Design insights for more-than-human context-aware self-tracking systems

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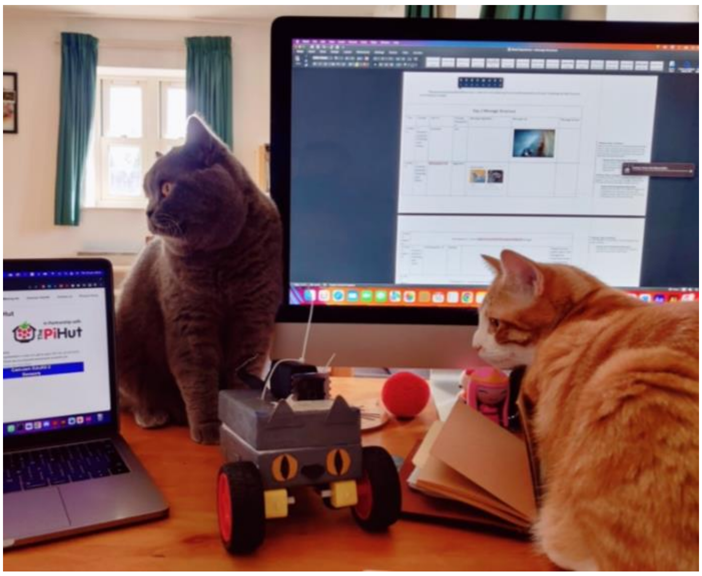
This thesis is submitted for the degree of Doctor of Philosophy

November 2023

Acknowledgements

To Dan, Joe, Roger for everything the past few years. Answering my endless questions, turning my rambles into coherent thoughts, actually knowing what I was talking about, expanding my list of sci fi movies to watch and being great human beings. To everyone in Imagination, you've created such a welcoming, special place to work and I'm glad I've been a part of it. All the participants that agreed to take part and engage with this research and help create the craziness of the Cat Study. The tomatoes, for keeping me sane through many entertaining coffee chats, navigating the complex journey of the PhD together, helping me pick the right coloured square, allowing me to spam you with cat photos and being the awesome people that you are. My wife Sofija, for being there when I needed you and always knowing what to say. Also for convincing me cats would be a good idea, looking forward to creating many fun memories with you and them in the years to come. My family, mum, dad, Lauren for supporting me every step of the way, dealing with me being a perpetual student and helping me get to where I am today. Lastly, my research assistants Pickle and Dumpling. For attending many meetings and greeting my colleagues, keeping my lap warm, checking my keyboard was working and providing everyone with an insight into your lives. Without you, this research would not have been possible.



Declaration

This thesis is my own work and has not been submitted anywhere else for the award of a degree. Some sections of the thesis are publications created in collaboration with other researchers. Where this research has been published is explained clearly in the relevant chapters with these outputs are also listed here. Many ideas presented in this thesis are the result of discussions with my supervisors Dan Richards, Joseph Lindley and Roger Whitham.

Snooks, K., Lindley, J, Richards, D., and Whitham, R. (2021). Context-Aware Wearables: The Last Thing We Need is a Pandemic of Stray Cats, in Extended Abstracts of the 2021 CHI Conference on Human Factors in Computing Systems (CHI EA '21), Association for Computing Machinery, New York, NY, USA, Article 25, 1–9. https://doi.org/10.1145/3411763.3450367

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Abstract

Self-tracking systems collate information about our bodies and present it through metrics about an individual's health and wellbeing (or their general wellness). As these systems have progressed, they collate data not just about ourselves but those around us, comparing our bodies to multiple other bodies, both human and non-human, including companion animals like cats. A key problem with the current dominant approaches is that they tend to miss out on contextualised information about our general wellness experiences showing a limited, singular perspective of what it means to be healthy and well. Such perspectives can result in harm, by supporting some selves' experiences over others. In this thesis, it is asked what if self-tracking systems considered different, "more-than-human" perspectives of contextualised general wellness information? Through the introduction of different perspectives of contextualised general wellness information, this thesis aims to understand what it would be like to interact with these perspectives. This involves understanding whether there would be implications with introducing alternative perspectives into self-tracking systems and what this would mean for future self-tracking system design. Using speculative design and design fiction through a 'Research through Design' approach, these perspectives are explored to provide design insights for more-than-human context-aware self-tracking systems.

Chapter 1 Introduction

This chapter presents an overview of this research, demonstrating what this research is and why it was conducted. Firstly, this chapter will list terminology needed to understand key concepts used throughout the thesis. Following this, the overarching questions this thesis aims to address will be outlined. This includes how these questions will be addressed and research motivations that explain why this research has taken this approach. A brief overview of the research area helps to summarise the key problem area that will be addressed within this thesis. A chapter structure is included at the end of this chapter, so readers know what to expect throughout this thesis.

1.1.1 Glossary

Throughout this chapter and the following chapters, different terminology is used to explain concepts related to this thesis. For clarity, some of these words are briefly outlined here:

Companion animals: In the context of animal-computer interaction, commercially available devices that track animals' activity are referred to as *companion animal technologies* (van der Linden, 2021). *Companion animals* refer to any cat, dog, rabbit, hamster, snake etc. that could be commonly referred to as a 'pet'. This terminology excludes animals in a professional role i.e., guide dogs or emotional companion animals (Ramokapane *et al.*, 2019) because the purposes of tracking technologies are different for these animals. Companion animals are used in this thesis over different fauna because of various self-tracking apps that provide humans with information about companion animal's health and wellbeing. While the term Haraway's (2003) *companion species* is used in this thesis, this term encapsulates both humans and companion animals.

Contextualised information: In this thesis, contextualised information refers to details about someone's general wellness that helps to understand why a certain behaviour or event is happening i.e., why someone is exercising less, not just stating what exercise they've done, or not done, in a week. To increase contextualised information, self-tracking companies are introducing context-awareness features, using sensors and data to infer behaviours and actions.

Data: Where *data* is discussed, it is referring to data about a human or non-human's health and wellbeing. Data in this thesis can be any number, character or value gathered from a sensor or the internet as well as unedited video or audio.

General wellness: Is about maintaining or encouraging an individual's physical and mental health and wellbeing, not linked to a particular condition or illness. This might be through monitoring different habits such as a diet, exercise, smoking, or alcohol consumption that can contribute to healthy living or *general wellness*. General wellness products relate to the term used by regulatory governing bodies such as the FDA to describe 'low risk' consumer products like self-tracking technologies (Simon et al., 2022).

Harm: In this thesis, *harm* relates specifically to the impact information can have on someone's mental or physical wellbeing i.e., causing physical or psychological distress such as bodily reactions or negative feelings that result in anxiety. Information might also cause harm if it reveals previously hidden details which might alter relationships or compromise privacy.

Information: Related specifically to tracking health and wellbeing, *information* is discussed within this thesis as data that has been interpreted. This is often shown in self-tracking systems through graphs, charts, artificial intelligence (AI) generated insights. Sometimes this will be referred to as insights or metricised insights.

Personal informatics: Both hardware and software tools that collect information about a person either digitally such as apps or manually through diaries. This can include health and wellbeing information but also anything that could be considered personal i.e., recording finances, productivity levels and hobbies such as how many books read, or craft projects completed.

Self-tracking devices/technologies: Physical hardware that can be used to monitor something about a human or non-human's health and wellbeing i.e., a watch, pet collar, sleep mat or earphones etc.

Self-tracking systems: Software that can be used to document, record, or analyse a human or non-human's health and wellbeing i.e., an application on a phone or website linked either to a self-tracking device or used independently. Where referred to as 'the system' or 'systems', this still means self-tracking systems.

1.2 What does this thesis aim to address?

Focusing on metrics and system capabilities means self-tracking systems miss contextualised information, only representing one small part of people's health and wellbeing experiences and providing one perspective of what general wellness is. The literature shows that this is resulting in harm, hindering wellbeing rather than supporting it. So, what if we acknowledge new considerations of contextualised information through different perspectives of health and wellbeing? How might designers do this? Would introducing these perspectives reveal possible implications, whether these are opportunities or challenges for designing context-aware self-tracking systems?

This is explored in this thesis using more-than-human theory to explore our connection to those around us and reflect on their unique experiences of the world. This can help explore considerations for context-aware self-tracking systems and provide insights for those designing these systems. Therefore, this research will address the following questions:

- What if self-tracking systems considered different (more-than-human) perspectives of contextualised general wellness information?

- What would this mean for future self-tracking system design?
    - As in, what would it be like to interact with these perspectives in self-tracking systems?
    - Would there be implications with including these new perspectives?

To answer these questions, this research needs to consider the following:

Inclusion of information beyond metrics & bodily focus:
A focus on metrics about bodies, regardless of whether that body is human or non-human, highlights current problems with designing for a collective. Including information beyond these bodily metrics can begin to explore other parts of health and wellbeing experiences. This could reveal possible implications for future context-aware self-tracking systems. Design methods can include this type of information in the early stages of developing context-awareness systems (in the preliminary design phase) before these self-tracking systems have the potential to impact people's wellbeing. This includes understanding what it might mean to interact with these types of information and the associated opportunities or challenges with this. We can explore this type of information through different perspectives based on more-than-human theory.

