The Inflatable Cat: Idiosyncratic Ideation Of Smart Objects For The Home

Arne Berger
Chemnitz University of Technology
Chemnitz, Germany
arne.berger@cs.tu-chemnitz.de

William Odom
Simon Fraser University, School of Interactive Arts + Technology
Surrey, British Columbia, Canada
wodom@sfu.ca

Michael Storz
Chemnitz University of Technology
Chemnitz, Germany
michael.storz@cs.tu-chemnitz.de

Andreas Bischof
Chemnitz University of Technology
Chemnitz, Germany
andreas.bischof@cs.tu-chemnitz.de

Albrecht Kurze
Chemnitz University of Technology
Chemnitz, Germany
albrecht.kurze@cs.tu-chemnitz.de

Eva Hornecker
Bauhaus-Universität Weimar
Weimar, Germany
eva.hornecker@uni-weimar.de

ABSTRACT

Research on product experience has a history in investigating the sensory and emotional qualities of interacting with objects. However, this notion has not been fully expanded to the design space of co-designing smart objects. In this paper, we report on findings from a series of co-design workshops where we used the toolkit Loaded Dice in conjunction with a card set that aimed to support participants in reflecting the sensory qualities of domestic smart objects. We synthesize and interpret findings from our study to help illustrate how the workshops supported co-designers in creatively ideating concepts for emotionally valuable smart objects that better connect personal inputs with the output of smart objects. Our work contributes a case example of how a co-design approach that emphasizes situated sensory exploration can be effective in enabling co-designers to ideate concepts of idiosyncratic smart objects that closely relate to the characteristics of their domestic living situations.

CCS CONCEPTS

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

KEYWORDS

Co-design; Co-Design Method; Co-Speculation; Internet Of Things; Smart Things; Emotional Qualities; Sensory Qualities

ACM ISBN 978-1-4503-5970-2/19/05…$15.00
https://doi.org/10.1145/3290605.3300631

ACM Reference Format:
Arne Berger, William Odom, Michael Storz, Andreas Bischof, Albrecht Kurze, and Eva Hornecker. 2019. The Inflatable Cat: Idiosyncratic Ideation Of Smart Objects For The Home. In *CHI Conference on Human Factors in Computing Systems Proceedings (CHI 2019), May 4–9, 2019, Glasgow, Scotland UK*. ACM, New York, NY, USA, 12 pages. https://doi.org/10.1145/3290605.3300631

1 INTRODUCTION

Smart home applications, technologies, and systems comprise a multi-billion connected devices market [35]. Yet, not many successful smart objects for the home exist outside the realm of security, comfort, and efficiency [33, 34]. There is an opportunity to explore this emerging design space together with people and explore how to enable them to conceptualize better what would be meaningful and emotionally valuable smart objects in the context of their own everyday lives and needs [1, 4]. Nonetheless, designing smart objects together with people is challenging, because smart objects combine the tangible material of everyday things with the intangible material of services and networks. Additionally, 'the home' itself is a highly diverse, idiosyncratic, and emotional context that people associate with strong feelings of attachment and personal or familial well-being. Co-design is a useful approach for such sensitive settings because it offers ways to enable people to explore and reflect on the possibilities, consequences, and implications of future technology.

Co-design tools can be useful in making (in)tangible components of technology more understandable and accessible to people. These tools can be particularly useful in inviting participation among people in conceptualizing new types of Internet of Things (IoT) design interventions, which often combine tangible objects embedded with distributed connectivity and computation. Here, co-design tools can embody functional building blocks, such as sensors and actuators, to permit an immersive exploration of the design space [3, 14, 15, 19, 20]. Co-design tools can also simulate such building blocks together with contextual concepts, such as places, people, and goals. However, a key challenge is that this process requires some degree of abstraction [2, 8, 16, 26].

Taken together, these types of co-design tools embody core elements for IoT design (i.e., how sensors and actuators can be integrated into people's lives). Yet, this raises the problem that, in using them, a technical solution may be framed without a clear connection to a well-considered problem. Moreover, the fact that 'the home' is associated with strong feelings for many people with a great deal of diversity, not many co-design tools enable people to explore emotional or sensory qualities that could emerge from interacting with smart objects. This is surprising, because research on product and interaction experience has a history [24, 30] of investigating the relationship between objects and the emotions they elicit [6, 11, 12, 22]. However, this notion has not been expanded to the IoT co-design space.

This paper reports on findings from a series of co-design workshops in which we used the co-design tool Loaded Dice [20] together with a vocabulary of sensory qualities [7, 22]. These workshops enabled co-designers to ideate concepts and visions of smart objects that foregrounded unique and particular sensory and emotional qualities. We present three of these examples and analyze the creative strategies of our co-designers. The examples presented illustrate the diversity of the individual homes of our study. As such, they differ from the existing domestic IoT scenarios common to the Western consumer electronics marketplace. We refer to them as 'idiosyncratic' because they mediate distinct relations between people and other humans or non-humans through a careful negotiation between sensory and emotional qualities. They are not blueprints for future things to be built, however. Rather, our work offers new insights into how this co-design method can be employed to better understand, explore, and reflect on how people negotiate emotions and sensations in 'sticky life situations'. To this end, our analysis reveals, that these workshops enabled co-designers to ideate emotionally valuable smart objects that do not build on objective measurements towards efficient communication, but rely on the situated knowledge of the people involved to imagine emotionally valuable communication.

We contribute a workshop design that enables co-designers to explore sensory and emotional qualities of smart objects. These smart objects contribute towards a corpus of exemplars that represent the diverse contexts of what constitutes the home. We also contribute a footing for HCI to build co-design tools that (i) support sensory and emotional exploration as a way to co-design meaningful smart objects and (ii) support co-designers in reflecting on the diversity of what makes up their homes, through ideating and reflecting sensory and emotional qualities of smart objects.

2 BACKGROUND AND RELATED WORK

Related work falls into (i) a background on human senses and emotions and intersecting research in HCI design and (ii) a review of co-design tools for the IoT that relate senses and emotions to qualities of smart objects.

Sensory and Emotional Qualities of Interaction

Humans have a variety of senses. Sight (visual), hearing (auditory), taste (gustatory), smell (olfactory), and touch (somatosensory) are commonly described as our five basic senses [9, 13]. There are other forms of senses, such as temperature, kinesthetic sense, pain, balance, or vibration [13]. Senses provide data for perception [9], which, in turn, is a necessary precursor for emotion. And while emotion is certainly not a simple phenomenon, it is a function that connects sense, perception, and cognitive evaluation [17]. For example, we smell something, which is translated into perception that in turn elicits an emotion, such as sadness or happiness. Emotions are commonly described and differentiated as dyadic dimensions [23]. For example, the intensity of a person's happiness or sadness can be registered as a point on a scale that ranges from happy through neutral to sad [31].

