung up in a crucifix and (d) added clothes peg as part of the telecare system use.

is in the location where she registered as “home”, the icons huddled together in the same Clock region gave the feeling of reassurance and togetherness. When he sees the icons are in their proper region in that specific time, he is assured that all is all right.

Users of the Clock find different intended (e.g. coordination) and unintended (e.g. reassurance) purposes for it. Family members also found creative ways to make the clock present information in a way that is convenient, for example peculiarly registering locations to specific Clock regions. A daughter registered her parents' house and her boyfriend's house as “home” and the train station where she picks her boyfriend up as “school”. The retired mother registered walking the dog as “school” and gardening in the house or in their far garden lot as “work”. The retired father regularly registered and re-registered his location from “work” to “home” as he switched his home activity from being on the computer to watching TV. The authors believe that this is a way for them to assert their social position in the family by broadcasting their identity [8].

This study showed how five families used the Whereabouts Clock and what the clock meant to each family and its members (see Figure 2). “Reading” the Clock is unique to each family and its members.

Case 2: The Emergency Care Pendant: I am what I wear (therefore I will not wear that!)

The emergency care pendant is part of a telecare system that enables social and health services supporting older adults who live independently in their own home. In case of an emergency, the user presses the button of the pendant or the one in the terminal device connected to the home telephone line. A telephone operator will answer to assess and respond to the alarm raised. Users in a more critical state are required to push the button of the terminal once every 24 hours to reset the alarm, otherwise an alarm will be automatically raised.

Gómez [23] analysed the “little arrangements that matter” to older people to shed light on the many unique ways that they used a personal emergency care pendant. Rather than simply wear the pendant around their neck, which many found cumbersome and intrusive, older people devised a variety of different ways of placing the pendant in different parts of their home at different times. How they placed the

pendant reflected their many different attitudes towards death, monitoring, and their perceived likelihood of needing emergency care during particular activities. Gómez argued that this is the case with all services and technologies. They must be arranged, which “implies something more than simply placing them in the home”.

For example, an older adult accepting mortality placed the pendant in the crucifix on her bedside table. Peculiar, it may seem, but this reminded her of her mortality at the same time as not having the idea consume her. Reflecting her faith and belief in a higher being, it gave her comfort. Similarly one 82-year-old pendant owner hung up her pendant in the kitchen even though in so doing, the pendant's purpose was defeated. In this particular case, she believed that she was okay, healthy with no serious medical concern, and that she didn't need it at the moment. She hangs up the pendant for future use saying that the pendant is only for the old and frail.

Another older adult placed a clothes peg near the emergency system terminal to remind himself to push the button daily to alert the telecare system that he is well. By helping his memory, he is also asserting that he is well and able to retain his independence, enabling him to stay in his own home and avoid being institutionalised. Some older adults do wear the pendant but they sport it as a brooch or hide it under their top to avoid the stigma the pendant represents when worn as is.

The study highlighted how users were able to adjust their use (or non-use) in the long run. All had different attitudes towards monitoring, mortality and achieving autonomous living (illustrated in Figure 2) which were reflected in how they personalised and arranged their use of the pendant.

Case 3: The Messaging Kettle (It's not just a glowing light, but it's the presence of my mum.)

The Messaging Kettle [7,52] augments an ordinary kettle with sensing and messaging capabilities to allow connection between geographically distant friends or loved ones while undertaking the simple routine of boiling water in the kettle. Two kettles in two distant homes are connected enabling each party to see when the other's kettle is on and enabling casual communication through scribble and voice messages.

The Messaging Kettle, as seen in Figure 3, consists of two interoperating devices: a Kettle Mate senses the state of use of the real kettle by measuring the temperature at its spout, and acts as a calm situated display that gently glows when the remote kettle is in use; additionally, a Tea Box with screen, stylus (and a draw full of tea bags) supports handwritten messages and sketches. Voice messages can be recorded and played through a microphone and speaker.

The design was inspired by a contextual enquiry with an older person in their home which sought to understand which objects were favourites, were commonly used and the daily routines that they served [6].