Different perspectives of information through more-than-human theory:
While we cannot directly access non-human's experience of the world, considering how non-human's health and wellbeing experiences differ from our own highlights normative values embedded in current self-tracking system design. Providing more-than-human perspectives of health and wellbeing experiences could highlight implications for introducing these new types of information in self-tracking systems. These implications might not be revealed from human-centric approaches.

New considerations of contextualised information:

These different perspectives will help explore new considerations for contextualised information in self-tracking systems. As argued by Dourish (2004) context is something which is dynamic, emerges and is lively so it arises from an activity taking place. Therefore, context can be seen as interactional. Through these new considerations, we can explore the implications of having this type of information for those both directly and indirectly involved in self-tracking systems.

1.2.1 What approach will this research take to answer these questions?

Testing contextualised information can be difficult to do in the early stages of developing context-aware systems because of the need for large data sets (Kulkarni and Rodd, 2020). This thesis will take a research through design (RtD) approach, using and developing speculative design methods to evaluate future self-tracking system designs in the preliminary design phase before context models are developed and tested. This is to understand potential implications of a system design before they are implemented with the ability to impact on wellbeing. Design approaches can therefore help create self-tracking systems that explore inequalities and consider harm, supporting wellbeing rather than hindering it. Using this approach means this thesis will be able to provide explicit examples for what different perspectives of general wellness information might look like and might be used in self-tracking systems. While these methods will be explained in depth in the research process chapter (Chapter 3), previous work taking a similar approach is explained here to provide an idea about what this thesis will entail.

An example linking to the self-tracking field is Howell et al's Heart Sounds Bench (2019). Reflecting the ethical focus in this paper which acknowledges biosensing beyond metricised insights, the term heart 'sounds' is used by the authors instead of the term heartbeat. This is to reflect "the continuous sounds of the heart and body, rather than only the discrete beats per minute" (2019, p. 4) showing embedded theory in the approach. The bench has stethoscopes attached to each arm where people can listen to each other's heart sounds with the aim of reflecting on other people and their lives in a public space. This shows how RtD can be used to focus on ethical considerations of future design before it exists in a live setting where it could cause harm, showing the benefits of using this approach for designing new technologies. Using speculative techniques, the bench acted as a probe with a Wizard of Oz method (Gaver *et al.*, 1999) used to make people feel the bench was a working prototype, when in fact it was the same pre-recorded heart sound on a mobile phone connected to a speaker in the stethoscope hidden inside the bench arms. By interviewing participants before and after they interacted with the probe, the researchers could use these reactions about the artefact to outline why life-affirmation could be important in future designs around the public space. The techniques used reflect similar approaches taken for the final stages of this research as explained in depth in the Cat Study (Chapter 6).

Additionally, it should be noted that research through design can also be done with non-humans as well. In their paper outlining RtD in animal computer interaction (ACI), French et al (2017) present a case study of a project they carried out with captive elephants to understand how to develop interactive systems, where little is known about how elephants interact with interfaces. Due to this unfamiliar area, making became a vital part of the process, designing prototypes with the keepers and letting the elephants interact with the prototype was vital for this context. This is because the elephants could not give feedback on more abstract representations of a prototype i.e., sketches. The authors make it clear that design decisions made to create the prototypes were just as important and therefore needed to be documented through traditional RtD techniques i.e., annotated workbooks that show the development of prototypes and help document the RtD process. This helped to understand and share how knowledge was produced as part of the making process.

1.3 Research motivations & background

It is important to consider the background and context this PhD was completed in, as this helped influence the work developed in this thesis. Before starting this PhD, I completed my MSci in Computer Science and Design in the School of Computing and Communications at Lancaster University. In my final year I worked at an m-health start up, exploring how the company could create future products to stay ahead of the competition. This fed into my Masters dissertation creating speculative prototypes (a digestible nanobot, wearable patch) and interfaces (website, patient and doctor app) to discuss speculative future digital healthcare systems. This experience has influenced the use of speculative methods and a focus on digital health technologies presented in this PhD thesis. Following this, I applied for a PhD as part of the Beyond Imagination project and became part of the factory and workplace group. This group focuses on transforming the what, how and when of work through data-driven approaches i.e., machine learning in a healthcare setting.

As will be discussed, current technological design can promote biases and reinforce societal structures. This provides a lot of the critique of system design presented in this thesis. The first book I read as part of this PhD was Meredith Broussard's Artificial Unintelligence (2018) after she appeared on a podcast explaining techno-chauvinism (the idea that tech will solve everything) and unconscious biases in system design. My interest in feminist studies from a young age has made me aware of ways the world has not been designed for myself and many others. I seem to always be drawn to any topic of discussion around inequalities in society. This has influenced doing design research to understand the problems with relying on technological systems to address social issues that can impact people's lives.

1.4 Introduction to this research area

1.4.1 What are self-tracking systems?

People have been tracking things about themselves as far back as the 16th century (Sysling, 2020). From diaries, notes, photographs, analogue devices (thermometers, weighing scales) to today's digital devices and tools (wearable devices or spreadsheets); people are recording their bodies and daily habits to document, analyse and reflect on data about themselves (Crawford *et al.*, 2015). Digital devices are making tracking practices more appealing. Internet of Things (IoT) devices collect and share data via the internet and are expected to grow to over 150 million in 2024. Consumer wearables make up over 40% of all IoT connections (Government Office for Science, 2021). Consumer wearables can be any device that typically attaches to and measures our bodies, whether this is an activity tracker or watch, earphones or specialised shoes used to track heart rate, step count etc. Within this thesis, this form of tracking is referred to through the term self-tracking. Self-tracking technologies are digital devices that allow people to capture or infer data about themselves. These technologies often use applications, either through websites or mobile devices, to present information about an individual. These applications in this thesis are referred to as self-tracking systems. These insights relate specifically to someone's general wellness, otherwise known as day to day functioning as determined through physical and mental health & wellbeing (sometimes just discussed as health and wellbeing).

1.4.2 How is general wellness information currently presented in self-tracking systems?

1.4.2.1 Through quantification focusing on metricised insights

Self-tracking systems are designed to collate data about an individual using sensors either in our phones or wearable devices, processing data from these sensors into digestible, quantified metrics. Through self-tracking interface design, metrics provide information about someone's general wellness. A self-tracking application might show different metrics about psychological or physiological measurements i.e., stress or sleep quality (Figure 1A&B). Different colours, sometimes in ‘traffic light’ schemes i.e., green, amber, red, might be used to indicate various metrics or show whether a goal was close to being achieved (Figure 1A&B). Charts, graphs, or percentages might be used to summarise activity levels (Figure 1B). Gamification aspects like badges can show achievements linked to events such as World Environment Day or for an activity goal reached i.e., 10,000 steps (Figure 1C).

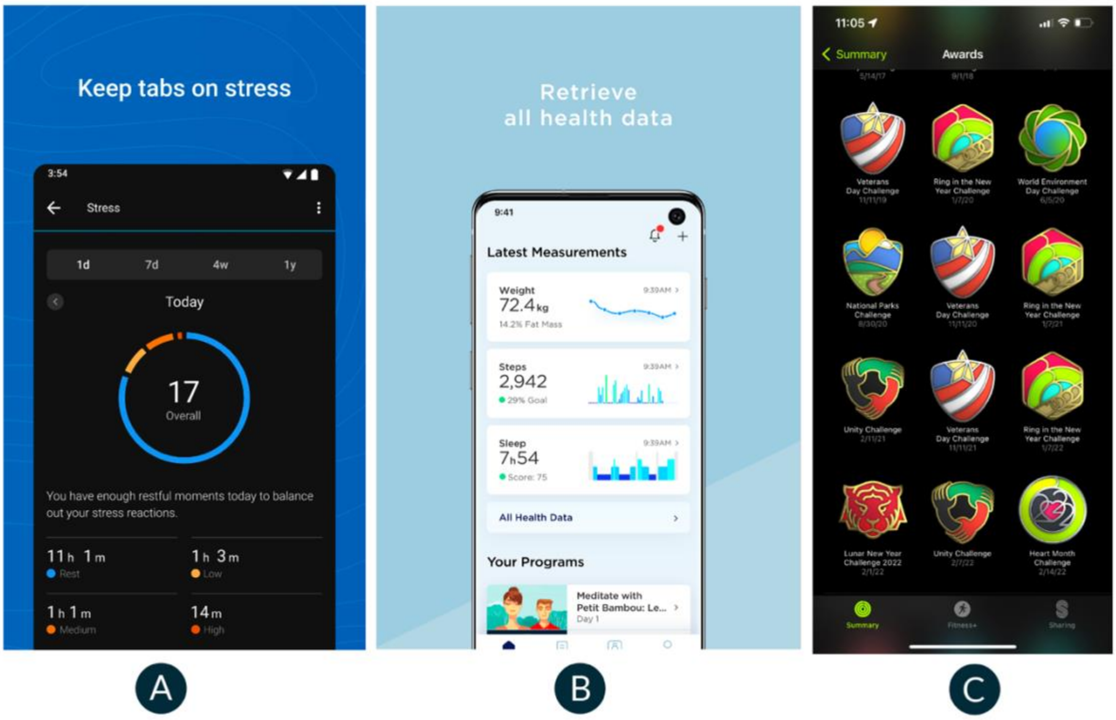


Figure 1 – Self-tracking systems. Left (A) Garmin Connect’s breakdown of stress levels source: https://play.google.com/store/apps/details?id=com.garmin.android.apps.connectmobile. Middle (B) Withing’s overview of different metrics like sleep quality and step count source:. https://play.google.com/store/apps/details?id=com.withings.wiscale2. Right (C) Apple Watch Fitness app showing various badges that can be obtained source: https://discussions.apple.com/thread/253727938.