What humans sense provides them with what to feel, but likewise, what humans feel also influences what their senses will pick up [38, 41]. Furthermore, humans associate different qualities of their senses with different descriptors of emotion and vice versa [37]. While there is no consensus on whether a set of either basic human emotions or sensory qualities exists [29], research in HCI and design has a history of relating human emotion to sensory qualities and experiential evaluation of designed objects. A number of frameworks exist, to describe the emotional or experiential qualities of designed objects. Desmet [6] provided the first systematic approach to describe emotions evoked by designed objects, and settled upon a framework of 14 dyadic items, such as dissatisfaction–satisfaction. This framework is useful for evaluating the emotional qualities of products, services, and experiences [6]. Moreover, the playful experiences framework, PLEX [25], proposes 22 categories, such as humor or thrill, to foster idea generation through the emotional exploration of experiences.

However, neither framework mentioned above accounts for the sensory qualities of objects. Moreover, there is no direct relationship between a designed object and the emotion that is triggered in a person. Rather, emotion remains subjective to the person evaluating an object, which is dependent on the person's perception. To this end, Diefenbach proposes a framework for describing the sensory qualities of interaction with objects. It relies on dyadic dimensions to describe the 'how' of interaction [7, 22]. Dimensions such as powerful–gentle or approximate–precise are proposed to differentiate and nuance the sensory qualities of interactions. While Diefenbach developed this framework as an inspiration, it does not rely on emotional judgments. Rather, it proposes a repertoire of dyadic dimensions that describe the sensory qualities of interactions without being prescriptive.

Our work builds on this prior research on frameworks that have explored the connection between the emotional and sensory qualities of interaction by adapting a vocabulary of sensory qualities for the IoT design space and by creating a co-design method that adopts this vocabulary for the realm of co-design for the home.

Co-Designing Smart Connected Objects

Card-based ideation tools are proven methods for ideating and exploring design options in co-design (see [40] for an overview). They have a long history in HCI design for supporting divergent thinking and the exploration of design spaces to create new scenarios. They embody elements of the design space on printed cards according to a specific context. These cards contain text, symbols, and pictures, are often color-coded to form categories, and come with a rule set. These abstract representations of technology, people, or services are a powerful means for inspiring and guiding a co-design process. They are often successfully used in design research and practice to structure design processes and to define problems in co-design.

A number of design cards for the IoT design space exists [2, 8, 16, 26]. Most prominently, Know-Cards [2] are a catalogue of 162 cards in four categories (input, output, power, connection), representing the technical building blocks of smart objects. By showing a picture and a description of the functionality, they help to explore the design space but also require the faculty of abstraction. Additionally, such card sets can be used in combination with other card sets to specify very detailed solutions.

Technology-enabled ideation tools [3, 14, 15, 19, 20] foster the design process by providing actual functionality and are particularly valuable for prototyping. This is a challenging balance between offering the full flexibility of a limited set of functions or limited flexibility of a broad set of functions. One example that provides a limited set of functions with full flexibility, is littleBits. Here, functionality is provided in small electronic components, which can be plugged together magnetically to build circuits. littleBits offers power sources, sensors, actuators, and connector tiles [3]. However, design methods with littleBits are limited by the availability of different tiles and the predefined arrangement of tiles. Physikit permits the physical visualization of data sources using cubes [15]. Each data source is mapped to a single cube. Thus, data can have physical manifestations, such as temperature, light, airflow, or motion. However, setting up a data-cube connection requires a web-based app. This makes it difficult to exchange data sources and cubes on the fly to rapidly test new ideas. Overall, such tools tend to focus on defining problems based on existing technology.

A number of co-design tools consider emotional qualities of interaction. A card-based design tool based on the PLEX framework supports designers in ideating for playful experiences [25]. The Positive Emotion Granularity Cards [18] make it possible to reflect emotions triggered by products. The design method "The Thing from the Future" allows co-designers to invent a future object by drawing cards from four decks. Here, one deck represents "mood" and aims to describe emotions that a thing from the future would evoke in an observer from the current time [32]. The IoT Deck [10] incorporates a category, called "emotion", that makes it possible to reflect on the emotional needs of objects or people. It makes it possible, for example, to answer questions such as "What if an object has perception?". This is a starting point for reflecting emotion, but it provides no vocabulary of emotional qualities. While some co-design tools acknowledge the emotional qualities of artifacts, none focuses on the sensory qualities emerging from interacting with smart objects. Even so, the vocabulary of sensory qualities developed by Diefenbach [7] provides a starting point for designing a card set to describe and ideate for the underexplored space of sense and emotion.

Beyond prior research, our work contributes to co-design approaches for the IoT by combining the benefits from three strands of research: (i) card-based methods for structuring design processes and defining problems, (ii) technology-enabled methods for prototyping functionality, and (iii) a vocabulary of sensory qualities for ideating on sensory and emotional qualities.

3 RATIONALE OF THE CO-DESIGN WORKSHOP

There is a growing interest in the CHI community to support people to come up with new ideas for the IoT in the home. Not many approaches consider sensory and emotional qualities, however. To explore this opportunity, we developed a co-design workshop that utilizes Loaded Dice and a card-based set of sensory qualities. This workshop aims at supporting co-designers to ideate smart objects that relate to sensory qualities. Building on our related work, we believe that a sequence of problem definition with a card-based method and a detailed ideation with a technology-enabled tool offers a potentially valuable combined approach to explore the interplay of sensory and emotional qualities. This workshop consists of three phases. In order to explore a problem space, the first phase ignores all technology and has co-designers focus on an issue or problem they encounter in the context of the home. In this phase, the co-designers structure their reflections and choose qualifiers to describe a design scenario. Here, design cards are used to define the location, actors, and sensory qualities of the design scenario. Once the design scenario is defined, in a second phase of the workshop, co-designers translate the scenario into a technological solution concept with the help of the technology-enabled co-design tool Loaded Dice [20, 21]. Here, co-designers directly reflect on how sensory qualities could manifest themselves through functioning sensors and actuators. In a third phase, the design scenario is documented.

First Phase: Problem Framing

In the first phase of the workshop, a domestic problem to be resolved is defined by the co-designers. To explore this problem, co-designers specify context and interaction through goal, actor, and space cards. Co-designers also define sensory qualities for these categories with property cards. For each category, we pre-designed a number of cards and provide blank cards so that co-designers can create their own cards.

Table 1: Description of Design Cards

Goals	tell …that you want to do something together; tell…that you need help; tell …that you think about him/her; tell …that you need peace and quiet; tell …that the meal is ready; tell …that …;
Spaces	inside; outside in the same room; in two different rooms; …;
Actors	human; animal; plant; event; …;
Properties	approximate–precise; casual–attention grabbing; direct–mediated; friendly–angry; graded–binary; incidental–targeted; instant–delayed; objective—poetic; powerful–gentle; private–public; stable–changing; slow–fast; soft-–angry; tender–harsh; …–…;

Goal cards set the goal for the scenario to achieve. Actor cards describe who is involved in the scenario. Space cards define the spatial properties and property cards describe sensory qualities. The pre-defined property cards are an adaptation of the sensory-quality vocabulary of Diefenbach et al. [7, 22]. Property cards relate to how interaction is to be conveyed and perceived. We updated some of properties of the original vocabulary to match the IoT design space. Taken together, these cards are used to frame a problem in the following way: The first step consists of choosing a goal card that sets the main theme of the design scenario. Co-designers interpret the goal card and decide on who will be involved and where these actors will be located. They place space and actor cards on a blank table, which is then partitioned into a left input and a right output section. An arrow below the actors depicts the direction of communication, from sender/input to receiver/output. Together, these cards define the relationships between actors. For example, an animal (actor) that is outside (space) shall communicate with a human (actor) who is inside (space). Once goal, spaces, and actors are defined, co-designers decide on the sensory qualities of input and output by placing property cards at the corresponding sides. Co-designers select and discuss property cards and choose those relevant for the envisioned outcome.