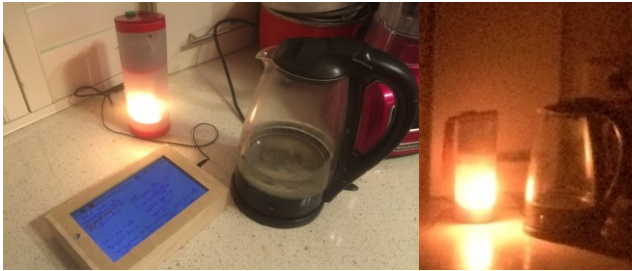


Figure 3. The Messaging Kettle in use. Left: The Kettle Mate exhibits a gently dynamic lava lamp like glow to signify that the kettle at the other person's home is currently boiling. A hand-written message has been left on the Tea Box. Right: Late night kettle mate glow.

Importantly, objects were arranged around the house to be at hand where they were often used. Of particular note, the participant kept a kettle in her bedroom “so she can make her morning cups of tea in bed and listen to the radio without coming downstairs to the kitchen” [5, p.22]. The Messaging Kettle was then conceived to take advantage of spatial interaction strategies already in use in the elderly person's home, attaching communication capabilities to existing objects that are already part of established routines.

A longitudinal study of the everyday use of the Messaging Kettle is currently being conducted. Two installations have been deployed so far: one trial running for almost two years is with an older adult in her late 80s and her adult child who lives in another country, several time zones apart. A second installation connects the kettles of one older adult in her early 80s with her adult child who lives two hours drive away in the same time zone. This trial has run for three months.

Both older adults are active, live independently and have a busy social life. Their adult working daughters hoped for a connection other than what can be offered by phones or social media applications. The Messaging Kettle provided the means to have an exclusive and intimate connection between the older adult and the adult child.

In both cases we are paying particular attention to two main aspects of the interaction dynamics. First, how is the Messaging Kettle received within the habits and routines of the older user? If the overall goal of augmenting a

habituated object (the existing kettle) is to leverage the old person's attachment to the routines and rituals that are made possible by that object, how is this process taking place (if at all)? What can we learn from the process of place making that necessarily accompanies the introduction of a new device into an already smooth and established routine? The kitchen of all places in the home is often cluttered with objects, appliances, tools and crockery. Space is at premium, as are power sockets. We found that the new object took some time to be actively accommodated. The adult child of the second family recalls that “*at first she [her mother] had the [Messaging] kettle on one side and the [Tea] Box next to it, but it was taking up a lot of room*”. Similarly, the older adult of the first family asked to put the Tea Box up on the wall, so it did not take up counter space (see Figure 4) and together with her adult child, they made a hole in the back. Taking ownership of the placement, she had in mind a particular kind of hook that would be good to hold it and went to the hardware store to get one.

Second, how is the interaction shaped by the aesthetic qualities of the design? Interestingly, several entries in the participants' diary related to aesthetics of the interaction. The gentle glowing of the Messaging Kettle (Figure 3) was characterized as “*lovely - so much more lava lamp than smoke alarm - it is both exciting and calming*”. A clue as simple as the Kettle Mate glowing was received as a hint of virtual presence when “*Sometimes, in the middle of the night, I walk into the kitchen and see the glow of Mum's boiling kettle in the dark. It is a lovely night time surprise. The rest of the family is in bed and it is very quiet but I can see my Mum is around. I think about what time it is there and what she might be boiling her kettle for.*”

Finally, how does the particularity of the concrete object that needs to be accommodated in the users' home both constrain but also create possibilities for interaction? In both trials, we found the kettle is no longer just an object used for boiling water. It now represents the loved one from far away making tea. The thought goes to the other person, and the eye glances at the display looking for messages.



Figure 4. Top: One of the participants got a new kettle, but she still uses the Kettle Mate with the new one. Bottom: Plugs in the older person's home that she has modified with labels and arranged to support her ease of use.

INDIVIDUATION AND TANGIBLE EMBODIED INTERACTION

In this section we aim to show how an augmented tangible object supports meaning within relationships over time through everyday practices. To this end we draw upon Hornecker and Buur's Tangible Interaction Framework [27]. This framework draws together a number of streams of work that focus on tangible interfaces and articulate their relations to social and embodied aspects of interaction. However, Hornecker and Buur's framework focuses on how tangible interfaces invite and support collaboration. Its case studies all draw upon collaboration that took place in the form of public installations, exhibitions and collaborative design.