1.4.2.2 Through comparisons between human and non-human bodies

Self-tracking systems often focus on our own bodies in relation to health and wellbeing. As these systems have progressed and become integrated in our day to day lives, they collect data not just about ourselves but those around us. Figure 2 shows self-tracking apps using metrics to compare our bodies with *multiple bodies* (e.g., family members or friends). Gamification metrics can collate information about fastest run times (Figure 2A), collectively ranking everyone using the app and comparing us to each other. Users can also create challenges comparing themselves to close connections such as friends or work colleagues (Figure 2B). Interestingly, despite the physical differences, our bodies are also compared to non-human relations such as companion animals (Haraway, 2003), otherwise known as pets i.e., the step count between a dog and owner (Figure 2C).

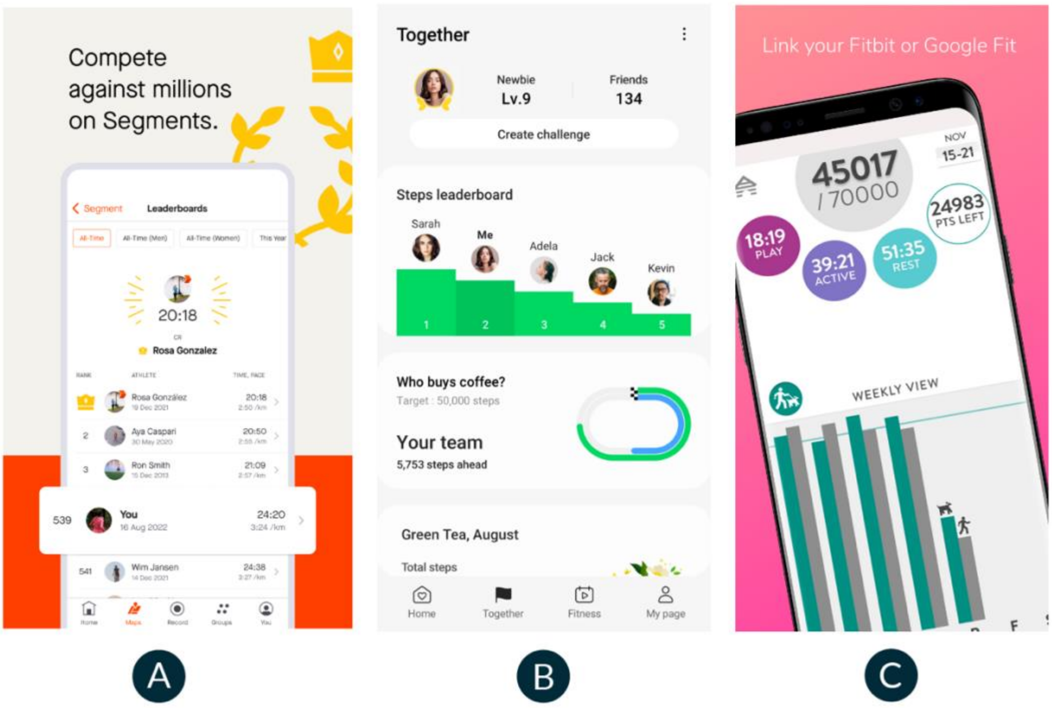


Figure 2 – General wellness application screens showing how ourselves are compared to other humans and non-humans. Left (A) Strava showing a leaderboard of fastest running time source: https://play.google.com/store/apps/details?id=com.strava. Middle (B) Samsung Health showing a step challenge set between friends source: https://play.google.com/store/apps/details?id=com.sec.android.app.shealth. Right (C) FitBark linking to FitBit to show comparative steps between you and your dog source: https://play.google.com/store/apps/details?id=fitbark.com.android.

1.4.2.3 But focusing on system capabilities lacks context about people's health and wellbeing experiences

As outlined by Hong (2020) self-tracking systems are focused on turning things like friendship and happiness into metrics “not in terms of what is most meaningful [to a person] but what aspects of it [i.e., friendship] can be rationalised at the lowest cost-and, increasingly, recombined and sold on for maximum profit" (ibid, p. 182). Relying on system capabilities (representing complex behaviour through metricised bodily insights) to sell more products, might not align with what people want from their self-tracking systems. Bietz et al., (2016) explain how focusing on objectivity results in a lack of context as self-tracking systems fail to "capture the nuance of the investigated phenomena [the user's overall health, for example] and the richness of how we actually live" (ibid). This is also reiterated by Spiel et al., (2018) who explain how measuring only discrete metrics indicates that "a joyful step and a miserable step have the same value". Instead, Spiel et al., argue that self-tracking systems should consider "a person's experience while taking it [the steps]" (ibid, p.5).

1.4.2.4 Context-awareness features

To try to determine people's context, companies are introducing context-awareness features, using sensors and data to infer behaviours and actions. We can see this through some existing self-tracking features. Figure 3A shows Apple's AirPods new feature 'conversational awareness'. This detects when a user speaks, reducing volume in the headphones allowing people to continue a conversation without having to pause their music (Apple, 2023a). Self-tracking systems are also utilising machine learning (ML) to provide new features like automatic activity recognition (Dorn et al., 2019). This can be seen in Figure 3B which shows how FitBit can determine if someone is walking or riding a bike etc.

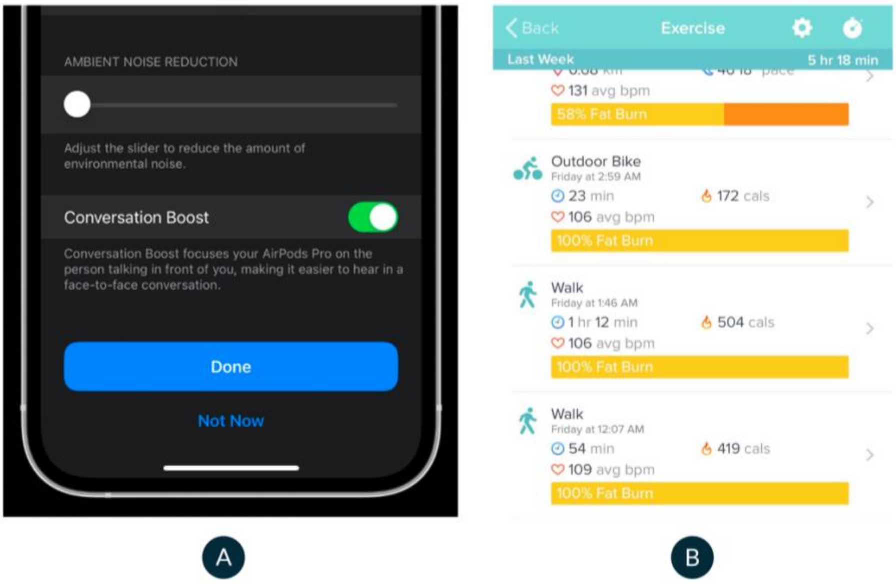


Figure 3 - Context Aware Self-Tracking Examples - A: Apple's AirPods 'conversational awareness' source: https://9to5mac.com/2021/10/06/turn-on-airpods-pro-conversation-boost/. B: FitBit's automatic activity recognition source: https://www.freecodecamp.org/news/how-i-analyzed-the-data-from-my-fitbit-to-improve-my-overall-health-a2e36426d8f9.

However, these approaches to context assume that context can be known as it arises from a particular setting or activity, following a technical approach to context as outlined by Dourish (2004). This means that it is presumed that everyone completes activities in the same way, providing generalised insights rather than insights that are specific to an individual. But what are the problems with providing generalised insights based on bodily metrics?

1.4.2.5 Technical approaches to self-tracking system design reinforces systemic inequalities and causes harm

Vincent explains how measurements have become necessary for humanity to “measure the world around us and, as a result, understand it better” (2022, p. 3). Also, that this is not distinct to humans with non-human animals also using measurement “to distinguish between bigger and smaller piles of food” (ibid). However, as explained by Guyan using quantitative data means decisions are “made about who to count, what to count and how to count [which] are not value-neutral but bring to life a particular vision of the social world” (2022, p. 1). Through viewing us as a collection of bodies, self-tracking systems prioritise certain bodies over some, highlighting which lives these systems feel are important to count.

Through excluding or ignoring certain bodies, it can mean self-tracking systems are detrimental to wellbeing. Self-tracking systems present one view of what it means to be healthy and well and that the same actions are capable by all bodies. These assumptions imply that everyone self-tracks identically and that every goal is achievable. This can result in increased pressure to constantly engage or to form a reliance on the information provided, even when the final goal i.e., pregnancy might not even be achievable (Figueiredo *et al.*, 2018). This process causes an emotional toll for people, causing physiological i.e., delayed menstrual cycles and psychological i.e., anxiety responses (ibid) effects. For those with chronic illnesses having these metrics reminds them of their illness, sometimes resulting in hopelessness because of the normative notions included in system design (Ayobi *et al.*, 2017).

