Living with Drones, Robots, and Young Children: Informing Research through Design with Autoethnography

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Figure 1: The DJI Tello Drone, picked up by the small hands of a three year old.

ABSTRACT

Supporting the study of child-drone interaction in domestic spaces is a difficult endeavour, but of value to the development of this robotic platform. This paper presents an autoethnographic study, serving as an exploratory first-person method to surface issues and opportunities in this design space. Autoethnography is increasingly popular in HCI, but to further support its application, I combine it with a Sociotechnical Systems (StS) perspective, informing the analysis and development of descriptive narratives with systems theory. This paper is based on a year-long documentation of the interaction between my family and a set of three land robots and one flying robot. I present work in the form of critical incidents and lessons learned, and a set of design opportunities for child-drone interaction to inform a research through design probe development. The combination between StS and autoethnography proved fruitful in understanding how drones may currently be brought or gifted into the home without fully considering the effects and implications of their use. Furthermore, I offer reflections on the use of autoethnography for other researchers when living and involving their family with their research material.

CCS CONCEPTS

• **Human-centered computing** → **Field studies**.

KEYWORDS

human-drone interaction, human-robot interaction, autoethnography

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1 INTRODUCTION

Drones are becoming increasingly common in public and domestic spaces, and bring with them a set of complex challenges in, for example, design, legislation, engineering, and ethics. It is fundamental to research how this technology is impacting society and what considerations should be taken when designing drones. To support research within Human-Drone Interaction (HDI) I present an autoethnographic study as a first step towards a research through design (RtD) approach: putting emphasis on detailed and evocative qualitative data to support work on small provocative RtD probes

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[17]. To inform the design, I have been conducting a year-long longitudinal study at home, with my own children (aged 6 and 3) and four commercially available robots, one of them being a drone. While the focus of this paper is drones, the combination of different robots aimed at supporting a variety of perspectives, and finding potential common or divergent characteristics between flying robots and other types of domestic robots. The study contributes with a description of experienced qualities of flying robots in a natural domestic setting.

Figure 2: An image of the three indoor robots: Doc, the humanoid robot; Tello with feathers (the drone); and Purrble, the stuffed animal robot. Elsa's and Anna's hands can be seen for scale.

This article is grounded on my own first-person knowledge as part of the system being studied, conducted as an autoethnography. In order to structure and facilitate the systematisation the knowledge acquired through the autoethnographic method, I have combined it with a Sociotechnical Systems (StS) approach. I define and describe my family as a micro-sociotechnical system (micro-StS) supported by an existing StS framework. The novel combination between the method and the StS perspective aims to be translated into an experimental system approach to design research [7].

The combination of methods resulted in valuable and intimate insights which might have been otherwise missed, aiming to understand aspects of the incorporation of (potentially disruptive) robots into everyday family life, and what implications they bring. What are the expectations of a grandparent who buys a toy drone for their grandchild? What is the impact such technologies have within a family? While policy-making and regulations are important, and should be informed by research within HDI, this autoethnographic approach instead puts emphasis on unpacking some of the values and qualities materialised into the design drones [47] for children from a micro-ethics perspective [42]. Through this study, I have found how my home was impacted in this manner and witnessed unexpected changes in the relationships between family members.

2 BACKGROUND

In this section I give insight into the theoretical and methodological background of this work, starting with a departure from an epistemological description of Third-Wave HCI. This is followed by the suggested role of autoethnography as an essential part of the designerly work within Research through Design (RtD), and finally a novel combination between Sociotechnical Systems perspective and autoethnography to facilitate sense-making and analysis as well as a description of the family as a micro-StS. This combination is framed by two research questions: *"What is the contribution of an auto-ethnographic study, supported by Sociotechnical Systems, in formulating design considerations for Research through Design?"* and *"What is the impact of incorporating toy drones in a domestic environment with small children?"*.

2.1 Situated Perspectives

The present research is placed within the third wave of HCI [3, 18, 27], which is informed by many perspectives grounded on understanding interaction as phenomenologically situated. "The goal for interaction is to support situated action and meaning-making in specific contexts, and the questions that arise revolve around how to complement formalized, computational representations and actions with the rich, complex, and messy situations at hand around them. Because of its emphasis on multiple meanings made in context, we term the third paradigm situated perspectives." [18]. In short, the third wave recognises the prominence of relationships and meaning-making between humans and machines in context. This wave brings an emphasis on experience as the primary object of study, which has a relevant impact on what methods are suitable.

Design problems are generally wicked [5, 38], and therefore, can only be tackled with a large degree of flexibility, where methods need to often be adapted to the specific and unique issue at hand, with more interest in their direct applicability than in generalisation [43]. This justifies a shift towards a less strict use of methods, where pragmatism is the rule. If all knowledge, use, and experience is assumed to be situated and contextualised, then it is not surprising that ethnographic methods saw a rise in acceptance in this third wave HCI, particularly as a set of approaches that inform system requirements [24].

Ethnography is a common way to tackle the situated nature of these interactions, including longitudinal studies being applied to families in their homes, in order to reveal the intricacies of their experiences. Fernaeus et al. [15] for example, describe a longitudinal study where a robotic toy animal was sent to six families. Petrelli and Light [37] on the other hand presents an intricate study of eight families in Northern England, where the results are presented in the manner of rich and detailed histories of how these families celebrate Christmas, without any new technology being the main object of study. Mazmanian and Lanette [34] set out to understand the difficulties of parenting in a digital age through ethnography stating even that "as with all ethnographic research, the ideal of a large and 'representative' sample size is replaced with depth of insight and nuance of findings.". Derix and Leong [9] uses probes to understand different perspectives within sets of parents. While all these studies support a rich and phenomenological situated understanding of the interactions, they do not serve to give a first-person

perspective to the researcher, nor to inform a RtD process from a unique personalised and intimate standpoint. The detail in the reports in the third person may lack some of the more interesting critical challenges which surface through autoethnographic approaches.