We extend upon this work by emphasising the importance of routines, identity and arrangements that lead to individuation of the technology when the interaction is sustained in continued use and the experience is lived in the home setting (illustrated in Figure 5).

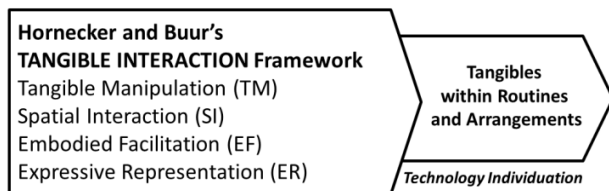


Figure 5. Tangible interaction with Individuation

Our focus is then more on exploring tangible interaction in personal living and intimate communication, and less on examining collaboration and group activities.

Tangible Everyday Object Use

In Hornecker and Buur's Tangible Interaction Framework, the dimension of Tangible Manipulation is the physical interaction of the user with the tangible system that then in some way also controls computational resources [27]. Technologies that make use of existing household objects can utilise natural interactions in the home with those objects, without the need to explicitly indicate activity in some other way. For example, simply boiling the kettle indicates activity, with the Kettle Mate detecting the boiling and sending the signal to effect a comforting glowing light at the other end. The Kettle Mate can also simply be turned away, if there is a desire that its eye (temperature sensor) will not see the kettle boiling. Similarly, the Whereabouts clock which found its place in the kitchen or living area is checked from time to time for information like a regular clock. The shape and size of the emergency pendant make it suitable to be disguised under one's clothes or to be worn as a brooch. Utilising manipulation of existing objects for communication, and by making it simple to also not communicate, for example, by turning an object away is an example of a lightweight, legible tangible approach, that might be adopted in designing for the IoT.

Spatial Interaction Rearranged and Extended

Spatial Interaction refers to the understanding that a

tangible interface takes up real space, is situated in place and the user needs to move around in that space to interact with it [27]. In personal communication through IoT objects such as a messaging kettle, it is important that people can use and arrange those objects to fit into their own places and routines. Further we have found that the Messaging Kettle changes the nature of the space and place. The kitchen becomes the place one sees the activity and messages of the connected loved one. It invites a glance toward the Tea Box to see if a new message lies there, and a glowing Kettle Mate light gently shows you that far away the ones that you care about are in their kitchen too, extending one's imagination to a faraway place. As for the emergency alarm pendant [23], one user added an element in his routine to remind him to use the system – a clothes peg. The clothes peg is now a staple on his bedside table to remind him to push the button indicating he is well. Likewise the Whereabouts Clock chime sound prompted those who are present in the house to check who changed location. This has the effect of making and extending routines to new spaces, where they would otherwise not exist or exist in a different form. Every new piece of technology needs to have its place made in the home, within the many other existing objects, tools and routines.

Intuitive and Restricted Embodied Facilitation

Embodied Facilitation describes how the physical structure of tangibles shapes the emerging social configurations around them. This theme has clear implications for how tangibles support collaboration in collocated space. For IoT tools and applications to find their way into the homes of people, they must fit within the constraints of space, people, skills, and routines in order to extend and augment these routines. Their placement, (on shelf, wall, or mantelpiece etc) determines who sees and uses them.

A Messaging Kettle will facilitate messaging over tea or while cooking, and the glowing presence of the Kettle Mate is experienced by anyone within view, thus being shared by kitchen occupants, changing the nature of interaction in the kitchen. When a message is received or the Kettle Mate is glowing, there is a certainty that the other person is, or has recently been, physically present at the remote end. Facilitating interaction in a place such as the kitchen both enriches the experience of the kitchen and restricts the experience to the kitchen, such that the kitchen takes on a more personal meaning.

Similarly, in the case of the Whereabouts Clock, the designers could have easily implemented the clock interface as a mobile application but they opted instead to give the clock a tangible form, exploring what routines and behaviour would emerge by making information available in a situated manner at a particular place. Seeing the activities of other family members on the clock gave a sense of togetherness and reassurance, to the point that one father used to glance at the clock often to check that everything is okay. At the same time, to keep an eye on the

clock one needed to be home in the first place. Aspects of embodied facilitation and limited information contributed to avoiding the device being received as an intrusive monitoring system.