Comparisons used to compare our bodies in self-tracking systems can help create narratives across time that reinforce roles within society, which might view some selves as lesser i.e., where women are compared to men (Crotty, 1998). Additionally, by not acknowledging certain people using a self-tracking system they may erase or misrepresent identities in the process i.e., not acknowledging non-binary individuals through fixed binary categories (Guyan, 2022; Figueiredo *et al.*, 2018). They could also be seen to ignore certain experiences, such as how our companion animals experience the world (Leong *et al.*, 2020). Designing their wellness experiences in the same way as our own could miss out vital aspects of their health and wellbeing. Equally, this could reinforce power relations i.e., between an owner and a cat (Tsaknaki et al., 2022). Also, these comparisons can reveal previously hidden information about people's behaviours which can result in tensions in relationships (Tolmie et al., 2016).

These issues can be seen in new features added to self-tracking systems, like the ‘tone’ feature on Amazon Halo’s self-tracking app (Amazon, 2023). While discontinued, it highlights problems with relying on system capabilities to address social issues and context-awareness. As seen in Figure 4, tone detected voices through a microphone to help determine how you are perceived by people in a conversation (i.e., amused, friendly, happy) regardless of context. By quantifying complex emotions into a few words and comparing voices to a non-representative dataset[1], this feature reflects a certain worldview[2] with assumptions and biased judgements about whose tone is considered positive. This means that by viewing us as a collective, certain groups or voices underrepresented in the dataset could inaccurately be viewed as having a negative tone. This could result in negative consequences, potentially hindering someone’s wellbeing i.e., questioning whether they sound approachable which could increase anxiety levels in social situations. This highlights how future self-tracking design needs to change to create systems that support rather than hinder wellbeing, better representing everyone using these systems in the process.

[1] Amazon states it does not work for ‘everyone’ and best supports male American voices.

[2] This will be explained in more depth in later chapters, but essentially how you see and experience the world or your ‘worldview’ will differ dependent on your identity, culture, background, locality etc. This can impact the way you design as these decisions are often a reflection of yourself.

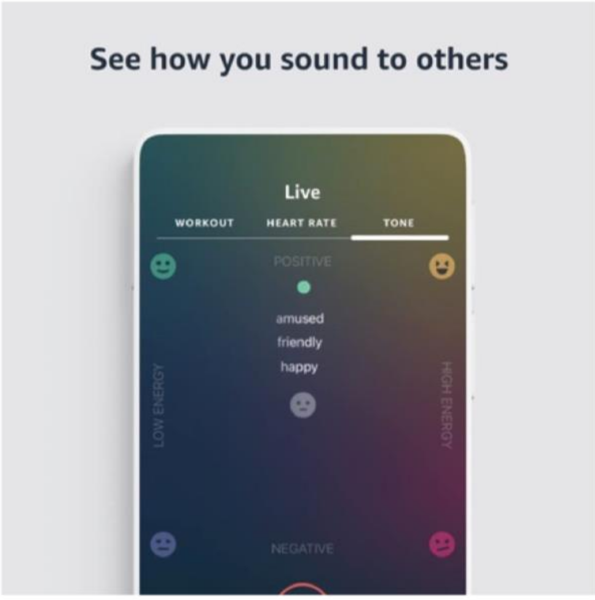


Figure 4 - Amazon Halo Tone feature which shows how you sound to others source: https://www.amazon.com/Amazon-Halo-Fitness-And-Health-Band/dp/B07QK955LS

1.5 Chapter structure

The following chapter structure will show how the chapters respond to the research questions presented in this chapter. The project chapters build on each other to help explain how design can be used to create different perspectives in future self-tracking systems. This will also provide a brief overview of what to expect at each stage of the thesis.

Chapter 2 – Literature Review: Expanding on the framing of self-tracking technologies discussed in this chapter, this chapter outlines important terminology and related work. This helps justify why introducing new perspectives into self-tracking systems could reveal possible implications for considerations of contextualised information. This related work spans various fields, including but not limited to self-tracking, context-aware computing, wellbeing and more-than-human research. By outlining existing gaps, it is explained how this research positions future self-tracking system design.

Chapter 3 – The research process: This chapter explains how my views about knowledge and reality differ from how knowledge and reality is represented in current self-tracking research. Following this, it is outlined how research through design, speculative design and design fiction, with an emphasis on world-building, are used within this research. Making and developing artefacts are shown here to be a vital part of this process. The positionalities discussed influenced the theory I was drawn to, and the way projects were conducted, and the form of analysis produced.

Chapter 4 – Understanding what context is (CoCo): Exploring the creation of a fictional world Connected Companion (CoCo), a context-aware health tracking wearable and application, the complexities of designing with context are highlighted. This project reflects problems with using a system perspective to include contextualised information in self-tracking systems. Insights from this project indicate that self-tracking systems can have social consequences when capturing information about our lives. This helped to develop insights presented in the following chapter around whether adding new considerations of contextualised information, through different perspectives, could have implications for future self-tracking system design.

Chapter 5 – The self, multiple beings and their bodies (Selves and Beings): Based on the insights gained from CoCo, this chapter outlines different considerations the self, their bodies and how these systems compare those bodies to other selves (multiple beings) in self-tracking system design. As briefly outlined in this chapter, this can be problematic, indicating that there needs to be new considerations for including contextualised information in future self-tracking systems. This chapter outlines what it means to move beyond bodily metricised goals to consider other aspects of health and wellbeing experiences. Drawing on more-than-human theory, the way we relate to each other (both human and non-human animals) reveals considerations for depicting relationships in self-tracking systems but also reveals problems based on different social factors. This chapter proposes alternative perspectives to contextualised health and wellbeing information. It also indicates the possible implications of introducing these new perspectives into self-tracking system design.

Chapter 6 – Data experiences about those around us (the Cat Study): This chapter builds on the insights discussed in chapter 5, to explore more-than-human perspectives in context-aware self-tracking systems. This involves understanding how people might interact with new perspectives of information about those around us. This is explored through a study titled introducing more-than-human perspectives of contextualised general wellness information about cats. In this study, 6 cat owners were sent varying levels of contextualised information about my cat's health and wellbeing. This study revealed potential implications for including these new perspectives in self-tracking systems.

Chapter 7 - Discussion: Bringing together insights from the previous three chapters, this chapter will outline design insights for more-than-human context-aware self-tracking systems. This will show the implications (including the opportunities and challenges) when people interact with different perspectives of contextualised general wellness information and what this will mean for future self-tracking system design.

Chapter 8 – Conclusion: This chapter will explain the key takeaways from this thesis and why this research was necessary to do. It will do this by addressing two contributions to knowledge. Firstly, the main contribution, introducing more-than-human perspectives of contextualised general wellness information and the design insights these provide for self-tracking system design. Secondly, the design methods developed to introduce these perspectives that helped to apply more-than-human theory to design practice and introduce contextualised information in the early stages of the development process. Additionally, it will discuss the limitations and recommendations for future applications of this research that were outside the scope of this PhD.

Chapter 2 Literature Review

This chapter begins by explaining terminology within this research. This includes what self-tracking and personal informatics are (section 2.1), how context is used to provide more informatics in self-tracking system design (section 2.2) and the associated challenges with this (section 2.2.4). This is tied in with a psychological and technological perspective of what wellbeing or 'wellness' is (section 2.3). It is explained that self-tracking systems might be hindering our own wellbeing (section 2.3.3) and the wellbeing of those around us (section 2.4.2). Looking in depth at how we currently understand these informatics about our health and wellbeing (section 2.4), new directions for future system design are outlined by introducing different perspectives of contextualised information from more-than-human theory (section 2.5). Introducing these new perspectives could have possible implications (whether these are opportunities, challenges or insights for future self-tracking system design). This chapter ends with an outline of where this research positions itself in relation to gaps presented in the literature (section 2.6).

2.1 Personal Informatics

2.1.1 What are Personal Informatics?

Personal informatics (PI) refers to a collection of tools that allow people to gather "personally relevant information for the purpose of self-reflection and gaining self-knowledge" (Li et al., 2010). This "personally relevant information" is often provided through digital technologies such as wearable technologies (a watch or activity tracker) or through mobile applications. Data is obtained from sensors such as accelerometers, GPS, as well as online activity, and user inputs to infer information about people's behaviours or actions (Rooksby et al., 2014). This information can include quantified insights such as graphs or metrics but can also be qualitative such as notes or images. These informatics can be used in many areas including health (Liao *et al.*, 2020), wellbeing (Costa *et al.*, 2019), productivity (RescueTime, 2023) and finance (Mint, 2023). Over time, the design of PI systems has largely been about insights from metrics (Crawford *et al.*, 2015). The Quantified Self (QS) movement (Wolf and De Groot, 2020) helped expand this into a more mainstream setting, helping to popularise the idea that we can learn more about ourselves through numbers. Today, people still want insights about their general health and wellbeing or 'wellness'. In 2022, it was reported that 40% of UK consumers have access to a smartwatch or fitness tracker (Henshall and Carkett, 2022). This means this type of data is now part of our day to day lives entangled in our routines, relationships and environment.