Second Phase: Sensory Exploration

In this step, co-designers translate the scenario into a technological solution with the help of Loaded Dice [20, 21]. Loaded Dice consists of two wirelessly connected cube-shaped devices that inherit the main interaction properties of the IoT through sensors and actuators. The first is a sensor cube with a different sensor on each of its six sides: potentiometer, microphone, infrared thermometer, passive infrared detector, ultrasonic transceiver, luxmeter. The second is an actuator cube with a different actuator on each of its six sides: thermo element, vibration motor, LED bar graph, fan, loudspeaker, power LED. Both devices interact with each other: the face of the sensor cube that shows upwards will sense and communicate the accrued sensor data to the face of the actuator cube that is showing upwards. The ability to reconfigure a sensor–actuator pairing with the simple turn of a cube allows for a tangible exploration of sensor and actor couplings and immediate prototyping of scenarios with sensory qualities.

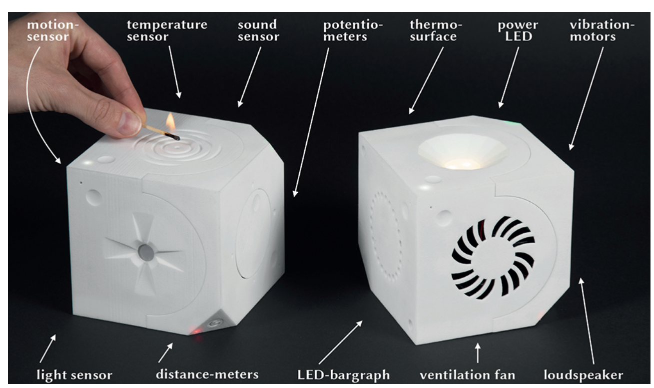

Figure 1: Loaded Dice: Temperature Sensor and Power-LED

After an explanation of the cubes by the facilitator, the co-designers explore Loaded Dice. With the next step, co-designers ideate IoT design scenarios for the home by playfully designing input and output devices, switching between the properties of the card-based scenario and the properties of Loaded Dice. The co-designers select sensors and actuators that they feel relate to the chosen property cards on the table. This triggers a phase of reflection, highlights new aspects, challenges the scenario, and enables it to be transformed into a technical solution. Upon successful testing, hypotheses based on the design cards can be expanded. Property cards can be exchanged, or other sensor–actuator combinations can be tested.

Third Phase: Documentation

Workshop outcomes are documented by taking photographs of how the design cards are laid out for a design scenario. Throughout the workshops, co-designers are encouraged to write directly on the cards to document their design scenario. For the workshops presented here, we also made audio and video recordings of the whole workshop.

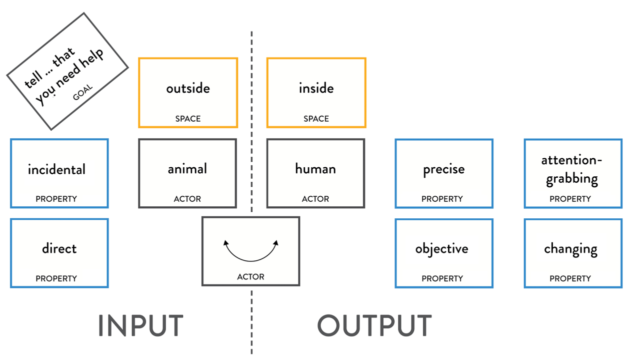

Figure 2: Exemplary design scenario. Here, an animal outside the home communicates with a human inside that it needs help, e.g. to get in.

4 METHODOLOGY

We conducted five co-design workshops with a wide range of co-designers. For WS1, two sisters (20–30) living with their parents participated, WS 2 and WS 3 were with two older adults (65–80), neither of which knew the other beforehand. WS4 was a mixed setting with two younger female students (20–30) and two older male co-designers (60–80). The co-designers in WS 5 were four younger adults (25–40) sharing a house. Our co-designers have a variety of social backgrounds, technology literacies, and design and domain skills. In each workshop, an average of three product ideas was conceived. All workshops were facilitated by the same designer, whose task was to guide co-designers in the design process and to answer questions.

One researcher facilitated the workshops, a second one was present to observe and to take notes. All workshops were audio recorded and transcribed. After each completed design scenario, the cards on the table were photographed. The resulting material was interpreted, coded, and analyzed following open coding, according to grounded theory [36]. The resulting codes were discussed between researchers and organized into emerging categories. Quotes have been translated from German to English by the authors.

5 IDIOSYNCRATIC SMART OBJECTS

Fourteen design scenarios were created by our co-designers. Two of them echo scenarios that, unbeknownst to our co-designers, had gained interest in the CHI community some time ago. The scenario “Gently Hugging You” proposes clothing with pressure actuators and flex sensors for hugging over a distance (see [27]), “Sending Invisible Messages” aims at transporting the pulse of one’s heart over a distance (see [39]). Both reflect a desire to tangibly “feel” close to loved ones and also show the high quality of the co-designs. The two scenarios “Let’s Party Together” and “Virtual Butler Invites” echo the human longing for company by suggesting people to drop in for a party or for sharing a meal. Only two design scenarios—"The Hamster Food Dispensary” and “Automatic Plant Watering”—fall into standard kinds of things people come up with when they struggle to develop radically new ideas for new technology. In the following, we focus on three design scenarios people developed to do relatively mundane, everyday things that they do not know how to accomplish well. We selected these to highlight distinct approaches for translating between sensory and emotional qualities. They illustrate idiosyncratic smart objects for the home.

The Anger Meter

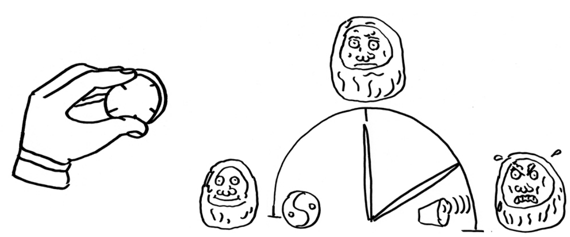

Figure 3: The Anger Meter

A relevant theme for a group of co-designers living together is that their next-door neighbor often complains that they are making too much noise in their home or garden. Thus, the co-designers developed The Anger Meter, a smart object consisting of two devices that helps negotiate noise level and annoyance between their neighbor and themselves. The neighbor would be able to signal his/her anger with a potentiometer, where he can dial up his annoyance level with a knob. At the same time, a microphone would measure the actual noise level. Co-designers frequently switched between their own perspective and that of their neighbor. They describe the neighbors’ communication as angry while stating that they want objective communication on their side. They allowed their neighbor to signal his/her anger by dialing up his/her annoyance level with a knob. Contrasting this, they also wanted to avoid misuse or overuse and added a microphone that allows for comparison of actual and legally allowed noise levels. The co-designers conceptualized an actuator device for their side, which communicates both the subjective anger and the objective noise level. The actuator device would then prompt an immediate reaction by constantly vibrating while also signaling the legally allowed noise levels via an indicator light.