The emergency pendant provided a sense of reassurance when its users saw it hanging somewhere close at hand, indicating that help is within reach. Different users decided upon different locations to place the pendant, reflecting their ideas of when and where they are more likely to be in need of help, and based on individual judgements about their own routines and physical condition.

The tangibles in our case studies shaped the emerging social configurations around them, both enriching and further specifying the nature of embodied interaction. They also increased the personal meaning invested in objects and places.

Subtle Expressive Representation

Expressive Representation refers to the expressiveness and legibility of the material and digital representation used by the tangible interaction [27]. Users of the Messaging Kettle found the subtle glowing light indicating the other kettle is boiling to be an unobtrusive and yet enchanting representation of the boiling pot on the other end. Whereabouts Clock users were amused by the chime sound and the transfer of the floating family member icon from one region of the clock to the next (e.g. from home to school). While Hornecker and Buur recommend bringing the tangible aspect of the interaction to the foreground, so that the system is immediately legible and there is a perceived coupling between actions and reactions, we found that subtle representations are valued, and that people value the opportunity to personalise and individuate meanings. Some IoT objects speak through their “silence”. For example, the Whereabouts Clock tells more than just the location, just as the emergency pendant represents more than help and the Kettle glow more than boiling water. The added meanings, contributed by the users themselves, are personal, encouraged but not provided by design.

The individuated characteristics developed over time by these augmented everyday objects - the foibles that are only understood by its users - are important aspects of tangible and situated interaction. In our extension of Hornecker and Buur’s Framework we now consider object use within routines and arrangements. Here we make a case for the importance of the personal values and history of use of an object, and the ability to appropriate it, arrange it with other objects, and communicate through it with particular people, which over time make it unique and individuated.

DISCUSSION: TANGIBLES WITHIN ROUTINES AND ARRANGEMENTS

Each physical object is unique, being physical matter that occupies a physical place and wears over time with use. Through augmentation with messaging and communication capabilities, objects can be enabled to support

communication within a particular relationship, imbuing the object with further meaning. The augmented functionality may be separable from the object, as it is in the case of the Kettle Mate and kettle; one older user was quite happy when she replaced her old kettle with a new one, not being attached to the kettle itself but rather to the tea making routine. The routine takes on an added dimension when enhanced with communication capability. However, attachment to a particular object may develop through using it over time and through memories invested in its use. Vaisutis et al [58] found memories vested in objects such as a car in the driveway that an older adult was no longer able to drive and a shoehorn that went on a trip around the continent and was used by children in swordfights.

Nansen et al [41] describe the process of reciprocal habituation through which people get used to technologies and technologies are adapted to people. Theories of socio-material relations have also demonstrated how social relations and objects are mutually constituted. Latour [34] discusses how you are different with a gun in your hand and how the gun is different with you holding it [55].

We use tools, collect objects, inhabit homes, wear clothes, and by doing so we adapt these objects to suit our needs, routines and values. In turn, objects, homes and clothes determine the reach and limits of our agency, our appearance, and ultimately contribute to define who we are and what we can achieve. We thus highlight the importance of the way that we make places for objects in our lives and the way that they contribute to forming our habits, supporting our agency and representing our values.

The case studies illustrated these aspects. Some users of the emergency care pendant [23] placed it in different parts of their home at different times reflecting their attitudes towards death, monitoring, and emergency care need. Users of the Messaging Kettles carefully considered where they would place their kettle mates: one of them had two kettles, one in the upstairs bedroom, for a morning cup of tea before getting out of bed, plus one in the kitchen. She decided to have the messaging kettle in the kitchen, but then needed to decide where exactly to place it and where to find power sockets for it. She later decided she might hang the Tea Box on the wall, so it was easy to see and did not take up counter space. When asked if she might place it near the sockets where several jugs were hanging, by moving the jugs elsewhere, she insisted that she needed each jug in that handy spot as each one was just the right size for a different kind of sauce, gravy, custard or milk for tea. Careful consideration of the power socket arrangement was also evident in little labels placed on each plug, so it was easy to identify to which appliance it belonged. The arrangements of all of the objects in the kitchen had been carefully considered and emerged over time. Each one had a story.

As Gómez [23] argued, services and technologies to be embedded in the home should be designed to support such arrangements. The very placing of the emergency care

pendant to suit one's philosophies and activities, or the arranging of plugs and jugs, are enabling resources for action. They are taken for-granted aspects of people's autonomy. Yet it is this "inalienable undertaking of caring for these arrangements which configures our autonomous, yet ageing lives" [23] p91. As Gómez identifies, autonomy enabling innovations are those that allow people to care for their arrangements.