2.2 Autoethnography in RtD

Autoethnography is an increasingly popular approach within third wave (and potentially fourth wave [16]) HCI, which takes into consideration the importance of first-person understanding of the technology at hand and uses the personal experience as research material [13]. Ellis et al. [13] describe how autoethnography is a merging of an autobiographical method with the ethnographical one, while challenging ideas about the separability of researcher and research product. Within HCI, Ljungblad [31] used a life-logging passive camera alongside her participants, while Höök [22], for example, transfers many of the qualities she found in her own practice of horseback riding into design. Lucero [33] reports on living without a mobile phone, offering important themes to be considered when designing for that technology. Homewood et al. [21] propose removal of technologies as a method for fourth wave HCI based on two autoethnographies on self tracking. A similar approach, connected to RtD, is named autobiographical design, where probes are used by the designers themselves [35]. Yang and Neustaedter [49] reports on a three month period use of a telepresence robot to support a long distance relationship, and Lockton et al. [32] develop the notion of autoethnographic 'kits' through the work of undergraduates related to their sleep routines. In a more intimate context, Helms [19] uses autobiographical design to discuss more-than-human materials and agencies in the context of breastfeeding.

In this privileged position as a researcher, we are endowed with the capability to tell stories. But this process is not without ethical and epistemological trouble, which could end up in severe difficulties to be executed and published [48]. Desjardins and Ball [10] present sincerity, collaboration and authority, and inventiveness as recommendations for autobiographical design projects. I incorporated these into my work in the form of values to be followed while reporting the results.

When approaching design projects with a RtD agenda [17, 29, 51], we must understand that designers "make all kinds of decisions and judgments, such as, how to frame the situation, who to listen to, what to pay attention to, what to dismiss, and how to explore, extract, recognize, and choose useful information from all of these potential sources." [43]. Ellingson [12] describes how autoethnography incorporates embodied experiences directing attention not only on what is said or done, but how it is felt, how the researcher's body is positioned and understood in space. Therefore, it is vital to incorporate the first-person perspective of the designer into the research process, particularly when defining the design space. Hence, I consider autoethnography necessarily and directly connected to RtD. However, I recognise a difficulty in analysing data generated by the researchers themselves, and in articulating design considerations which can be applied in further research. Therefore, I set out to experiment on a combination of methods which would work to this end, and recruited a perspective I had been interested in: Sociotechnical Systems.

2.3 Sociotechnical Systems

Sociotechnical Systems (StS[1]) is an example of a holistic theory compatible with design research. It can be combined with an understanding of 'soft systems', which opens up for not only focusing on the system itself, but on one's methodological approach to it [6]. 'Soft systems' are open and ill-defined systems, where there are divergent views of what constitutes a problem, and even on what the system boundaries are (what elements constitute the system). In the context of this research, studying social drones could encompass a large number of specific goals to be tackled. Social drones, as defined by Baytaş et al. [2] are "applications where fully autonomous drones operate in spaces populated by human users or bystanders". In the case of current research we depart from teleoperated drones to study relationships built in society which will eventually inform the design of fully autonomous drones. In the case at hand, I advocate for an approach where a singular research goal is not primary, and that the wicked nature of the research field of social drones requires alternative methods.

By combining StS with autoethnography, the aim is not to abstract knowledge or reduce designer bias into the design process, but instead to incite deep phenomenological first-person experiences as a part of the design process and a factor to consider as part of the system itself [23]. The main aim of this paper is to inform a detailed understanding of a design space, and to that end I propose and engage with autoethnography combined with StS as a suitable method for designers, as it allows for a deep, personal, and detailed understanding of the systems themselves. To be able to study other families, it is important to consider one's own standpoint as a researcher and designer as a first threshold in sensibility towards other engagements with emerging micro-interactions. Applying methods and frameworks pertaining to StS when planning, conducting, analysing, and presenting ethnography may be a suitable approach.

As exemplified by Kirwan [28], the application of StS and 'soft systems' is more clearly connected to industries and work places [28] [2]. In this paper, I argue that a family is a 'soft' multi-level (albeit small) system. Due to the relatively small number of elements in families and the tacit nature of the relationship built between them, I denominate the system being studied a micro-sociotechnical system (micro-StS). The distinction between StS and micro-StS is made to allow for systems with much more limited boundaries to be studied and analysed while indicating a high degree of variability and flexibility stemming from the volatility of the elements. The emphasis on a micro-StS is on short emergent and tacit situations which may at first seem nearly insignificant.

[1] STS can also be an abbreviation for Science and Technology Studies, which is not to be confused with the use of StS in this paper for Sociotechnical Systems

[2] I feel however that I must take an epistemological stance against Kirwan's understanding of soft science as described: "The paper itself is written in less formal style than is usually the case for journal articles; this is partly because it is very much a condensation of practical experience rather than of scientific knowledge or data, and also because a more formal style may lose some of the impact of the lessons that have been learned." [28] Practical experience is most definitely worthwhile knowledge which should not be directly connected to informality or lack of rigour.

Silverstone [40] refers to "domestic socio-technical systems" while studying in detail the intricate network of computers, televisions, telephones, all of which have shifted from having a particular place in the domestic environment to now being mobile. The domestic space has been extended outside the walls of the home, and therefore, the StS I am studying considers the family its core, rather than the technologies. Even without always explicitly mentioning StS, there are studies that already describe families as system. An example is provided by Taylor and Swan [44], where the systems created by caregivers to organise their own families result in design artefacts in the home. One of the robots appropriated in this study (Purrble) is the result of a well developed design process informed by StS [41, 45]. Multiple stakeholders in families inform the design, becoming an example of how the whole family ought to be taken in consideration when creating domestic probes "The principles of socio-technical design then apply on multiple levels: how the (technology-enabled) intervention becomes embedded into the current practices of an individual or the family unit; which mechanisms are assumed to lead to shift of these practices; and on which timescales and through which 'levers' this happens in the family context." [41]

3 METHOD

To gain a deep understanding of incorporating small drones into domesticity, I have conducted a longitudinal autoethnographic study with my family and the places where we live as a unit. As pointed out by Leite et al. [30], longitudinal studies are helpful to explore beyond the novelty value of social robots, particularly in a domestic setting. In this article, I report on a year long introduction of off-the-shelf remotely controlled DJI Tello drones into the micro-StS (our family). The goal was to understand how a drone may be experienced and used by a family in everyday life over a longer time period. The insertion of new technologies into the existing micro-StS results in new interactions which can be turned into important design insight: "Humans and technologies in households are interconnected as members or elements of the same system. When a new element is introduced to the system, the system goes through a process of integration that may result in the re-organization of roles, relationships and functions." [26]

The studies started in December 2020 and span so far until November 2021. I have documented the events through photo, video, and diary notes. The results presented stem from the most relevant events and opportunities to serve the definition of the design space. I identified and organised elements in the sociotechnical system as shown on Figure 3. Each of these elements or nodes is described in the following subsection.