The Automated Rent Debtor

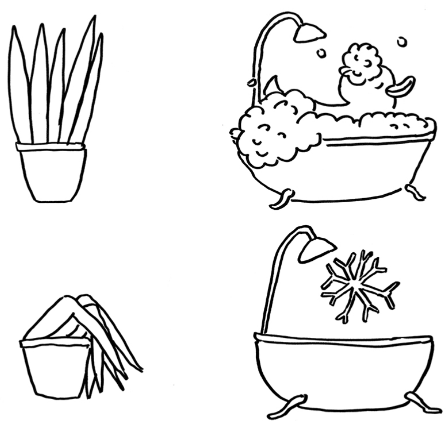

Figure 4: The Automated Rent Debtor

A commonplace issue for co-designers living in a community housing project is that housemates may not pay their rent on time. This has led to frictions within the otherwise harmonious community. To balance these frictions, the residents developed a gradually escalating message system: If one resident does not bank wire his or her rent on time, he or she will first receive a simple text message on a phone. When the rent is seriously overdue, the message would escalate into a form of penalty—the tenant would not be able to take hot showers, for example. This left co-designers with the ambiguous view that this device would be inhumane but simultaneously interesting in terms of design. After this scenario was developed, residents expanded the notion to a helper with household chores that are equally divided between residents. Building on this, residents developed a system that would work with other unfulfilled tasks—when someone has failed to clean up the community workshop, for example. The resident co-designers refused to automate communication between each other, so they decided against text messages and for a slightly ambiguous messaging board for a specific common area, so that all residents would know if a task has been completed on time. They developed the idea of a steampunk to-do list. This message board features a list of tasks with a multicolor light next to each task. Each of these tasks would be monitored by an appropriate sensor, such as a dust sensor for checking whether the workshop is clean, for example. Then, a green or red traffic light next to the portrayal of a task would indicate whether the task has been completed or is overdue.

The Inflatable Cat

Co-designers living together decided to develop a scenario that involves their three-legged cat, Alfred (pseudonym), which they consider to be cooler than people. Co-designers wanted to design a smart object that would support Alfred in what he actually desires. Since the co-designers' flat has no cat flap, Alfred often meows in front of their door hoping for someone to let him. As this can take any time from one minute to one hour, especially at night, they long for a remedy they believe would make Alfred happy. One co-designer formulates the scenario as follows: "Alfred wants to tell us something". The co-designers describe the communication of their cat as poetic and targeted. They decide that a sensor at the front door would recognize Alfred. They subsequently settle for a microphone as a sensor to ideate animal speech recognition that recognizes the meows of Alfred and distinguishes him from other cats. Thus, the co-designers settle for a scenario where the presence of Alfred but not the presence of any other cat would be communicated inside in order to raise attention. They also state that this communication would need to be poetic and friendly, yet instant and attention grabbing. The desire of the co-designers for imaginative and distinct animal–human communication leads to several ideas of what they consider to be poetic. Their final idea, however, consists of a fan instead of a loudspeaker, to not disturb conversations through un-poetic sounds, but still grabbing attention. When Alfred meows at the door, an inflatable but larger copy of himself would be inflated by a fan, then rise to the ceiling and shake. This inflated cat would be located in the residents' bedroom and would only be triggered by the meowing of Alfred the cat via a microphone.

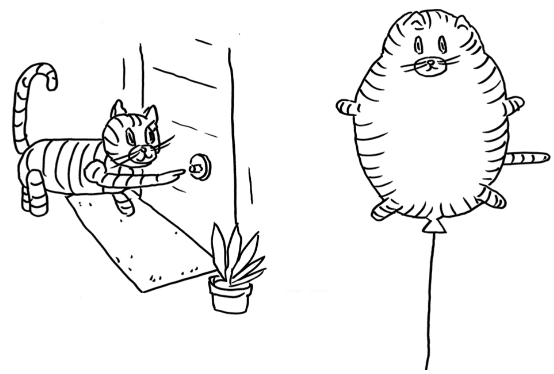

Figure 5: The Inflatable Cat

6 NEGOTIATING SENSORY & EMOTIONAL QUALITIES

We now highlight three salient themes that relate to how co-designers negotiate and translate between sensory and emotional qualities. In particular, we discuss (i) how co-designers are empathic towards absent communication partners, (ii) how they translate and match different qualities of sensory input and intentions, and (iii) how they negotiate interaction through smart objects when non-human actors are involved.

Empathic Inputs

One dominant aspect brought up was the role of emotion, particularly anger, for communication in the domestic context. This becomes visible with the Goal card "Tell … that you need peace and quiet", which was provided as an example only, but was chosen disproportionately often as a starting point. It was interpreted by co-designers as a conflict between themselves and their neighbors. When choosing this card, co-designers systematically chose the sender property card "angry". To understand the issues revealed by this pairing, we rely on "The Anger Meter", where co-designers reasoned:

> *M1: "Targeted, it was direct"*
> *F1: "Yeah, and angry (reading) ... that too"*
> *M2: "And I do not think he wanted to tone that down"*
> *F1: "It was also fast"*

In this scenario, co-designers described a recurring problem of their daily life that can have severe consequences. If they are too loud too often, they could face both personal and legal ramifications. Their neighbor regularly expresses his anger about the noise caused and may eventually escalate this to the police. The neighbor did not participate in the workshop, but co-designers demonstrated empathy in the creation of their scenario by trying to describe their neighbor's point of view and choosing property cards that describe what and how the neighbor might want to express: targeted, fast, angry. As receivers of this information they would only need to know whether the neighbor is angry and whether the noise level would be legally permitted. Accordingly, they first chose the property "binary". In reflecting the other dimension of this card "graded", they figured they might be able to understand better how angry the neighbor actually is. Interestingly, they chose to receive his/her emotion in a non-emotional way by selecting the receiver properties: objective, precise, attention grabbing, and fast. This system was conceived as transforming one person's subjective emotion into objective information. Co-designers acknowledge their neighbor's issues, but reject his anger. As such, they translate the neighbor's emotion into concise and objective interaction on their side. During the second phase of the workshop, co-designers settled on the potentiometer as tool for the neighbor to communicate his/her anger level, which is consequently graded. They then also opted for another level of correctly judging the neighbor's anger. In exploring their design scenario with the help of Loaded Dice, they understood that they could also compare the subjective information of the neighbor's perception of the noise level with an objective measurement of the actual noise level. In addition, the co-designers chose a microphone to measure noise levels. From these two measurements received separately, the recipients would be able reflect on whether the noise level is legally allowed. This would also be used as feedback for the neighbor to reflect whether his irritation is excessive.