Personal informatics are discussed in this work through the term self-tracking with this term providing a focus on the health and wellbeing area (Neff and Nafus, 2016). Self-tracking technologies allow people to capture or infer data about themselves which is then used to inform general wellness decisions. This might be through self-tracking systems i.e., mobile or web applications used for tracking activity levels, weight, hydration & diet, sleep, recovery & stress levels, periods, pregnancy[3], UV levels, alcohol intake etc. These applications are often connected to a wearable. This could be a device like activity trackers or smart watches (Figure 5A) (Fitbit, 2021; Apple, 2023b; Garmin, 2023) or jewellery including smart rings (Figure 5B) (Oura, 2023). This could also be wearables that tackle more targeted health and wellbeing needs such as hearables (Figure 5C) (Kokoon, 2023), sleep mats (Figure 5D) (Withings, 2021), smart shoes and sports clothing i.e., swimsuits (Figure 5E) (WHOOP, 2022; Under Armour, 2023). Examples can be seen in literature around physical representations of self-tracking data (Sauvé et al., 2017; de Haan et al., 2021; Houben et al., 2019; Khot et al., 2015) and analogue tracking such as journaling (Abtahi *et al.*, 2020; Ayobi *et al.*, 2018). Within this thesis, the focus is only on the digital side of self-tracking, aiming to analyse the design of current self-tracking systems and

[3] Even though the goal with fertility apps is pregnancy, or prevention thereof, rather than 'fitness' or 'wellness', these fertility apps track physiological and psychological measurements including temperature & mood changes and so fall under the term self-tracking described here.

reflect on possible implications of future self-tracking system design.

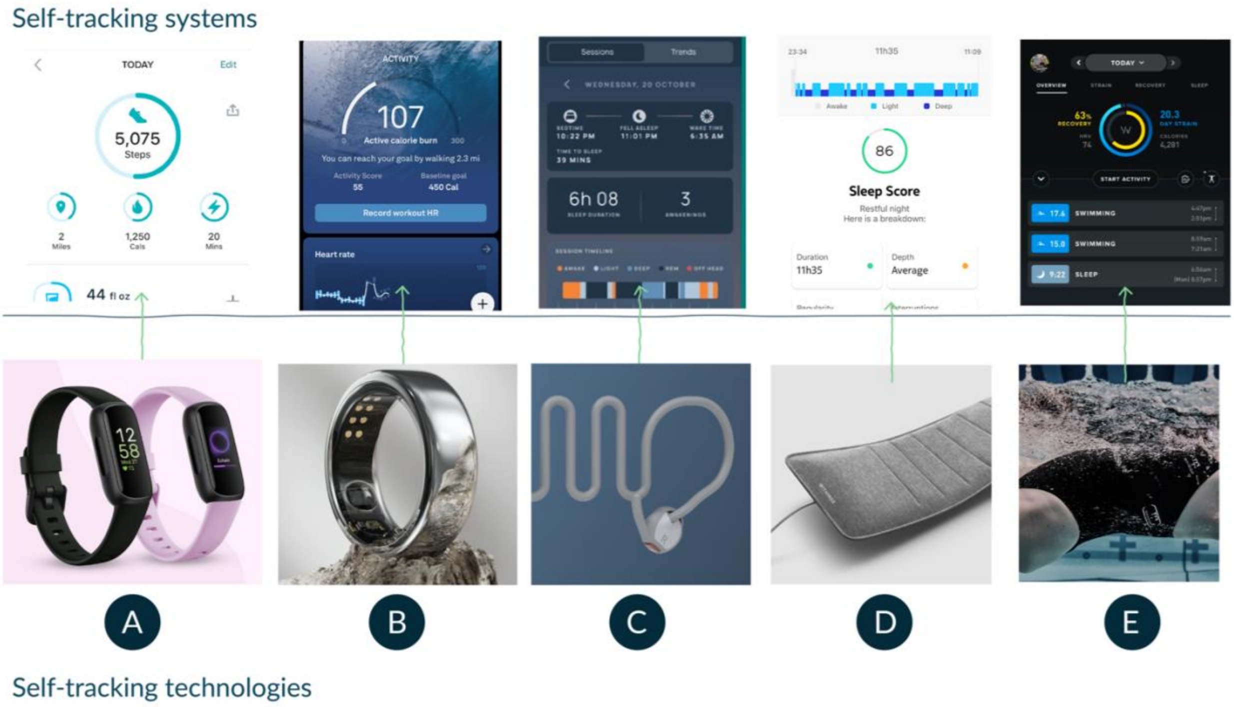


Figure 5 - Self tracking technologies and their associated systems. A – Fitbit sources: https://help.fitbit.com/articles/en_US/Help_article/2435.htm and https://www.fitbit.com/global/uk/home. B – Oura smart ring source: https://support.ouraring.com/hc/en-us/articles/360058599753-How-to-Use-the-Oura-App https://ouraring.com/. C – Kokoon headphones source: https://apps.apple.com/tt/app/kokoon/id1533992618 and https://uk.kokoon.io/?region=uk. D – Withings sleep mat source: https://support.withings.com/hc/en-us/articles/360023570034-Move-ECG-What-is-the-Sleep-score- and https://www.withings.com/us/en/sleep. E – WHOOP x Tyr swimsuit source: https://www.reddit.com/r/whoop/comments/krah2k/highest_strain_ever_with_two_swim_workouts_each/ and https://shop.whoop.com/en-us/products/tyr-x-whoop-womens-diamondfit-swimsuit-1/?sku=932-02-00-1-3 Why do people self-track?

There are varying reasons why people might self-track such as for self-knowledge and self-reflection (Li *et al.*, 2010). Rooksby et al (2014) split people's tracking intentions into a few categories, described below. They refer to self-tracking as lived informatics to represent the messier ways people track in their day to day lives.

- *Directive tracking* - Those that track with a goal i.e., to lose weight.
- *Documentary tracking* - Recording events rather than trying to improve or change the insights provided.

- *Diagnostic tracking* - Diagnosing a particular illness based on data from various sensors.
- *Collecting rewards* - Might be in relation to a health insurance scheme or simply enjoying the gamified aspects of these systems i.e., badges representing different step counts completed.
- *Fetishised tracking* - People's interest in gadgets and technology therefore having a curiosity around new-found knowledge about themselves.

These intentions for tracking provided inspiration for the speculative artefacts created in some of the projects outlined in the following chapters. With these different intentions for self-tracking, it has been found that there are many pitfalls to tracking such as lack of scientific rigour (Choe *et al.*, 2014) as well as informatics that are too in depth and technical (Sheth *et al.*, 2018) but also might not give people enough relevant information (Rooksby *et al.*, 2014). Li et al (2011) noted how reflecting on PI data often indicates a mismatch between user goals and data collection. They refer to the *relevance paradox;* people don't necessarily know what data is important to them and don't track it, but when it is important, they don't have the necessary data to reflect. This leads into the relevance of context within this work and why context and context-awareness have been considered important within the self-tracking space.

2.2 Context-aware computing and self-tracking

2.2.1 Ubiquitous computing

Ubiquitous computing was first described by Weiser (1999), creating technologies that blend or 'disappear' into our everyday life and are available all the time everywhere. Pervasive computing (Saha & Mukherjee, 2003) was introduced later using technological advancements such as wireless communications to make the idea of ubiquitous computing possible. Pervasive computing relies on systems that can make contextual decisions to help adapt and respond to human needs. This is best seen through Internet of Things (IoT) devices which can connect to the internet and communicate with other devices.

For example, your alarm clock syncing with your coffee machine to make coffee when you wake up. Self-tracking devices are an example of IoT devices becoming increasingly pervasive (Perera *et al.*, 2014). They learn over time by combining multiple sensors to process, interpret and produce insights about different health and wellbeing contexts such as steps, analysing sleep quality or monitoring weight loss etc. These technologies rely on contextual information for making decisions about our health and wellbeing, but how is context defined within this work in relation to self-tracking devices?

2.2.2 What is context?

Within Human-Computer Interaction (HCI) and Computer Science, context definitions are based on early research into context-awareness. Abowd & Dey discuss how context is information that is used to “characterise the situation of an entity” (1999, p. 3) with this entity being either a person, place or object that is relevant to “the interaction between a user and an application” (1999, p. 4). Schmidt et al., in a vaguer way, state that context is “that which surrounds and gives meaning to something else” (1999, p. 1). Schilit et al’s (1995) work into context, highlights how context is not just about a person but also the physical environment like time, temperature, noise levels, lighting etc. as well as the computing environment such as the network capacity and available sensors. Schilit et al., highlights that location is not the only important thing for context, with Abowd & Dey also stating that identity, activity and time are important context aspects to consider.

However, what context *is* can be debated, Dourish (2004) suggesting that there is a mismatch between the technical and social aspects in the way context is discussed. Rather than focusing on representations of context, Dourish argues that context is an interactional problem with context being dynamic and that context is “actively produced, maintained and enacted in the course of the activity at hand” (ibid, p. 22). Acknowledging that context is something that emerges and is lively rather than a particular setting is important to consider when looking at context-aware systems. Abowd & Dey state that a system is context-aware “if it uses context to provide relevant information and/or services to the user, where relevancy depends on the user’s task” (1999, p. 6). Combining these two definitions, the framing of context as an interactional problem is how context and context-awareness is considered in this work.