As a novel approach to autoethnography and an aid to guide the reporting and documenting of the results, I have used representations of the system based on the framework presented by Davis et al., which stems from a schema that has been developed by a number of authors. For Davis et al. "the core idea is that any complex organizational system can be represented in the form of a hexagon" [8]. The framework is described as: "(...)a work system will usually have a set of goals and metrics, involve people (with varying attitudes and skills), using a range of technologies and tools, working within a physical infrastructure, operating with a set of cultural assumptions, and using sets of processes and working practices. The system sits within a wider context, incorporating a regulatory framework, sets of stakeholders (including customers), and an economic/financial environment." [8]

This framework is used in this paper to support the reader's interpretation of the narratives exposed which can be highly tacit and difficult to pinpoint. The advantage of this framework in particular is that it focuses not only on accident analysis which is important for many work systems, it instead "is an attempt to provide a simple yet powerful representation of the interdependent nature of work systems, providing a framework for analyzing the linkages and relationships between the different social and technical aspects. The potential value of applying such an approach is that it provides a structured and systematic way of analyzing a variety of complex systems, problems and events."[8]

In the current work, the wider context is given by the research project it is framed within, and driven by the academic and research expectations described in the background.

3.1 Description of the System

In this section I describe the elements or nodes represented in Figure 3. Each of the elements or nodes can also be found on Table 3.1. The study was conducted with our core family of four, composed of the **people** mentioned on Table 3.1. This description was developed at the start of the study in order to support a reflective analysis of the context at hand. As the system is being researched through autoethnography, I based the description on my own perception of our family and of my goals with the study. While the use of an StS approach attempts to make the representation of the autoethnographic context more systematic, it is also not possible to read this description as an objective characterisation of my family. As a member of the system myself, my views are undoubtedly biased, and the forging of the system does not attempt to hide that fact.

The **buildings/infrastructure** involved are mostly our apartment, but also a couple of other family vacation locations. Our apartment is a three bedroom on the second floor, 95 square meters, but located in a three family villa where we share a garden and outside space.

The **robots or technology** studied can also be seen on Table 3.1. There are 3 land robots and 1 flying robot. Firstly, Grassy [3] is an outdoor lawn mower and existed in our home before the study started. Doc [4] is an educational humanoid robot with a simple set of tasks and games to support learning programming, and had also been bought at least two years previous. Since the research is focused on drones, Tello [5] represented the most relevant robot and was acquired at the start of the study. The Tello drone is sold and advertised as a drone for children, also supporting activities to learn programming. To match it with another robot, I brought home Purrble [6] as an important addition due to the research background behind its development [41, 45] and contrasting characteristics to the drone (soft, quiet, static).

The main **goals** for the system for this particular study are threefold: wellbeing, documenting, and research. Wellbeing is an

[3] https://www.worx-europe.com
[4] https://www.clementoni.com/fi/78281-doc-educational-talking-robot/
[5] https://www.ryzerobotics.com/tello-edu
[6] https://www.purrble.com/

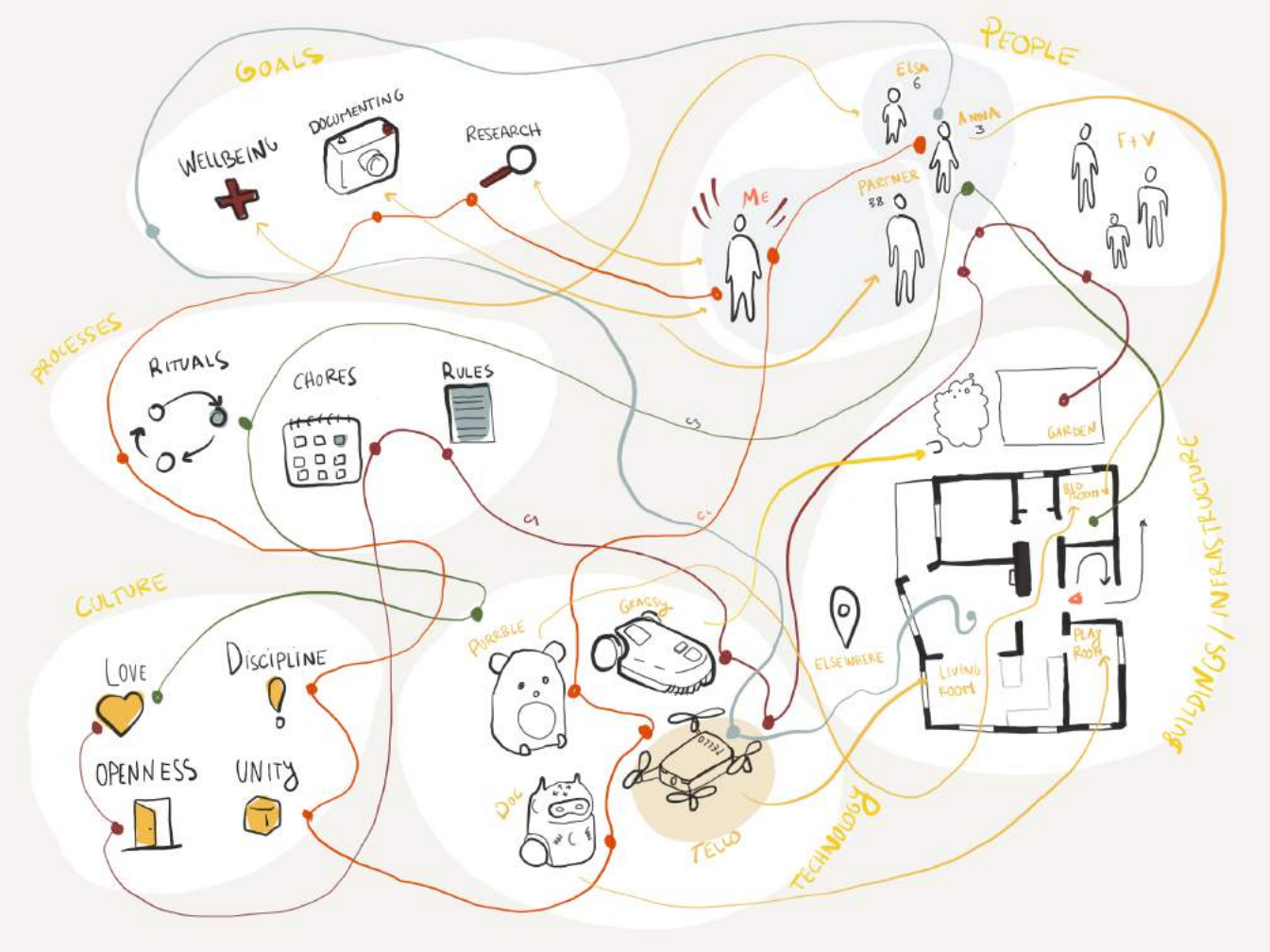

Figure 3: To the left, the autoethnographic study as a micro-sociotechnical system based on the StS framework presented by Davis et al. [8]