Overplayed Outputs

To illustrate how co-designers negotiated a collective intention and how sensory modalities affect that goal, we unpack the scenario of the rent debtor. Here, co-designers ideated a solution for a recurring problem in their housing situation that also seems to be common for other similar co-housing situations. One of the residents frequently does not pay his or her portion of the rent on time. Co-designers picked the property cards "direct", "targeted", "casual", and "fast". They began to question the most important information to communicate: How much money has the debtor to pay? How many days is the debtor late? Here, the cards worked as a support for collective decisions in the first phase:

> *M: "One could also make a different grading and go another way when sometime it won't be private anymore since it concerns everyone when someone owns money."*
> *F: "If it is something like three rents, the whole housing project should probably know."*

Co-designers collaboratively decided that the communication would need to be friendly the first time, but if the payment is extraordinarily late, the qualifier "attention grabbing" would be chosen. The possibility of a graded way to represent the information was discussed, from "friendly" to "factual", depending on the delay and the number of late payments. Co-designers discussed when this information should need to change from "private" to "public". For when the debt becomes too serious, it would concern all residents, who would have to collaboratively cover the rent. We can see here how the cards support going into in-depth reflection about a real-life topic for the residents and their co-living situation, and how the cards helped them to navigate the nature of potentially embarrassing information. During the second phase of the workshop, however, co-designers reflected on how information could gradually shift from "friendly" to "factual" and from "private" to "public"? In exploring the heating element of Loaded Dice, they figured that a smart system could prevent the debtor from taking hot showers, and that a smart system could shut down the heating system in the debtor's room. In these cases, information would be communicated in a private way. While at first conceived as only a private reminder, their decision was skewed by the availability of a suitable actuator for punishment. This was further reinforced when co-designers considered how this could be made public by illuminating the debtor's room with red light. The co-designers noted that their ideation was drifting toward unethical output modalities and considered options without punishment by notifying the person responsible of the house's finances in advance. The initial scenario was concerned with information about a pending payment by a resident. Co-designers considered that this information should be kept private. Later during the workshop, co-designers expanded this scenario to also cover reminders of household chores. Here, they only turned the card "private" to "public" to indicate that this scenario is not overly interfering with money issues, but with more general and less intrusive chores.

Non-Human Poetry

Another indicator that co-designers embrace in the ideation process is the poetic nature of some of the emerging design scenarios. Our workshops encouraged co-designers to reflect on poetic aspects of communication through smart objects, which we will highlight through the scenario of The Inflatable Cat. The smart object conceived in this scenario would allow the cat Alfred to tell residents that it would like to go inside. In the first phase, the co-designers started generating the scenario by choosing an actor card for Alfred that was specified as "alone" and, on the receiver side "several actors". This was to reflect that, outside the door, Alfred does not really care which resident would open the door. When choosing property cards, co-designers tried to qualify the meaning of the meowing. They unanimously selected the qualifier "poetic" to describe the nature of the meowing of their beloved cat, because they can obviously distinguish between different meanings of different meows. They also chose the qualifiers "direct", "targeted", and "fast". They also decided that only Alfred, but no other cat, can go inside after specifying the actor card with "stranger/close relation". They began to reflect on how the information should be received and agreed that the information should be represented by "attention grabbing", but also "poetic" to mimic the cat's intentions. They figured that the actuator of the smart device could literally read aloud random Shakespeare over a loudspeaker to amplify Alfred's voice. It became clearer what co-designers meant by "poetic" in the second phase of the workshop. With further possible technological translations, they detailed a non-conventional and funny way to represent the meowing of Alfred. They drew a parallel between the qualifiers "private" and "poetic" through the following reflection: since Alfred is addressing all inhabitants of the house, the message could be personal, referring to their relationship with their cat, and be adapted to their living context. Co-designers reflected through exploring a microphone placed outdoors to capture the cat's meowing, and that this could distinguish it from other cats. For translating the meowing, various possibilities were considered.

> *F: "A fan in my room ... whenever Alfred meows the fan will start wickedly so that my hair gets blown away. And I will think 'Wicked I really want to open the door now'. ... that would be funnier ... than a loudspeaker." (all laughing)*

What started with random Shakespeare was dialed up to amplified meowing through speakers. Exploring actuators by turning Loaded Dice, it was easy for co-designers to rapidly compare technical qualities to the qualities laid out with cards. The smart object could vary according to the loudness of meowing through a ventilator's air flow. As the final output, they settled on an inflatable dancing cat that would be inflated by a fan when Alfred meows.

7 DISCUSSING IDIOSYNCRATIC IDEATION

Designing new technology for intimate contexts such as the home is a challenging task. Indeed, the concept of 'the home' is a varied and plural concept, with a diverse set of meanings and associations for domestic dwellers. Domestic smart objects need to better account for this to reflect this diversity. While co-design is a useful approach for initiating participation, co-designing emerging technology—perhaps especially for intimate settings such as the home—is still a major challenge. New technology does not yet have social boundaries formed around it, and this can make it hard for people to have a frame of reference for generating design ideas. Next, we discuss how our co-design workshop, drawing on a vocabulary of sensory qualities and Loaded Dice, contributes new insights to help address these challenges. First, our workshop supported co-designers in creating a frame of reference for creating meaningful design ideas. Second, we shed light on the diversity of homes through the idiosyncratic smart objects our co-designers created.

Sense and Emotion as Frames of Reference

Our workshops enabled people to develop their own ideas and concepts for what an IoT artifact might be in the context of their own lives. By focusing on the lived experiences of co-designers, the card set allowed them to frame relevant issues from their homes in a self-determined way. Only later moving to considering issues of functionality, co-designers attributed and negotiated sensory qualities, such as "graded" or “fast”, to the functional attributes of sensors and actuators embodied in Loaded Dice. Looking at participants’ emphasis in both The Inflatable Cat and The Anger Meter, we can see that the co-designers explored various sensory qualities of the emotional status of a person using the sensor side of a smart object. They then translated such a quality into a different actuation to acknowledge this emotional status, while simultaneously translating it into an objective output. The first phase supported co-designers in reflecting on which kind of interaction might make sense in this context. Our cards also helped them to empathize with an absent person. In the second phase, Loaded Dice enabled them to fine tune this translation of sense and emotion, while also understanding that objective sensor measurements are a potentially helpful instance of smart communication. By doing so, even properties such as private–public or objective–poetic can be played out emotionally. This not only facilitates reflection on how a sensory translation between sensors and actors can unfold, it also helps to translate between people on either side of sensor and actuator. For example, it helped to negotiate and to reflect interaction modes between different housing situations and negotiate between conflicting values they have.