These arrangements over time will take in the novel technology and its uses, eventually endowing it with unique and personal value. This process shapes the technology to reflect one's self-identity and, symmetrically, shapes one's self-identity in response to the technology used.

Technology Arrangements as Personal and Intimate

The first reflection on technology individuation is that technology becomes personal and unique. In the case of the Messaging Kettle, the augmented kettle possessed straightforward and simple aesthetics that evoked memories and gave special meaning to its users. The penmanship, the glow of the light, the fact that the exchanges are handwritten, the short voice messages and the ambient glowing light became special [47]. The exchanges are personal in that they evoked fond memories of the past. One Messaging Kettle participant, the adult child of the first trial, said, "*When I see her handwriting, it reminds me of the handwriting I now rarely see on the occasional printed birthday card or in the letters she used to write. But it is unmistakably written by her hand.*" The interaction through the kettle is dedicated and personalised making it unique and intimate [24]: "[It does not] *feel like I have to open a computer and deal with emails from everywhere else.*

Likewise using the Whereabouts Clock, even though location names were fixed in the technology design, the family artfully differentiated their own Clock from the ones in use at other families. The location was individuated by each family and its members: it didn't just represent the place, but it represented the family's activity, where "work" doesn't necessarily mean 'office' but the activity that a specific family member identifies. The examples of one mother setting her location to "school" when she was walking the dog, and the retired parents setting their location to "work" while gardening show that location labels are individuated to represent the rhythm of the family's routine and to give reassurance and connectedness. Similarly, one user of the emergency alarm system adopted a clothes peg as a reminder that it was time to activate the reset button on the transmitter, therefore implementing a very specific and unique solution to his own problem of remembering this daily routine.

The examples concur to illustrate that some modifications that are developed over time, however small or mundane, are deeply rooted in the personal rituals and unique home settings, which in turn define who we are. By extension, such modifications cannot be transferred from one person to another, but need to be orchestrated on a case by case basis.

Unique Purpose and Orchestration in Place

Individuation also captures the idea that over time some technology may be engendered with particular meaning that makes it particularly useful for a unique purpose, sometimes different from its intended design.

In the case of the Kettle, its initial use is connected to a habit of making tea, already rooted in the user's routines [18,56]. The additional layer of interaction in the Messaging Kettle providing additional opportunities for communication, connection and emotional attachment, endowing the technology and its content with more meaning and special value. For Messaging Kettle and Whereabouts Clock users, the object is no longer just an everyday object but a connection to loved ones and a feeling of togetherness. How this connection is enacted and felt is unique in each case. As the emergency alarm pendant illustrated, it is not just a button to push when needing care but a symbol of mortality for one, a feeling of reassurance for another or a representation of one's identity. One pendant owner, feeling strong and healthy, felt no need to wear it at all; others fearing the loss of independence that may result from not using it, found ways to work around the issues it presented with (brooch, clothes peg, etc.). Their actions toward the technology is a reflection of their values and feelings [36]. Analogously, in the case of the Whereabouts Clock, people used the clock to express their social position in the family, for example, the retired mother registered home gardening as "work" and being in the house as "home". Parental identity was established by registering "work" on different activities.

Orchestration refers to how people arrange and rearrange their physical environment in order to use technology and how they adjust their social dynamics to accommodate that usage. Technologies become enmeshed to a specific place of habitual use [6]. In order to accommodate the Messaging Kettle in a small kitchen, a place had to be made which involved allocating countertop space, finding sockets for for the Kettle Mate and the Tea Box, rearranging already-placed objects and adopting new practices (reading and sending messages during tea time).

All case studies revealed the importance of the arrangements made by the users reflecting their identity and autonomy. Each family member using the whereabouts clock could read where other members were, based on the conventions that they created. While the Messaging Kettle is associated to a particular person, the aesthetics of the gentle, warm, ambient glow are important in presenting the activity of the remote person, "*I now associate The Kettle to my mum. When I go to the kitchen, there's fondness when I see the kettle mate glow... When I see it I imagine her in her house in the UK. I know just what her kitchen looks like and I imagine her there.*"

The uniqueness of purpose, situated aesthetics and placement of the technology in the constellation of other tools, objects and appliances, emerge over the pure

instrumentality of the Kettle, Clock and pendant. The particularities of the context of use [47] support the evoked reflection and meaning [24,54] that is distinct for each user.