overarching goal for our family and can include sub-goals such as play, feeding, supporting, or even supporting a quiet environment. The goals as a family are a lot more difficult to describe – these particular three were chosen as the ones leading the interactions and initiatives we take in our home in the context of this study. Therefore, DOCUMENTING and RESEARCH became the primary aim.

The **culture** in our home is relevant to the interactions that surfaced. I identified love, discipline, openness, and unity as essential principles for our family. In general, our parenting is focused on having open relationships where we discuss emotions without hiding them from the children, and promoting their sharing. Furthermore, we consider our home an open environment where friends are welcome spontaneously, but we still make sure to communicate that we are one unit in acting and making decisions. An important value is discipline, which results in clear rules and boundaries and rules everyone follows, such as keeping order and cleanliness in the apartment.

The most relevant **processes** in the study are rituals, chores, and rules. Related to the value of discipline, there are clear rules that we follow at home (e.g. shoes are left in the hallway, no candy during week days). Life with younger children is filled with rituals (e.g. bath-time, bed-time, story-time), but also chores (e.g. cleaning after play, taking plates from the table to the kitchen sink). Examples of these processes are relevant to the descriptions of the interactions that emerged.

4 RESULTS

The results are presented in two sections: (a) micro-StS system driven critical incidents which are "documented incidents of use; and careful articulation of the impact of design decisions on experiential qualities of the system in use" [35] and (b) opportunities for child-drone interaction design probes. The first section includes the description of critical incidents informed by the different categories in the StS system described above. Figure 3 shows particular threads

People	
Me	Me, aged 33, researcher and mother to Anna and Elsa
Partner	My husband, aged 39, father to Anna and Elsa
Elsa	Oldest daughter, aged 6, older sister to Anna
Anna	Youngest daughter, aged 3, younger sister to Elsa
F	Other close family members
V	Visitors

Buildings/Infrastructure	
Living Room	Kitchen, living room and dining room in open space
Bedroom	Elsa and Anna's bedroom
Playroom	Elsa and Anna's Playroom
Garden	Outdoor space in a garden / terrace
Elsewhere	Other outdoor locations

Culture	
Love	We care for one another.
Discipline	We respect each other and follow rules.
Openness	Our doors are always open, we share our experiences.
Unity	We value our small family as a priority.

Technology	
Tello	DJI Tello Drone
Purrble	Purrble, a stuffed animal robot
Grassy	Worx Landroid, robot grass mower
Doc	Clementoni DOC, educational talking robot

Processes	
Rituals	We have set rituals and routines we follow together.
Chores	We have tasks to do in the household.
Rules	We have set rules to respect.

Goals	
Wellbeing	The physical and mental health of all members.
Documenting	Producing documents our interactions.
Research	Producing valuable research.

Table 1: A table describing the identified elements in the six categories of the system as represented on Figure 3. These categories are as presented by Davis et al. [8].

connecting elements of the system which are described below as narratives.

4.1 Critical Incidents and Narratives

In the following sub-section I present diary extracts from incidents that happened, either during short phases or as repeated behaviour. The results presented are analysed through the StS framing, by first gathering and describing the situations through the diary logs, identifying the StS elements present, and developing a narrative of sense-making grounded in both the narrative and the pinpointed elements. Therefore, some of the extracts were written in one session, while others are composed from a set of different events. The selection of incidents to be included was curated to support and illustrate the understanding of the subsequent opportunities for child-drone interaction.

4.1.1 ***Not in bed:*** As we were going to bed, after brushing our teeth, Purrble was lying in Elsa's bed together with a number of other stuffed toys. Usually, we read a book before falling asleep but Elsa was more interested in arguing as to why we should get a pet, a real one, not a fake one like Purrble. This small discussion had entirely disrupted our usual bed-time ritual but since I was interested in her reflections I let it continue. As she was overcome by sleepiness, she asked me to turn off the robot and put it away but still in bed. When I asked her why, she said: "I am afraid it will wake me up.", Are you not afraid a real pet would also wake you up?,"Maybe...", But you are not afraid I will wake you up?, "I know you want me to sleep.", Do you still want a pet?, "Maybe not, not if it wakes me up.".

StS Elements: Goals: Wellbeing; People: Me, Elsa; Culture: Love; Processes: Rituals; Technology: Purrble; Building: Bedroom;

Sense-making: Even though the aim of this robot is to support children's self-regulation of strong emotions through a comforting heartbeat, the sound was not a welcoming factor in Elsa's most intimate moment of sleep. Its soft body made it a logical addition to all the other stuffed toys which "watch over" the children in bed, but its interactive abilities set it apart. Luckily, this led into a discussion about companionship and pet ownership which was valuable for our family.

4.1.2 ***Visitors, Fear, and Enactment:*** On a particularly sunny summer day, we had visitors over, including two girls aged 8 and 6. The father was interested in the research I am doing and immediately started touching and asking about the drones. We went outdoors to our garden, and I took with me some extra batteries. The visiting children were interested in being able to control the drone, but the father was very hesitant. We played for some minutes a game where the drone chased the kids, which had become the number one activity we did. The father in the visiting family suggested the kids would try driving the drone, but it became clear the drone was too difficult to drive for the visiting child. Instead, the children ended up pretending they were driving on the phone, while Elsa held the drone in her hand, enacting flight. An image of this enactment can be seen on Figure 4. A similar situation happened when we were out, during the winter, and I took the drone for a visit to the children's grandparents where we went snow sledging. Both of the grandparents never showed any inclination to fly the drone, and were genuinely afraid of driving it. The drone was seen as more of an annoyance rather than an interesting way to document the day.