With the scenario of The Rent Debtor scenario we can see how the cards helped co-designers to actively decide if the information on the rent delay should be conveyed privately to the debtor or publicly to all residents. The dyadic design of the cards allowed participants to carefully explore variations of the initial idea. For example, residents relied on the private–public property card. Leaving the initial scenario of The Rent Debtor untouched, co-designers turned the card from private to public. By doing so, they created a new scenario, where household chores would be indicated on a public notice board. The complex scenario of The Rent Debtor was changed in only one property, but a completely different scenario emerged. Designing with dyadic dimensions opens a space for carefully inquiring and precisely crafting based on gradation of sensory or emotional qualities, while keeping the scenario relevant.

The scenario of The Inflatable Cat demonstrates how the poetic qualifier supported co-designers in explicitly affirming the choice to develop personal, fanciful ideas. It also reflects a unique and idiosyncratic desire for smart objects to amplify and interpret outside events to serve personal goals and desires in a very poetic way. While the smart object is feasible and would solve a problem the co-housing situation has, it is intriguing to see how the co-design workshop enabled people to translate between sensory qualifiers laid out on the table and possible and suitable technical counterparts. The framework of sensory qualities acted as a catalyst for people to reflect on how a smart object would behave and ultimately would relate to how people feel. By doing so, co-designers were able to attribute emotion to humans and non-humans. For example, they emphasized with their neighbor and acknowledged his/her anger. Here, they designed a sensor that the neighbor can use to voice his/her anger, a device to prove if he/she is rightfully angry and finally an actuator to not only react appropriately, but also to not get emotionally entangled with the neighbor when responding to his/her wish. Likewise, people attributed poetry to their beloved cat in an attempt to solve a problem they understood their cat experienced. By exploring properties by alternating between vocabulary and toolkit, co-designers translated between what it would mean for an interaction to be poetic and meaningful and only then to make a creative leap and to attribute functional properties to an actuator. In doing so, it becomes meaningful for the residents that a fan inflates an air cat to communicate the needs of an actual cat in a poetic way.

In all scenarios, co-designers took various and repeated turns between property cards and Loaded Dice so as to explore a quality and prove its actual interaction. This was salient when co-designers negotiated between the dyadic dimensions of the property cards in reflecting on different behavior for private and public interaction, such as in the scenario of The Rent Debtor. While these are arguably small moves in the whole co-design process, they are key to understanding how co-designers negotiate between abstract qualities and functional aspects, aligning both sides during the process.

These findings raise new questions for the HCI community: How can HCI design further support these small (but crucial) moves of translating sensory perception to emotion and vice versa? There is an opportunity for co-design workshops on the home to start with reflecting and documenting the emotional needs and desires of residents, and then moving on to designing sensory properties of how sensors and actuators of smart objects interact.

Providing sensory qualifiers for co-design workshops increased the possibility for people to focused on emotional aspects in the description of their scenarios. With the cards laid out as formal design support, co-designers could explicitly take a collective decision to match sensors and actuators to emotions. While card-based design tools exist that focus on emotional aspects, or are fully dedicated to emotions [2, 8, 16], to date, none refers to the sensory qualities of smart objects. There is a need for future work for a detailed investigation on how the sensory and emotional qualities of smart objects relate. Taking frameworks on sensory and emotional perception as a starting point, there is a need for design to better understand how people emotionally relate to (micro)-interactions of smart objects and, conversely, how we can leverage the sensory qualities of smart objects in the home to adequately react to the emotions of residents? This is a multileveled inquiry, because sensory interaction can be initiated by objects as well as residents, and the emotional reaction also changes the sensory perception of residents, and perhaps could change that of smart objects too.

Understanding The Diversity of 'The Home' through Idiosyncratic Smart Objects

The overall quality of the examples indicates, that our co-design workshop supported people in ideating novel smart objects that reflect their individual living situations. For example, co-designers showed empathy toward the emotional status of an absent neighbor and toward non-human actors, such as their cat, by confronting and negotiating between cards that embody sensory qualities and parts of the digital co-design tool that depict technological functionalities. We have argued that emotion and sensation are key to understanding idiosyncrasy in the home (e.g., understanding the nuances of how people feel their neighbor would react to them, or how they try to negotiate conflicts through smart objects). Interestingly, co-designers were also able translate these qualities into actuations that embody different sensory and emotional qualities. This enabled them to constantly and explicitly reflect between sensory perception of a smart object and the emotional quality that it would potentially entail. Here, the question arises of how this translation can be leveraged as a resource for co-design in a pro-active way. Design research on smart objects needs to inquire into the emotional and sensory negotiations between people through smart objects.

Future work could also investigate the creation of a more dedicated vocabulary of emotional qualities. For example, how could such a vocabulary enhance a digital co-design tool so as to allow co-designing individual sensors and actuators with sensory qualities that match the emotional qualities selected beforehand? Investigating this question could enable future co-designers to design the sensory output of smart objects, to better match the idiosyncrasies of their home. In this way, our method may be mobilized in future co-design workshops to conceptualize smart objects that enable idiosyncratic communication. For example, sensitive sensor data from the home could be encoded into enchanted smart objects that would display the sensor data in a mode only understandable to the people from a particular home, thus making it harder for people outside that home to decode and subsequently interpret the sensor data.

The examples of idiosyncratic smart objects presented here are salient in the sense that they have significant but situated meanings for the individual residents that designed them and their individual living situation. These smart objects are idiosyncratic in the sense that the ideas are highly poetic and emotionally valuable, but only make sense in the idiosyncratic housing context. We did not deliberately focus on unusual living situations, like [5], for example, but our examples unraveled how idiosyncratic smart objects mirror the housing situation that the co-designers are living in. The Anger Meter makes sense in the context of an older neighbor's need for rest and a younger party crowd living next door. Likewise, The Rent Debtor sheds light on issues of co-housing, such as people paying their share of the rent late, or the ramification residents would consider for such issues. Obviously, in a more common family housing situation, The Rent Debtor would probably be rather unnecessary to have. But by looking at these idiosyncrasies, we unravel some of the values people associate with their homes. However, there is some opportunity for research to further and deliberately contrast unusual living situations [28] and to understand divergent living situations through the smart objects designed for them—which smart objects would unfold from a co-design workshop that focuses on sensory qualities in the house of the angry neighbor, for example. How would he/she design a smart object to deal with his/her anger and the unbearable noise from his/her neighbors?

Situatedness aside, there is a need for HCI design to carefully compare such intersections between neighbors that deliberately design for each other, but also, for example, between similar housing situations on different continents.

The structure of the workshop forced co-designers to first define problems of their domestic reality and only later translate them into ideas. Co-designers were able to actively negotiate between potentially embarrassing interactions and find how to design around them. By the same token, once co-designers drifted away into exploring technical functionalities, they ideated potentially unethical smart objects. While co-designers in our workshop actively reflected on ethical ramifications without interference from the facilitator, the question arises of how future co-design tools could support, and maybe even impose, ethical reasoning and reflection on ideas for future objects.

This ultimately raises the question of how to account for ethics in co-designing smart objects. The design space of always-on, always-connected smart objects raises questions on asymmetrical surveillance in the home. Here, co-design has the obligation to account for ethical decisions and to empower co-designers to design smart objects that are ethical, non-discriminating, and fair. Exploring this obligation for design through emotional qualities is a challenging task. Because, as we have seen with The Rent Debtor, it is easy to drift into designing questionable devices and services.