In his TED talk Phill Motuzas (2015) discusses how our devices exploit our natural skills from living in the world. Phones exploit sensors being sensitive to motion and touch as well as using features like the camera and microphone to replicate our ability to see, hear, move and interact with the world. He argues that this is an example of how our devices use context to create natural experiences with technology. As self-tracking devices are examples of IoT devices these devices’ connection to our bodies mean they have the ability to sense ourselves and our environment and can be considered ‘smart’. Motuzas states that these devices will only be smart when they have context, such as a watch using sensors to determine what someone is holding. This is the basis for context-aware computing, how our technology, including interconnected devices like IoT, can use sensors and masses of data to make intelligent decisions based on our context allowing for more dynamic system design.

2.2.3 Context-awareness in health and wellbeing

Context-aware features are commonly seen in activity trackers combining sensors with algorithms to determine what activity you are doing (e.g., running vs walking) and where you are doing this activity (e.g. a geolocated path within a local park). To better predict these contexts, technologies have started to learn about a person’s context from sensors, other technologies and environments for behaviour change interventions (Thomas Craig *et al.*, 2021) and personalised health feedback and monitoring (Khowaja *et al.*, 2020). Lupton (2020) also defines this as a "data assemblage"; a mix of data from people, sensors and their context which represents a ‘frozen’ moment in time, which also changes over time as different agents or people use them for decision making. The aim of gathering this data over time is to provide more *context-aware* insights into a person's behaviour and therefore give better recommendations or information related to health and wellbeing.

Some examples of these context-aware insights can be seen more broadly in sensor applications in the health and wellbeing space. Context-aware systems can be used for detecting movement for more accessible rehabilitation i.e., after a fall (Lo Bianco et al., 2016; Rick et al., 2019), as well as recognising behaviour such as using sensors to detect when someone is eating (Thomaz *et al.*, 2015). The insights provided can be used to provide recommendations (Gyrard & Sheth, 2020) and in some cases to change behaviour i.e., improve sleep quality (Lee *et al.*, 2017), nutrition (Nouh *et al.*, 2019) or provide interventions to help relieve symptoms (Lee *et al.*, 2018). This behaviour change might be as simple as a nudge, acting as a reminder to do something i.e., medicine adherence (Pater *et al.*, 2017) increasing autonomy and self-monitoring (Kalpouzos *et al.*, 2015). Equally these insights could be used for self-awareness of lack of movement (Van Dantzig *et al.*, 2013) or particular behavioural patterns linked to medical conditions (Tucker *et al.*, 2015). Where necessary this context can also be used to alert others if there appears to be a problem (Zhang *et al.*, 2013; Pater *et al.*, 2017; Ma *et al.*, 2018).

2.2.4 Challenges related to context

The examples in the section above also highlight challenges with using tracking technologies to infer health and wellbeing states. They show potential problems with designing for variable conditions such as location and show complications that can occur with using sensor data to interpret information about the human condition, for example the differences in human behaviour. Despite Dourish's work around context as an interaction problem, technical problems still seem to dominate the self-tracking context-aware literature (Solis *et al.*, 2019; Ghandeharioun *et al.*, 2016; Ng *et al.*, 2022; Katz *et al.*, 2018; Perera *et al.*, 2014). These problems include things like the internal and external context conflict. Internal conflict referring to two context sources that cannot determine where a user is i.e., a sensor says they're in the kitchen but the calendar says they're in a meeting. External conflict referring to inconsistency between two bits of context i.e., multiple motion sensors providing different readings.

For user experience designers, these technical problems are less useful as they may wish to look at how people interact with self-tracking systems when missing needed context about their health and wellbeing. Additionally, they may wish to look at what the potential implications of including new types of contextualised information in self-tracking systems might be. Kulkarni (2020) explains how testing context can be difficult early on because of the need for large datasets. This is explained through the cold start problem, with systems having insufficient information available at the start so are unable to adapt to someone's context. Design can intervene here, using methods (discussed under Chapter 3) to integrate contextualised information through exploring interaction with contextual information in self-tracking systems early on. This is referred to in this research as integrating contextualised information in a *preliminary design phase*. One of these interaction problems is seen through Liu et al's (2015) work highlighting issues with contextualised information in sleep tracking. For example, these systems don't necessarily interpret data within context. People with sleep issues know they sleep poorly; they need to know *why* they slept poorly rather than a system stating *how* poorly they slept. Looking at people's interactions with self-tracking systems and the contextual considerations around this could reveal implications for understanding health and wellbeing information. Missing this context can also be detrimental to wellbeing.

2.3 Technology and wellbeing

2.3.1 What is wellbeing?

While health and wellbeing are discussed throughout this work, wellbeing is focused on here because self-tracking technologies are referred to as general wellness devices by regulatory bodies such as the Food and Drug Administration (FDA) (Simon et al., 2022). Therefore, they do not follow the same protocols as *medical* or *health* devices, despite this line becoming increasingly blurred (Brophy and Hope, 2021). Equally, this thesis explores wellbeing in relation to the impact self-tracking devices can have on our wellbeing. However, it should be acknowledged that health and wellbeing influence each other, with both physical and mental health influencing wellbeing and wellbeing also impacting health (Department of Health, 2014). But what is wellbeing? As described in Calvo and Peters Positive Computing book (2014), our wellbeing is dependent on basic needs such as access to food, water and shelter and once these have been satisfied the definitions of wellbeing get complicated. These definitions, according to Calvo & Peters, fall into three philosophical standpoints; medical, hedonic and eudaemonic. The medical approach to wellbeing sees wellbeing in relation to our mental health, that is someone is well if their mood and behaviours don't fall into a "mental dysfunction" (Calvo and Peters, 2014, p. 14). This is like how being physically well or healthy means "without illness". This approach follows frameworks and guidelines (such as the manual of psychological disorders i.e., DSM) around how to diagnose and intervene to improve wellbeing.

Other approaches outlined by Calvo and Peters promote healthy functioning for the general population, rather than focusing on those that are 'ill' (also known as preventative healthcare). This aligns with self-tracking technologies that have a focus on general health, wellbeing and self-monitoring, referred to in this work as *general wellness*. The following approaches reflect viewpoints in the literature read that helped to build critique for future self-tracking design considerations. The hedonic approach, meaning pleasure, regards wellbeing as a combination of pleasurable experiences, also linking to our goals and attainments in life and how satisfied we are with these different aspects. While hedonism tends to focus on our positive emotions, the eudaimonic approach acknowledges that there is more to wellbeing than positivity. It explores how wellbeing links to our engagement, relationships and human potential which aligns the most with more-than-human theories included in this thesis, outlined in section 2.5. As this thesis includes people's understanding of contextualised information about health and wellbeing, how we are motivated to engage with technology designed to support wellbeing is important.

Part of this approach includes a theory by Ryan and Deci (2000) know as self-determination theory (SDT) stating that autonomy, competence and relatedness are key parts of motivation and wellbeing. Autonomy is the idea that we have control over our behaviour but more importantly that we act in alignment with personal goals and values. Competence is the feeling of being able to do something and relatedness is a sense of belonging and being connected to others. Competence and relatedness reflect ways to explore how people might interact with contextualised information in self-tracking systems and how it is explored within this research; understanding what this data means and feeling more connected with others through this new understanding of themselves and those around them.

As well as acknowledging there is more to wellbeing than positive emotions, a lot of the work in this area links with scientific approaches to defining wellbeing through quantitative measures such as scales or models. These include the Psychological General Well-Being Index (PGWBI), Satisfaction with Life Scale (SWLS) and the Subjective Happiness Scale (SHS) (Isaacs et al., 2013). Aligning with the eudaimonic approach, factors that contribute to wellbeing in this thesis consider things past what we can physiologically measure. This can include our past experiences, social circles and our environment, linking with more-than-human theories, as introduced in section 2.5. This also acknowledges that wellbeing for humans does not necessarily mean wellbeing for the flora or fauna and so may have its own definitions. Therefore, it is important to also include the terms subjective and objective wellbeing in relation to what individual wellbeing is. Subjective wellbeing (Riva *et al.*, 2012) (SWB) relates to an individual's perception of their own wellbeing and general quality of life. This perception might change depending on their view of the world (discussed in 2.5). Objective wellbeing (OWB) refers to external requirements such as housing and water supply that contribute to a person's quality of life. Desmet and Pohlmeyer

(2013) states that OWB is a determinant of SWB and can be used to increase our understanding of how objective wellbeing can increase subjective wellbeing. Acknowledging that wellbeing is more than improving our bodies but also about our environment and other external needs, highlights different considerations that could be explored through introducing new contextualised information in self-tracking systems.