StS Elements: Goals: Wellbeing ; People: Core Family plus Visitors; Culture: Love, Discipline; Processes: Rules; Technology: Tello Building: Garden and Elsewhere;

Sense-making: While the children had no reservations towards the drones, the adults were more careful. Upon further inquiry, I noticed they were either afraid the children would get hurt or the drone would be destroyed. Remarkably, children themselves found ways around the limitations, through deeply embodied enactment

of the technical interactions they could not perform. Their activity made the drone active even though it was turned off. Furthermore, the fact that I did not even consider flying the drone indoors with that many children at home made me realise I was afraid of doing so – would I not be afraid as well to conduct other ethnographic studies with other children?

4.1.3 ***A Broken Pool:*** Since its installation, the robot lawn mower (Grassy) had been an object of entertainment for the family. I found myself and the neighbour downstairs often staring at it as it moved around the garden. When it was first installed, the path it would follow was rather defective, and the children found it amusing to wake up in the morning and check where the robot had gotten stuck, and would say "Poor little robot". On a summer evening, we filled a small inflatable pool with water and left it outdoors over the night. The next morning, the robot had cut through the plastic and the pool was ruined. The feelings of the children towards the robot changed somewhat after this event, and in the morning, they were no longer as worried about the robot, but rather more concerned to remove things from its path. Curiously, Anna is a lot more comfortable with the mower than with the drone. When I asked her about it, she was unable to say why. But as time passed, I noted how she knew exactly what the lawn mower could do and where she would be safe from it, which she never could with the drone. Its predictability became a reassurance.

StS Elements: Goals: Wellbeing ; People: Core family ; Culture: Discipline, Openness ; Processes: Rules; Technology: Grassy; Building: Garden;

Sense-making: Both the children and adults in our household often laughed at the small troubles Grassy would find itself in during its grass-cutting tours (An example lawn mower in trouble can be seen on Figure 4). The mishaps became part of a constructed personality. But once it started harming their ownership, the children quickly started rearranging their environment around it because they could better understand where the robot would go: the predictability of the path of the lawn mower is a safety point and a quality. They never asked if the robot could be put away or turned off, they instead adapted their lives to its presence. What could be the potential accommodations made towards a companion drone in the home?

4.1.4 ***Talking About Robots, Autonomy, and Ownership:*** Six months after the drone was brought into our apartment, the children had been talking about robots in school. They came home imitating a robot (talking slowly, moving with stiff arms). We had repeatedly tried to talk about what a robot is or is not, but their opinions changed throughout the year. According to Elsa, of the robots we had at home, only the drone was not one. Why is that? "This one can speak.", she says, picking up Doc. But the other ones do not "Yes, the fluffy one does. Just a little. Like this.", and she starts imitating the gibberish Purrble does when happy or sad. But what about the lawn mower? "It is also a robot, it does what it wants.". When further questioned, the drone seemed to lack agency in her eyes, even if the humanoid robot (Doc) also needed to be controlled through the buttons on its head, the fact that it could talk back was perceived as agency. Another interesting piece of this conversation had to do with ownership. While the robots that lived in our home were seen by the children as ours, the lawn mower seemed to own itself, which contributed to its robotic status. It was clear to Elsa that the drone was mine, Doc was hers, and the Purrble was everyone's. Doc was therefore a toy robot, the Purrble a pet robot, and the drone just mom's stuff, therefore not a robot.

StS Elements: Goals: Wellbeing, Research; People: Me, Elsa; Culture: Openness; Processes: Rules; Technology: All; Building: Living Room;

Sense-making: The repetitions of ownership continued beyond this journal entry. Both the children had a hard time ever perceiving the drone as a robot: what was constant was the argument of ownership. This made me reconsider the way the drone was introduced to the family – perhaps I made a mistake not gifting it to one of the children. The Purrble, for example, has a very well designed box where the transfer of ownership is made to the children in a careful manner. In what way could the sense of autonomy and ownership be developed with the drone?

4.1.5 ***Excluding the Small One:*** During this year of engaging with robots, Anna, who has been between 2,5 and 3,5 years old has developed a complicated relationship with the drone. While at first both children were equally excited when the drone was flying, as time passed, Anna became wary of the robot. Her body language showed clearly that she was not up to any closer contact (e.g. the second image in Figure 6, where Anna holds her arms up. Picture taken from the drone's perspective), and very seldom asked for the drone to be active. In comparison, she was always happy to engage with the other robots at home. Anna is particularly sensitive to noise, and therefore she would often hide in another room when the drone was flying. Her mistrust of the robot eventually became just an annoyance for her (e.g. the third image on Figure 6 shows how she used the drone's box as a resting place for her pacifier, while every time I moved the box, Elsa would ask me to turn on the drone). The first image in Figure 6 shows Anna in the background and playing around me, my partner, and her sister while we figure out how to program the drone. Anna was completely uninterested in the situation. Because of this, I used the drone less and less in our family as I felt it was excluding Anna from participating in our activities, coming into conflict with our culture of unity. This was much unlike the use of Purrble, where Anna's interest developed during this year and she would more and more often reach out to it, and even have it close to her body. The last image on Figure 7 shows Anna holding the robot next to her face while petting it.

StS Elements: Goals: Wellbeing, Research; People: Core family towards Anna; Culture: Love, Unity; Processes: Rituals; Technology: Tello; Building: Indoors;

Sense-making: When a drone is introduced into a home – even if the robot is age appropriate for one of the children or adults – there is a strong bystander effect where many others may be affected. Unlike the other robots, the drone strongly impacted the feelings in our home and created conflict where the younger child found herself being excluded. In this moment, the wellbeing of our family came over the other goals, and the lack of care we had had with our youngest became evident. This is an important factor to be considered when developing drones. While all robots may be

Figure 4: Three images showing (left) two 6 year old girls enacting the control and flight of a drone, (middle) a snow sled ride on a winter day, and (right) a lawn mower stuck on a net.