8 CONCLUSION

Currently, the smart home design space is primarily filled with homogeneous objects that mainly support automation, efficiency, or security. This notion of 'one solution to fit all' is both unsustainable and at odds with the complex richness, fluidity, and diversity bound to 'the home'. The domestic domain is a different place for everyone and, unsurprisingly, it is filled with different meanings and emotional values for different people that dynamically change over time. It is surprising that so little co-design work for this design space has considered designing smart objects that might better account for a diversity of sensory and emotional qualities of people.

We have reported on co-design workshops where we used the co-design tool Loaded Dice [21] together with a vocabulary of sensory qualities [7, 22] that we updated to better match the IoT design space. Through examples from five workshops, we have shown that the workshops enabled co-designers to ideate smart objects based on their sensory reflection. Our analysis was guided by the notion that sensory and emotional qualities of smart objects are actively negotiated by our co-designers and that this allowed them to ideate smart objects that carefully mirror the idiosyncrasy of their homes. Supporting co-designers through sensory qualifiers, led them to associate sensory and emotional qualities in a situated manner. This encouraged co-designers to ideate smart objects that negotiate between wanted and unwanted emotional interaction qualities within the individual boundaries of their home. The creative strategies exhibited are idiosyncratic in the sense that co-designers created ideas for smart objects that are emotionally valuable and that only make sense in their housing situations. Providing a basic set of sensory qualifiers supported co-designing smart objects that relate to emotional needs of residents, neighbors, and non-human actors affected by the living situation.

Our goal has been to shed light on some properties of co-designing smart objects by considering sensory and emotional qualities. There is a need for more research to fully embrace how the IoT design space can be complemented with a vocabulary to describe the sensory perception and emotion of people regarding smart objects and vice versa. Our approach is a starting point for how to explore and negotiate sensory qualities of domestic IoT objects and the emotions they trigger. We hope this to be a starting point for more situated explorations in other contexts, such as different housing situations and different cultural contexts. The idiosyncrasy of the home is a critical angle for HCI design researchers and practitioners to understand and to articulate what people call 'the home', and what they consider fits within its shifting dynamic, socially constructed boundaries. By better supporting people in negotiating between sensory and emotional qualities of potential smart objects for the home, future HCI design efforts can get a better grip on how to design for the idiosyncratic home, beyond the one-size-fits-all approaches bound to current dominant visions of smart objects for the home.

ACKNOWLEDGMENTS

We thank our co-designers for working with us. This work also would not have been possible without Kevin Lefeuvre, who majorly contributed to conducting workshops, gathering data, and offering input on an earlier draft of this paper. Parts of this research are funded by the German Ministry of Education and Research (BMBF), grant number FKZ 16SV7116.

REFERENCES

[1] Aloha Hufana Ambe, Margot Brereton, Alessandro Soro, and Paul Roe. 2017. Technology Individuation: The Foibles of Augmented Everyday Objects. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems (CHI '17)*. ACM, New York, NY, USA, 6632–6644. https://doi.org/10.1145/3025453.3025770

[2] Tina Aspiala and Alexandra Deschamps-Sonsino. 2017. Know-cards, http://know-cards.myshopify.com. Retrieved August, 28, 2018.

[3] Ayah Bdeir. 2009. Electronics As Material: LittleBits. In *Proceedings of the 3rd International Conference on Tangible and Embedded Interaction (TEI '09)*. ACM, New York, NY, USA, 397–400. https://doi.org/10.1145/1517664.1517743

[4] Margot Brereton, Alessandro Soro, Kate Vaisutis, and Paul Roe. 2015. The Messaging Kettle: Prototyping Connection over a Distance Between Adult Children and Older Parents. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems (CHI '15)*. ACM, New York, NY, USA, 713–716. https://doi.org/10.1145/2702123.2702462

[5] David Chatting, Gerard Wilkinson, Kevin Marshall, Audrey Desjardins, David Green, David Kirk, and Andy Boucher. 2017. Making Home: Asserting Agency in the Age of IoT. In *Proceedings of the 2017 CHI Conference Extended Abstracts on Human Factors in Computing Systems* (2017) *(CHI EA '17)*. ACM, 526–533. https://doi.org/10.1145/3027063.3027081

[6] Pieter Desmet. 2002. *Designing emotions*. Ph.D. Dissertation. Delft University of Technology, Department of Industrial Design, Delft. http://studiolab.ide.tudelft.nl/studiolab/desmet/files/2011/09/thesis-designingemotions.pdf Retrieved August, 28, 2018.

[7] Sarah Diefenbach, Eva Lenz, and Marc Hassenzahl. 2013. An Interaction Vocabulary. Describing the How of Interaction.. In *CHI '13 Extended Abstracts on Human Factors in Computing Systems* (2013) *(CHI EA '13)*. ACM, 607–612. https://doi.org/10.1145/2468356.2468463

[8] DSD Cards. DECKAHOLIC. 2018. DSD Cards. http://www.deckaholic.com/lib/dsd-cards Retrieved August, 28, 2018.

[9] Frank Arthur Geldard, Rhys O'Hehir, and Deborah Gavens. 1953. *The human senses*. Wiley New York.

[10] Yen Hao. 2011. IoT Deck: A Digital Card-Based Ideation Game To Inspire Internet Of Things Design. In *Proceedings of IASDR2011, the 4th World Conference on Design Research* (2011), N.F.M. Roozenburg, P.J. Stappers, and L.L. Chen (Eds.).

[11] Marc Hassenzahl. 2004. The interplay of beauty, goodness, and usability in interactive products. *Human-computer interaction* 19, 4 (2004), 319–349.

[12] Marc Hassenzahl. 2018. The Thing and I: Understanding the Relationship Between User and Product. In *Funology 2: From Usability to Enjoyment*, Mark Blythe and Andrew Monk (Eds.). Springer International Publishing, 301–313. https://doi.org/10.1007/978-3-319-68213-6_19

[13] Michael Haverkamp. 2013. *Synesthetic design: Handbook for a multisensory approach*. Walter de Gruyter.

[14] Elina Hildén, Jarno Ojala, and Kaisa Väänänen. 2017. Development of Context Cards: A Bus-specific Ideation Tool for Co-design Workshops.

In *Proceedings of the 21st International Academic Mindtrek Conference (AcademicMindtrek '17)*. ACM, New York, NY, USA, 137–146. https://doi.org/10.1145/3131085.3131092

[15] Steven Houben, Connie Golsteijn, Sarah Gallacher, Rose Johnson, Saskia Bakker, Nicolai Marquardt, Licia Capra, and Yvonne Rogers. 2016. Physikit: Data Engagement Through Physical Ambient Visualizations in the Home. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems (CHI '16)*. ACM, New York, NY, USA, 1608–1619. https://doi.org/10.1145/2858036.2858059

[16] IoTServiceKit. 2018. IoT Service Kit by Futurice. http://iotservicekit.com/#open Retrieved August, 28, 2018.