2.3.2 How is technology applied to wellbeing?

Within academia, specifically the HCI space, tools and methods are created to explore ways technology can be used to support our wellbeing, as well as analysing our relationship with technology and how that can impact on our wellbeing. For self-tracking technologies that aim to improve our general wellness, it is important to consider both how technology is designed *for* wellbeing while also acknowledging the distinct difference of designing technology *with* wellbeing in mind. Different areas have emerged to consider both designing for and with wellbeing. Positive computing focuses on designing technology that promotes psychological wellbeing and human flourishing, which is the "optimal (rather than just the average) end of human psychological functioning" (Calvo and Peters, 2014, p. 14). This field of computing has become quite complex and multi-disciplinary expanding from both Positive Psychology and Positive Design. Positive Psychology is the study of conditions and processes that contribute to flourishing (Gable and Haidt, 2005) Positive Design is a high-level design framework addressing individuals' happiness (Desmet and Pohlmeyer, 2013). Positive technology (Riva *et al.*, 2012) focuses on the quality of our personal experience through the invention of new technology to support psychological (or eudaemonic) wellbeing. Whatever viewpoint is discussed, some focus on designing features *for* specific wellbeing technology such as wellbeing apps (Roquet and Sas, 2019) and some *with* wellbeing theory such as gratitude (Ghandeharioun *et al.*, 2016), self-awareness (Kauer *et al.*, 2012), resilience (Peters and Calvo, 2014) etc.

More recently, wellbeing-driven design research has formed (Klapperich *et al.*, 2018), using technology design to improve everyday lives by acknowledging how technology can shape our "habits and preferences" (ibid, p. 1). They note that through trying to create systems that are adaptable and customisable, wellbeing is often neglected. This aligns with the focus of this thesis. Through new considerations of context, it is important to explore possible implications of introducing these new types of information in self-tracking systems before they are implemented, with the potential to hinder our wellbeing.

2.3.3 Problems with technology and wellbeing

Lots of valuable research is being done to highlight and explore real technological harms (AI Now Institute, 2023a; DAIR Institute, 2023; Data Justice Lab, 2023; AJL, 2023). The examples outlined in this section, make it clear that despite those advocating for change, for many years responsible innovations (and with them, considerations around ethics and wellbeing) have not been a priority within technology companies.

An early example of this can be seen through a decision made by Facebook (Goel, 2014). On their live platform, Facebook designed and implemented an alternative feed. This feed contained an overwhelming number of 'negative' posts to see if this had an impact on people's mental health. However, people, including those with mental health conditions, were not informed of these changes to their feed so they could not consent or opt out putting real people's wellbeing in danger.

These design decisions made by technology companies have continued to emerge. Through decisions made about what to include, who to include and how they might be included, technology design has resulted in algorithmic models that have perpetuated bias, increased inequalities, and altered people's lives. These algorithmic models, for example have decreased students' grades meaning some missed out on university places (McKeever, 2020). Surveillance apps have targeted specific communities, resulting in citywide manhunts of innocent citizens (Benjamin, 2022, p. 76). Emotional recognition technologies have been noted as failing to capture “diverse emotions across different cultures” and may misrepresent atypical facial expressions of people with disabilities such as those who have experienced a stroke or have Parkinson’s disease (Access Now *et al.*, 2023). Facial recognition software has also been found to assume gender identity or sexual orientation, causing emotional distress and erasing identities in the process (Leufer, 2021). Additionally, bots have been placed in charge of providing advice and recommending content which has been found to exacerbate eating disorders (Paul, 2021; Bailey, 2023). Through the conversational design of these models, these technologies reinforce “racist, sexist, ableist, extremist or other harmful ideologies” “through interactions with synthetic language” (Bender *et al.*, 2021, p. 2).

Recent media has seen an effort to make the public aware of these harms and make it harder for companies to ignore. Documentaries like Coded Bias (Kantayya, 2020) reflect issues from those most effected by the design of these technologies. The Social Dilemma (Orlowski, 2020) slightly more problematic, coming from the perspective of those in industry with financial gains to be made from these technologies. This industry perspective can also be seen through technology companies hyping potential AI risks to draw attention away from discussions around current harms embedded within system design (AI Now Institute, 2023b).

Applied to wellbeing contexts, marketing terms like digital wellbeing are being adopted (at least theoretically) and promoted by ‘big’ tech firms like Google (2019), Apple (2020) and Microsoft (Cecchinato *et al.*, 2019), focusing particularly on addiction to social media apps and the amount of time we spend on our devices.

These companies have introduced digital wellbeing features acknowledging there is a problem with our relationship with technology (Roffarello and Russis, 2019). However, these features focus on self-awareness of our reliance on technology (Lu and Lopes, 2022) and limiting the time spent on our devices (Roffarello *et al.*, 2022). This focuses on user's excessive use and how they can optimise their time (maybe through using other products) rather than acknowledging the designers' role in the experiences we're creating. While digital wellbeing tends to focus on social media, multiple technologies are becoming increasingly social and complex resulting in unintended consequences. Within self-tracking technologies, it is even more important to consider where harm might be present in system design as these systems are aiming to improve not hinder our wellbeing. Harm here is described as something that negatively effects someone's life by decreasing their subjective wellbeing in some way. For example, self-tracking information could be seen as harmful if the content shown causes physical or psychological distress such as anxiety. It may also be harmful if the information in these systems reveals information that can impact an individual's wellbeing beyond bodily factors. For example, changing their relationships like highlighting they're the one using the shower more or compromising their privacy such as revealing where they live.

Literature demonstrates that there can be unintended consequences, or harm, from people using self-tracking systems. A focus on quantified symptoms can create emotionally loaded contexts promoting *healthism* (Spiel *et al.*, 2018). Healthism implies that health and illness are the responsibility of an individual, requiring us to improve, adapt and also perfect our bodies in the same way because of the 'one-fits-all' approach. For people with chronic illnesses there is an additional burden as these metrics remind them of their illness (Ayobi *et al.*, 2017). This can result in a sense of hopelessness when they can't improve on these metrics, due to the normative notions embedded in system design.

Equally there is an unpredictability with tracking certain things that is not replicated in system design. For example, in situations such as pregnancy there is increased pressure for constant engagement and becoming dependent on the data, perceiving the tool as something that will achieve positive results even though the final goal might not be possible. For those who cannot conceive and therefore cannot achieve the goal and for those trying to achieve the goal of pregnancy, this process can result in anxiety, guilt and judgment and may also impact on physiological elements such as delaying menstrual cycles (Figueiredo *et al.*, 2018). Equally being dependent on this data can mean that the data only feels valuable if it's being captured by the system and can also change behaviour if the data contradicts their lived experience (Kersten - van Dijk *et al.*, 2015). For example, a self-tracker saying a person hasn't slept well and then the person believing they are more tired as a result. Behaviour might also be changed to suit what the system can track, rather than what a person wishes to track or can mean they deceive themselves to achieve goals i.e., not logging sugar because it was only a small amount (Gross *et al.*, 2017). People can become obsessed over the data provided (Eikey and Reddy, 2017) especially as numbers imply that a higher level of precision can be achieved (Kersten - van Dijk *et al.*, 2015). There are also questions about who these systems are designed for, with assumptions made about who is using an app. This contributes to the erasure of people's identities, alienating them from these systems as they are not seen as valid i.e., a "normal woman" (Figueiredo et al., 2018).

As explained in later chapters, these systems are designed to support the way we think, using complex models and algorithms to collate masses of complex data from sensors into simplified metrics and insights to reduce cognitive load (Kahneman, 2011). However, this means that features are created based on a system's capabilities rather than user expectations resulting in friction. With advances in machine learning (ML) and artificial intelligence (AI), humans may no longer be involved in these decisions as these machines learn and adapt by themselves (Morley *et al.*, 2019). This could be harmful if incorrect assumptions, or lack of context about an individual's health, results in decisions and insights that could endanger lives. For example, a large step count could indicate high activity for a person with a sedentary lifestyle but low activity for an athlete but currently both types of people are measured in the same way (Sheth et al., 2017). This shows a problem with the way systems perceive health and wellbeing by viewing contextualised information through a singular perspective of what it means to be health and well. To tackle the generalised 'one-size fits all' model present in current self-tracking systems, this thesis argues for new considerations of contextualised information. This is through introducing different perspectives of health and wellbeing information which could highlight possible implications for self-tracking system design. This is particularly important when these systems capture information not just about us but the world around us.

2.4 Our world in relation to data

As data becomes entangled in our lives, it is involved in our relationships (both human and non-human), the situation we're in and the environment around us. Acknowledging data is lively i.e., created and recreated for different purposes, is vital for understanding how contextualised information is considered in self-tracking systems and how these considerations could impact our lives (Lupton, 2016b). Humans are one part of this complex system, which can be seen through technologies such as the Internet of Things. Humans are "just one node in a network of software, digital data repositories and smart objects that configure and exchange digital data with each other" (Lupton, 2016a, p. 2).

While Human-Data Interaction (HDI) (Mortier *et al.*, 2014) takes a human-centric view of a data-driven world, it wishes to understand how people interact with more complex pervasive data. HDI refers to data that has been created consciously by us such as social media posts, as well as data inferred by both people and machines to create information such as insights about, for example our eating habits. It also acknowledges who data is used by and how this understanding might differ depending on individual's viewpoints. HDI refers to this through the term 'boundary object', stating that it is open to multiple interpretations, especially from different stakeholders' perspectives including those collecting the data, those legally responsible and the parties using the collected data. This framework provides a starting point to explain the messy reality of living with data and how complex it can be to understand both our relationship with data, what it represents and reveals, as well as how we interact with it.