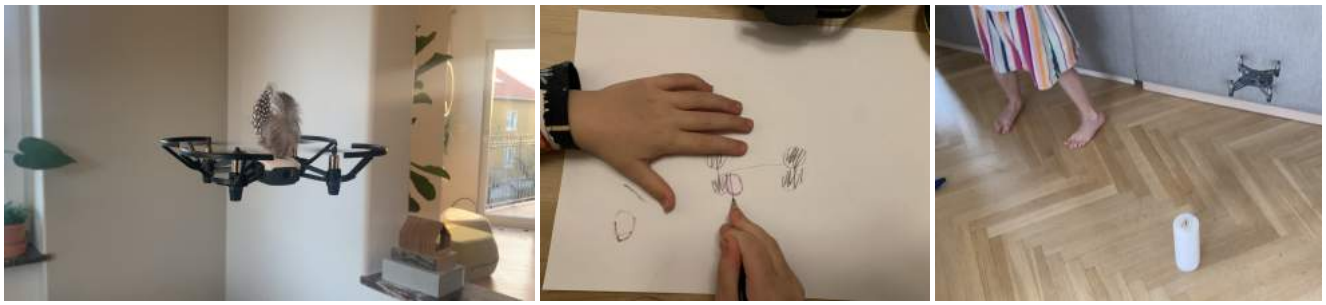

Figure 5: Three images showing (left) a drone decorated with feathers, (middle) Elsa's drawing of a drone, (right) Tello putting out candles on a flying track conceived by Elsa.

appropriate for different ages, the drone is the one which caused the most harm outside of the recommended age group. Should age appropriateness therefore include potential harm to other groups, particularly in a home context?

4.1.6 ***Command and Embodied Interactions with the Drone.*** Elsa was from the start eager to be able to control the drone herself, but I was hesitant. The times she tried, it was too difficult for her to remote control the drone, which eventually felt unsafe in her hands. She had difficulties programming the drone from its perspective, and not hers. Her enthusiasm for the drone was great at first and we could even start to see representations of it in her drawings (See Figure 5). To try to compensate for her own lack of potential direct control, Elsa came up with games and obstacles in our living room which she would then ask me to overcome with the drone. The hurdle tracks she would create included furniture and pillows, and one time, it even included candles that the drone should blow off through the air movements of the propellers (Figure 5, on the right, shows a drone flying over a candle). While she could eventually understand how Doc was programmed (step-wise, in a grid), the drone was always too complicated for her, with too many dimensions and granularity of movement. But because of its intricate movement, the paths she imagined the drone could fly were more interesting than any of the spaces of the other robots. The drone had the capacity to make her imagine worlds where it could do things by her pointing, following gestural command, but even to be able to engage with other toys in our home. For example, she imagined the drone could turn off the lights, carry other toys to her, or even be part of the stories in the games. On Figure 6, Elsa can be seen trying to program the drone with me, but her most important contribution was picking up a small figurine that would ride the drone (it can be seen lying next to the drone in the image).

StS Elements: Goals: Research People: Elsa, Me; Culture: Openness; Processes: Rules; Technology: Tello; Building: Indoors;

Sense-making: The clear advantage of the drone over the other robots is its freedom of movement. While the other robots did not seem to inspire any other possible interactions, the drone supported a creation of worlds and functions in a three dimensional space. Is there an opportunity for truly engaged embodied interactions in the home, expanding the space of the home from the floor to the ceiling? This particular situation made me reflect on the antiquated user-bystander dichotomy. In this situation, who was the user and who was the bystander? To me, Elsa was the user and I was merely a translator between her and the drone. This means any age limit in the box of the drone is rendered almost irrelevant – even if the Tello drone is not advised for such small children, the actual user (me) was well above the age recommendation.

4.1.7 ***My Own Relationship with the Research Material.*** As this year of autoethnography started, I would fiddle with the drone often. I was excited to get started, and recruited my partner to start documenting if he saw anything interesting. The enthusiasm wore off on our oldest daughter, who showed a lot of interest at

Figure 6: Three images showing (left) Elsa and I setting up the drone for programmed flight, in the background, Anna can be seen playing, (middle) picture taken by the drone where Anna covers her face from the drone, (right) Anna leaves her pacifier on top of the drone box

Figure 7: Four images showing (left) Elsa chasing the drone to help it land by climbing on furniture, (middle-left) Elsa fiddling with the drone propellers, (middle-right) Elsa with the drone stuck to her hair and (right) Anna holding Purrble close to her face.

first on what the drone was and could do. But as time went by, I found less and less patience to cope with yet another noisy element in our home during the evenings. Living with small children leads to a hectic environment, and the noise of the drone became too much to bear at times. When taking the drone with us to interact with others, I often felt as if the people around me were bothered by the presence of the drone and showed a lack of interest in it - it was my research object and not theirs. It was extremely rare that anyone asked or was willing to control the drone themselves. So as time passed, I too lost interest in being engaged with the drone, and as I lost interest, nobody else picked it up. The drone started gathering dust, while both me and the children often engage with Purrble. Its calm nature helps in creating peaceful relationships with the children, while both Doc and the Tello contribute to a noisy but more active environment. Elsa did often ask if we could fly the drone, but in our busy lives, the addition of another moment of exciting and noisy activity in the evenings became less and less desirable. The documentation process was easier due to the drone's camera: when conducting autoethnography with children and robots, if there is no assistance in documenting, the act of documenting itself can be disruptive. Therefore, many of the interactions with the other robots were only registered through diaries, and many of the interesting quotes the children said were lost. I had expected the robots to be embedded into our rituals and routines, but this never happened, and alas, each documentation session felt somewhat forced.

StS Elements: Goals: Documenting, Research; People: Me, Partner; Culture: Love, Unity; Processes: Rituals, Chores; Technology: Tello, Purrble; Building: Indoors;

Sense-making: The novelty effect wore off quickly for the drone, not only because of our hectic lives, but also because of its disruptive nature. This resulted in some guilt on my side, where I felt like I was disconnecting from the technology I was meant to research. But most of all I did not know what to do with the drone itself as it started fading into the background of our home: was there an appropriate way to unmake its presence?

4.2 Opportunities for Child-Drone Interaction Design

Through the relationship created between the drone and my children I have extracted design opportunities for child-drone Interaction as a guiding compass for the creation of design probes. These opportunities are described as ideas to consider and do not have any prescriptive value. They seek to offer perspectives to be added to a more sensible and critical approach to HDI, rather than desirable or necessary actions.

Figure 8: The children hide from the drone behind furniture.

Touch: The children created intricate touch interactions with the drone, which were not limited to carrying it. The propellers are easy to fiddle with when the drone is inactive. However, its cold surface never led to a closer contact with any other body part. Even when decorated with feathers (which the children did touch and play with), no further closeness was exhibited. The most exciting of activities were connected with the drone landing or taking off on body parts, such as on the hand. Although the ability to touch does not seem to have any relationship to the childrens perception of autonomy, it still promoted a clearer path to ownership. Carefully manipulating the materiality of the drone is a relevant endeavour to consider.