[17] Carroll E. Izard. 2013. *Human Emotions*. Springer Science & Business Media.

[18] JungKyoon Yoon, Pieter M.A. Desmet, and Anna E. Pohlmeyer. 2015. Positive Emotional Granularity Cards. Delft, Delft University of Technology.

[19] Zuzanna Lechelt, Yvonne Rogers, Nicolai Marquardt, and Venus Shum. 2016. ConnectUs: A New Toolkit for Teaching About the Internet of Things. In *Proceedings of the 2016 CHI Conference Extended Abstracts on Human Factors in Computing Systems* (2016) *(CHI EA '16)*. ACM, 3711–3714. https://doi.org/10.1145/2851581.2890241

[20] Kevin Lefeuvre, Sören Totzauer, Andreas Bischof, Albrecht Kurze, Michael Storz, Lisa Ullmann, and Arne Berger. 2016. Loaded Dice: Exploring the Design Space of Connected Devices with Blind and Visually Impaired People. In *Proceedings of the 9th Nordic Conference on Human-Computer Interaction* (2016) *(NordiCHI '16)*. ACM, 31:1–31:10. https://doi.org/10.1145/2971485.2971524

[21] Kevin Lefeuvre, Sören Totzauer, Andreas Bischof, Michael Storz, Albrecht Kurze, and Arne Berger. 2017. Loaded Dice: How to cheat your way to creativity. In *Proceedings of the 3rd Biennial Research Through Design Conference* (2017-03-20). https://doi.org/10.6084/m9.figshare.4746976.v1

[22] Eva Lenz, Sarah Diefenbach, and Marc Hassenzahl. 2014. Aesthetics of Interaction: A Literature Synthesis. In *Proceedings of the 8th Nordic Conference on Human-Computer Interaction: Fun, Fast, Foundational (NordiCHI '14)*. ACM, New York, NY, USA, 628–637. https://doi.org/10.1145/2639189.2639198

[23] Jennifer S Lerner and Dacher Keltner. 2000. Beyond valence: Toward a model of emotion-specific influences on judgement and choice. *Cognition & emotion* 14, 4 (2000), 473–493.

[24] Jonas Löwgren. 2009. Toward an Articulation of Interaction Esthetics. *New Rev. Hypermedia Multimedia* 15, 2 (Aug. 2009), 129–146. https://doi.org/10.1080/13614560903117822

[25] Andrés Lucero and Juha Arrasvuori. 2010. PLEX Cards: a source of inspiration when designing for playfulness. In *Proceedings of the 3rd International Conference on Fun and Games* (2010). ACM, 28–37. https://doi.org/10.1145/1823818.1823821

[26] Simone Mora, Francesco Gianni, and Monica Divitini. 2017. Tiles: A Card-based Ideation Toolkit for the Internet of Things. In *Proceedings of the 2017 Conference on Designing Interactive Systems (DIS '17)*. ACM, New York, NY, USA, 587–598. https://doi.org/10.1145/3064663.3064699

[27] Florian 'Floyd' Mueller, Frank Vetere, Martin R. Gibbs, Jesper Kjeldskov, Sonja Pedell, and Steve Howard. 2005. Hug over a Distance. In *CHI '05 Extended Abstracts on Human Factors in Computing Systems* (2005) *(CHI EA '05)*. ACM, 1673–1676. https://doi.org/10.1145/1056808.1056994

[28] Doenja Oogjes, William Odom, and Pete Fung. 2018. Designing for an Other Home: Expanding and Speculating on Different Forms of Domestic Life. In *Proceedings of the 2018 Designing Interactive Systems Conference (DIS '18)*. ACM, New York, NY, USA, 313–326. https://doi.org/10.1145/3196709.3196810

[29] Andrew Ortony and Terence J Turner. 1990. What's basic about basic emotions? *Psychological review* 97, 3 (1990), 315.

[30] Marianne Graves Petersen, Ole Sejer Iversen, Peter Gall Krogh, and Martin Ludvigsen. 2004. Aesthetic Interaction: A Pragmatist's Aesthetics of Interactive Systems. In *Proceedings of the 5th Conference on Designing Interactive Systems: Processes, Practices, Methods, and Techniques* (2004) *(DIS '04)*. ACM, 269–276. https://doi.org/10.1145/1013115.1013153

[31] James A Russell. 2003. Core affect and the psychological construction of emotion. *Psychological review* 110, 1 (2003), 145.

[32] Situation Lab. 2018. The Thing From The Future – Situation Lab. http://situationlab.org/project/the-thing-from-the-future/ Retrieved August, 28, 2018.

[33] Alessandro Soro, Margot Brereton, and Paul Roe. 2018. *Social Internet of Things*. Springer.

[34] Alessandro Soro, Margot Brereton, Paul Roe, Peta Wyeth, Daniel Johnson, Aloha Hufana Ambe, Ann Morrison, Shaowen Bardzell, Tuck Wah Leong, Wendy Ju, Silvia Lindtner, Yvonne Rogers, and Jacob Buur. 2017. Designing the Social Internet of Things. In *Proceedings of the 2017 CHI Conference Extended Abstracts on Human Factors in Computing Systems* (2017) *(CHI EA '17)*. ACM, 617–623. https://doi.org/10.1145/3027063.3027069

[35] Statista. 2018. Smart Home - worldwide | Statista Market Forecast. https://www.statista.com/outlook/279/100/smart-home/worldwide Retrieved August, 28, 2018.

[36] Anselm Strauss and Juliet Corbin. 1998. *Basics of Qualitative Research: Techniques and Procedures for Developing Grounded Theory* (2 ed.). Sage Publications, Inc.

[37] David MH Thomson, Christopher Crocker, and Christopher G Marketo. 2010. Linking sensory characteristics to emotions: An example using dark chocolate. *Food Quality and Preference* 21, 8 (2010), 1117–1125. https://doi.org/10.1016/j.foodqual.2010.04.011

[38] Patrik Vuilleumier. 2005. How brains beware: neural mechanisms of emotional attention. *Trends in cognitive sciences* 9, 12 (2005), 585–594.

[39] Julia Werner, Reto Wettach, and Eva Hornecker. 2008. United-pulse: Feeling Your Partner's Pulse. In *Proceedings of the 10th International Conference on Human Computer Interaction with Mobile Devices and Services* (2008) *(MobileHCI '08)*. ACM, 535–538. https://doi.org/10.1145/1409240.1409338

[40] Christiane Wölfel and Timothy Merritt. 2013. Method Card Design Dimensions: A Survey of Card-Based Design Tools. In *Human-Computer Interaction – INTERACT 2013* (2013), Paula Kotzé, Gary Marsden, Gitte Lindgaard, Janet Wesson, and Marco Winckler (Eds.), Vol. 8117. Springer Berlin Heidelberg, 479–486. https://doi.org/10.1007/978-3-642-40483-2_34

[41] David H Zald. 2003. The human amygdala and the emotional evaluation of sensory stimuli. *Brain Research Reviews* 41, 1 (2003), 88–123. https://doi.org/10.1016/S0165-0173(02)00248-5