Need for Sustained use

One aspect that emerged from all case studies is that part of the value attributed to technology arises from the effort invested over time to learn, adapt, and personalize it. This is somewhat at odds with principles of unobtrusiveness and intuitiveness that guide ubicomp and tangible design.

One of the Messaging Kettle users asserted that the reason that the use of the messaging kettle has endured for almost two years is because the Messaging Kettle and TeaBox constantly reminds them of each other and reminds them to communicate, while making it very easy to do so. The everyday kettle boiling which prompts the Kettle Mate of the other to glow, in turn reminds them of each other. The last message, visible in the kitchen, prompts each to want to change it by leaving a new one. These subtle reminders [60] lead them to continually leave an audio message or scribble a simple note to each other. The simple routine of making tea and each other's motivation to stay connected has sustained their use of the Messaging Kettle and strengthened the bond to the distant one. This enduring use characteristic of the Messaging Kettle reflects the call for durable, long lasting systems [61] sustainable design [54].

The Whereabouts Clock involved the active participation of all family members to not forget their phones or lose battery power to sustain "virtual togetherness" [8]. The participants showed positive effort in sustaining use, with two families deciding to continue use beyond the trial.

With the emergency alarm pendant there was conscious effort needed to use the system, and participants came up with clever ways to remind themselves to use it, or placed it where they thought it would most likely be needed in case of an emergency. However, this device, and others like it for personal monitoring, has several shortcomings: the device is only really useful in an emergency, which will take place at an unknown time, however its placement has to be attended to all of the time. It is stigmatising as its users are implied to be at risk. However it serves well to highlight issues in relation to arrangements, and personal values.

The routines, arrangements and connections in and around technologies that do foster continued usage (Messaging Kettle and Whereabouts Clock), and the conscious and active efforts made by users are what endows technology with its added value, and what contributes to the sense of 'togetherness' afforded by communication devices, and peace of mind afforded by the emergency care pendant.

CONCLUSION

Personal objects shape our lives just as we shape, adapt and customize those objects. Over time they may come to reflect our identity and social relations. They affect our agency, empowering (or disempowering) us and others see

them as a part of us. We articulate this concept in terms of *technology individuation* which emphasises the personal lived experience of technology beyond adoption, appropriation and habituation. It highlights identity, ownership, situatedness, arrangements and uniqueness.

We examined three longitudinal studies of technologies in domestic settings, the Messaging Kettle [7], the Whereabouts Clock [8] and the arrangements around an emergency alarm pendant [23]. Drawing from these three cases of everyday objects augmented with communication, monitoring or awareness capability, we show that technology individuation develops through continuous usage, shaped by the experience with the technology [36].

We framed our analysis using Hornecker and Buur's Tangible Interaction Framework and extended it to encapsulate the experience and shaping of tangible and situated technologies in lived routines and arrangements in domestic settings over the longer term. Our analysis revealed that over time through lived history, routines, and personal values, individuated technology becomes:

(i) personal, intimate and unique in purpose - people develop their own personal ways of reading meanings in the technology, and they use and shape it such that it becomes part of their identity and over time engenders unique purpose, in the eyes of its user;

(ii) orchestrated - people orchestrate the placement and use of technology putting effort into its arrangement in the context of other devices and relationships, which is important in ensuring their own agency and autonomy;

(iii) sustained in use - technology is used when it provides value but its use needs sustaining through its owners efforts, which includes controlling their participation, data, content sharing and identity. People then eventually come to rely on the technology to sustain their connection with others.

In designing for the Internet of Things, little attention has been paid to how things, augmented with communication and data sensing capabilities, will be used in social settings and particularly in domestic settings. Our analysis revealed that for augmented everyday objects, the nuances and intricacies of sustained social interaction and agency are important factors in tangible interaction design.

Individuation is a critical vantage point in design, because it examines and articulates how people will convey personal and intimate data through things, how their uses will be unique to their situations, the effort taken to orchestrate technology in place, to sustain its use, and to maintain agency and autonomy.

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