Enactment in 3D Space: A unique characteristic of the drone is its ability to be enacted as a flying robot. From an embodied perspective, the play that it generates is more interesting than what land robots do. The children were able to stretch their arms to the sky, and relate to the spaces higher above, while when interacting with all other robots, their bodily positioning was either crouched or curled up. Therefore the drone clearly opens up for a varied experience in the kinaesthetic relationship between the children and the robotic agent.

Directed Play in 3D Space: While the children were interested in learning how to program the robots, they were even more interested in being able to give it commands to follow verbally. While the land robots could easily reach the points the children wanted them to, the drone engaged them in a much richer repertoire of play. Because of its ability to move in all directions, move air, make noise, and collapse catastrophically, the children came up with paths and stories for the drone to enact around the apartment, using different obstacles and spaces in a dynamic way. Creating probes that take into consideration these substantial engagements with the context is worthwhile.

Wickedness and Attention: The drone had the ability to engage the children. While every time the drone was active there was general excitement, which was sometimes resolved by brave attempts to engage bodily in proximity with the drone, but mostly resulted in hiding or protective behaviours. The children would either hide behind furniture or an adult, and observe intensely the activity of the drone (See Figure 8). This wickedness of the drone had the great ability to fully absorb the attention of the children, and direct it elsewhere.

In-between States: Drones are either off, or on. And their off or on states are dramatic: a drone can not turn off mid-flight or it will collapse. It also does not exhibit stand-by behaviour. Therefore, when inactive, the drone appears to be entirely lifeless, when active, it is in constant movement.When constructing probes for the home it may be valuable to consider the possible spectrum of states designed for.

Difficult Ownership, Safety, and Right to Repair: The children had trouble understanding how they could independently engage with the drone. Simple tasks such as the handling of the batteries or replacement of the propellers make the drone an unlikely companion for young children. Considering independence in the design of all the stages of the interaction is fundamental to support a feeling of ownership. However, the difficulty here is to combine the possibility of ownership with the complicated task of making the drone safe or even compatible with small children, given that so many of their characteristics are inherently dangerous or inaccessible (e.g. high noise volumes, dangerous moving parts, unstable movement). There is a possibility that the care-taking necessities of the drone could contribute to the interaction, but these need to be carefully developed with all members of the families in mind. At times, the shelving of the drone was due to minor repairs that were too complex or time consuming. The right for repair to be conducted by the children is also a necessary element for the true sense of ownership to be developed through relationships of care, using simple interactions and modular open-access design.

Culture, Values, and Type of Play: When using the drone, it became clear that the structures in the family changed. Some distanced themselves, other engaged directly. Some family members were annoyed, disturbed, or even fearful of the technology. Most definitely, the drone created an impression. One must consider which cultural weight is designed into the drones, and what type of play it is supporting. Actively stating the goals, culture, and processes within StS the probe is aiming at may be helpful in appreciating which values and type of engagement the drone is creating within a family. Similarly, when designing and promoting the drones to a wider audience, it is important to clearly communicate which values the design is supporting, and inform on the potential harm it may cause.

Anticipated Experience and Death of the Drone: The packaging of the drone was not particularly appealing to the children

and required a lot of support from an adult in unpacking and making sense of all the information. When trying to store the drone, the packaging was not particularly helpful, and therefore the robot ended up literally collecting dust on a shelf. We were uncertain how to sustainably deal with the lack of interest from the children towards the drone. Ultimately – we were uncertain how to dispose of the drone in a sustainable way. It is necessary to consider how to support both the anticipated use [25], and the post-use of the drone as a part of the design. Together with work on the right to repair, the death of the drone may be more sustainably delayed.

Unmaking: Most importantly, when designing drones, one should consider if they should at all be designed for the context at hand. While a product can be labelled as not appropriate for a 3 year old, it may still be used in their vicinity, forcing them to interact with it. Through considerate reflection and the design of critical probes, designers can question unresolved issues of sustainability, safety, legislation, and ethics. The work of designers may be to aid in the unmaking of drones in certain situations, and support the discussion of issues such as the potentially obsolete user-bystander dichotomy.

5 DISCUSSION

In this section, I discuss the results as framed by the two research questions, starting with issues relating to drones, followed by methodological considerations, and a shorter discussion on the ethics of this study.

5.1 Drones and Children

The second research question that framed this study was: *"What is the impact of incorporating toy drones in a domestic environment with small children?"* After one year of cohabiting with these robots, observing, facilitating, and supporting my children's relationship with them, I have found myself in a deeply critical posture towards children-drone interaction in a domestic context. As a designer, I am concerned about which values are embedded into the systems we produce. And indeed, this ethnographic account brought forward the disturbances that the presence of a drone left in our family, and the impact in terms of relational concerns from an ethics perspective e.g. [13]. As mentioned in the introduction, it is vital for my research to understand why families bring these potentially disruptive robots into their everyday, and what value they bring. It is fair to say that the grandparent who buys a toy drone for their grandchild is unaware of the imbalance they may unwillingly bring into the home. Previous research has shown that there are concerns both on how drones may be used to stalk children, but also when regarding children as users [4]. Boucher [4] notes how a number of participants in a survey were surprised that toy drones were available on a small budget and feared deliberate and accidental misuse. As designers, it is our responsibility to clearly state and communicate the values materialised into the design [47], and seek to either prevent these risks, transparently communicate them, or work together in the potential ethical unmaking of these drones. This call for transparency is not novel within technology for children [50], but it seems to be particularly relevant for drones. The lack of studies with children and drones [36] is problematic, not only when perceiving children as users, but by merely considering their encounters with drones. It is perhaps no surprise that there are nearly no research studies with children and drones, given the ethical and safety issues they could cause. The few studies that can be found make sure, for example, to reduce all risk by casing in the drones [39]. This lack of studies seems to be in mismatch with the reality of toy drones, as a simple search on Amazon for "toy drone" generates more than 2,000 products and some with more than 15,000 reviews. But the issue with children interacting with drones exists beyond considering them users in a traditional way. My autoethnographic study could have been conducted in the same way by describing myself (an adult) as the sole user of the drone – and yet, the children would have been exactly as impacted and engaged with it. This indicates that the borders of user-bystander may be less helpful than we would think in HDI.

5.2 Autoethnography and micro-StS in RtD

I applied a combination of methods in order to answer the first research question, *"What is the contribution of an auto-ethnographic study, supported by Sociotechnical Systems, in formulating design considerations for Research through Design?"* From a methodological perspective, I found resonance with many of the difficulties presented by Wall [48], in a struggle to make the value of this study clear to my academic peers. In fact, these studies may have harmed my relationship to drones as an RtD design material: I find myself often questioning if drones and children are at all a compatible combination, and to what extent I would like to introduce these machines as objects of study in other families. Simultaneously, the knowledge gained made me acutely aware of my importance as a researcher and designer within HDI. While this study made me rather sceptical of the role of drones in the home, it also opened up for a more nuanced and techno-critical stance moving along. The conclusions presented offer a reflective longitudinal account of a shared space informed by a genuine and contextualised appropriation of the technology which can be easily translated into RtD probes, particularly ones of a provocative nature. However, any researcher considering conducting autoethnography with their own design material should be aware that while the conclusions and the process are useful and substantial, they come at the cost of an understanding of the technology at hand which will strongly impact their approach to the research material. Helms and Fernaeus [20] exemplify these struggles, mentioning for example how autobiographical design researchers may have trouble in the dual relationship between designing for loved ones and being a good researcher.

The use the novel micro-StS approach combined with autoethnography was helpful as a base to express tacit experiences, and to be able to reflect upon the interactions that emerged and make them explicit. Because the documentation and results were centred on a negotiation of the goals, processes, and values in our home, it was easier to pinpoint and report upon changes in the relationships within the system. In hindsight, for example, my ambition to make this work happen should have been regarded as a clear value in the system – this missed cultural value could have resulted in further reflections when analysing the data. As the work continues, I propose informing the method with further research done in the social sciences within autoethnography in order to inform a more

appropriate framework which could lead into evocative narratives. The attempt to summarise the findings into design implications may have reduced some of their usefulness as rich stories, as the stories themselves are tacit and derived from a daily reality which is not always appropriate or possible to express into design knowledge. The design implications may be misread without the coupling to the stories. Apropos, Dourish [11] questions the formulation of results within ethnography as implications for design, arguing that they are not necessary – furthermore, that expressing ethnographic knowledge as design requirements is instead a limitation:

> "the liaison between analytic ethnography and design could well form the field of a practical sociology committed to a serious engagement with the design problematic - the interventionist impulse. Such a practical sociology could not eschew prescriptivism, as designers frequently accuse ethnography of doing. But its prescriptions and predictions may well not match those that designers currently seek. Instead of providing yet more grist to the mill of conventional design solutions, ethnography may offer sensibilities that will cause designers to question the presuppositions of their conventional outlooks." [1]

In this aspect, the novel micro-StS approach presented is a valuable tool to document and make explicit to others what is relevant in the system being studied, rather than focusing merely on requirement gathering or even prescription of action. While the results presented are helpful from a reflective practice perspective, they are difficult to express as design knowledge. The opportunities suggested are topics to be consider rather than best practices, and have no particular intention in solving problems, but rather in offering critical perspectives which ought to be considered in future research in a sensitivity-building manner. However, to be able to transmit and represent tacit ethnographic findings in a readable manner, we can make use of StS frameworks. It is likely that this first year of ethnography was highly stained by what criteria I perceive to be important to present as results within HCI. In following work, I find the need to reconsider how to best present the work and its narrative:

> "The narrative text refuses the impulse to abstract and explain, stressing the journey over the destination, and thus eclipses the scientific illusion of control and mastery; and the episodic portrayal of the ebb and flow of relationship experience dramatises the motion of connected lives across the curve of time, and thus resists the standard practice of portraying social life and relationships as a snapshot. Evocative stories activate subjectivity and compile emotional response. They long to be used rather than analysed; to be told and retold rather than theorised and settled; to offer lessons for further conversation rather than undebatable conclusions; and to substitute the companionship of intimate detail for the loneliness of abstracted facts." [14, 744]

5.3 Ethics and Limitations

The question of ethics in this study is a complicated one – while I advocate that incorporating the perspective of children is fundamental, the process of involving them in research should be careful through and through. As a parent, I consider that my children have benefited from this autoethnographic study, but that is no guarantee that further studies would have the same result. My children learnt about and had the opportunity to discuss robots with me, and expanded on their knowledge of technology in a critical manner, but this relied heavily on my own consistent and situated understanding of the ethical approach accepted within our family. The inclusion of children in research and design processes has a long history, and their influence in the development of robotics and AI along with their own understanding of the technology should be encouraged [46]. This paper contributes to the discussion from a micro-ethics perspective [42], as autoethnography leads into a great number of smaller exchanges. Many of the interactions that emerged in our home (e.g. the exclusion of the younger child when the older is interacting with the drone) could have easily been missed or ignored in larger and more representative studies. While generalisation is not the aim, nor can it be achieved through this method, the conclusions offered are still of great relevance to the research community. Autoethnography offers a strong and important methodological contribution to the field, as the changes (from disruptive to positive) between different parts of the micro-StS ought to be considered in research, the design process, and definitely in the development of regulation for drones.

6 CONCLUSION

As drones become more prevalent in our society, younger children will have contact with them in one form or another. Studying child-drone interaction is a worthwhile endeavour, but it does bring a set of difficulties. Drones can be dangerous, and are robots with a set of characteristics that definitely make contact between them and younger children a potential hazard. Simultaneously, their capacity to capture attention and their novelty opens up for critical approaches. Now is the time to tackle these issues.

To understand the role of this technology in a domestic context, particularly in relationship to small children, I engaged in a year-long autoethnographic study with my family and my two children (aged 3 and 6). We progressively learned how to live with different robots at home, and absorbed attitudes towards these from each other. Autoethnography is a difficult method to apply, as it involves a deeply personal engagement both with the research but also with its participants. To aid in making sense of the emerging relationships, I introduce the combined use of a socio-technical systems (StS) approach and framework with autoethnography, representing this study as a set of different components and relationships which complement the existing methodology. The framing of the family as a micro-StS was helpful in supporting the analysis of the data and extracting design knowledge to be considered for the RtD of drone probes for this context, as well as developing and describing these tacit narratives to a reader. More work in making autoethnography a relevant method for RtD is needed, but in this paper, I present a set of narratives and design opportunities which can be made useful by other researchers in the field to support a more nuanced and

critical approach to child-drone interaction. They have, in many ways, already made a dramatic impact in my own understanding of this design space.

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