2.4.1 How do we currently make sense of or understand data?

As Crabtree & Mortier explain, "if users are to have the ability to exercise agency within an HDI system in any meaningful way, data sources must provide a minimum level of legibility as to what data they contain, what inferences might be drawn from that data, how that data can be linked to other data, and so on" (2015, p. 18). This means that the way data is presented (is made legible) is important so people can make sense of the data. *Legibility* requires clarity about how people's data is collected, processed and how decisions are made to create information for a variety of purposes whether this be advertising or predicting behaviour. Research focused on the complexities of legibility show how it can help introduce new technologies, interactions and features through iconography (Lindley *et al.*, 2020c) and allows people to generate their own sources of data from the home (Berger *et al.*, 2018). One of these complexities is that people can interpret data differently depending on their context, where they currently are as well as their own past experiences. For example, a graph produced in a hospital may be too complex for a patient with no medical knowledge to understand. Koblin (2009) showed how this interpretation can change even with the simplest task, asking people to draw a sheep and noting how responses varied in size, detail, shape etc. (see Figure 6). Interpretation is important when understanding how people interact with new considerations of contextualised information, so reflections are not based on considerations that support some people's understanding but not others.

Figure 6 - Interpretations of a sheep when asked 'draw me a sheep' source: http://www.aaronkoblin.com/work/thesheepmarket/

There is a huge amount of health and wellbeing data produced from sensors, devices and algorithms used in self-tracking systems. To help us make sense of this data, information and insights are derived from the data creating new knowledge about ourselves and others. Information is presented through limited words, numbers, and visualisations such as graphs, badges, or progress towards goals to help us process information and support our cognitive load (Kahneman, 2011).

Data visualisation can be seen back as far as Nightingale and Snow (Figure 7) (Drucker, 2014). Through displaying large amounts of complex medical information into maps, graphs and scatterplots, the creation of these visualisations can generate new knowledge and spread awareness of health discoveries. Drucker explains this through the causes of mortality and clusters of cholera outbreaks from pumps around the city etc. Today, data visualisation is still largely seen as a 2D entity displayed in an analytical way. However, data artists and researchers are looking at creating visualisations to help us understand more about ourselves and the world around us. This could be through new technologies such as machine learning and sensors (Mcduff *et al.*, 2012), VR (Ivanov *et al.*, 2019) and AR (Lau *et al.*, 2019) aiming to immerse people in data, increasing engagement, and allowing for an in-depth exploration of complex data patterns. Equally, for real time visualisations, sonification has been used to help understanding of how complex societies evolve, such as RAT systems mapping the movements of a naked mole rat colony (Freeman and Faulkes, 2016).

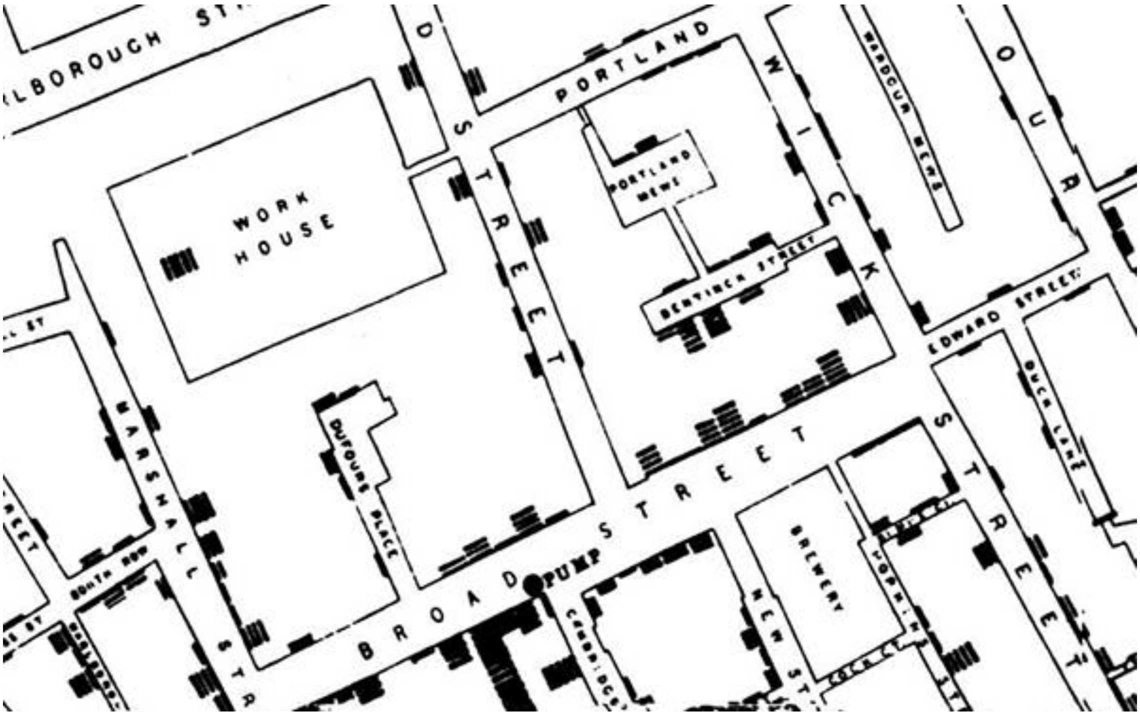


Figure 7 -John Snow's Cholera map showing clusters of cholera outbreaks from around the city source: https://www.giperspective.co.uk/mapping-diseases-then-and-now/.

How we make sense of data is complicated, the above examples show that there is a focus on representing numbers in different ways through visualisations and new technologies. Within self-tracking, these visualisations can be seen in current system design through simplified metrics such as graphs, charts, goals etc. to represent complex information about our health and wellbeing. As our self-tracking systems become more social, visualisations are produced reducing our relationships down to comparisons i.e., steps of an owner and their dog (Jayawardene *et al.*, 2021). This is shown through visualisations like leaderboards as well as comparing our metrics to humans and sometimes non-humans with overlapping characteristics i.e., how we compare to people of the same age and sex. While it has been explained how this focus on purely metrics can be problematic for an individual's wellbeing, these systems are no longer tracking just ourselves. This is not just through social aspects of an app but as Figure 8 shows, self-tracking systems documenting the general wellness of a human adult, infant or a companion animal (i.e., a cat or dog) in the same way i.e., through scores, graphs, goals etc.

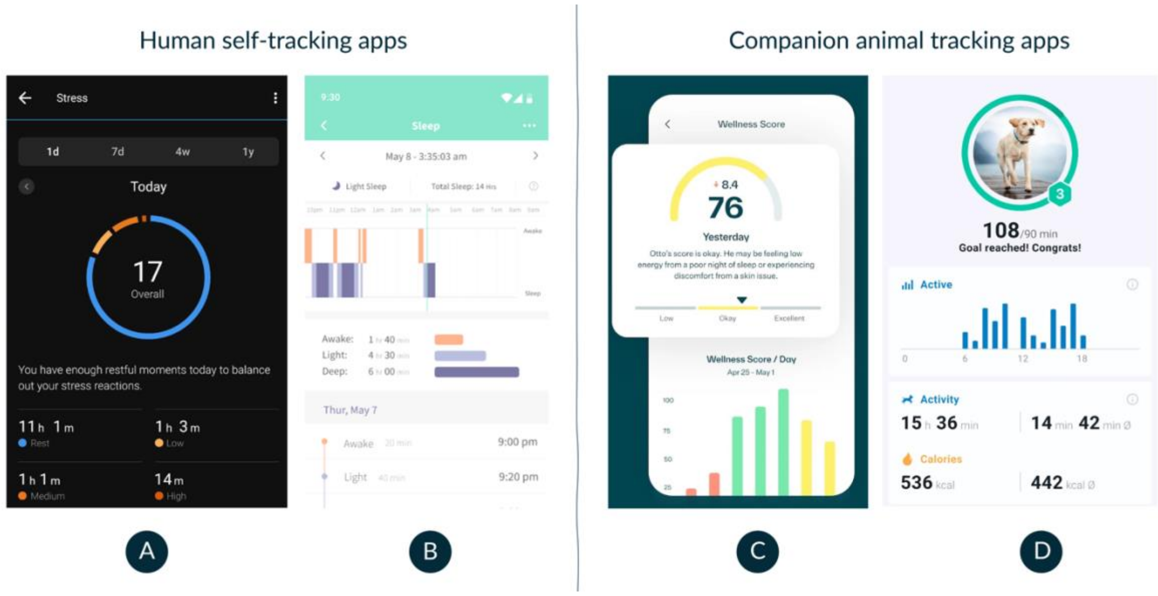


Figure 8 - Human and companion animal tracking apps are designed in the same way. A – Garmin fitness tracker source: https://play.google.com/store/apps/details?id=com.garmin.android.apps.connectmobile. B – Owlet baby tracker source: https://play.google.com/store/apps/details?id=com.owletcare.owletcare. C – Whistle tracking app source: https://play.google.com/store/apps/details?id=com.whistle.bolt. D – Tractive tracking app source: https://play.google.com/store/apps/details?id=com.tractive.android.gps.

Given this shift towards self-tracking beyond the individual, it is therefore important to see if current self-tracking system design also impacts those around us. But first, how have researchers looked at the 'social side' of tracking?

2.4.2 Self-tracking the world around us

Literature also shows examples of tracking those around us. A lot of this work focuses around awareness of other people (Jarusriboonchai *et al.*, 2016; Pearson *et al.*, 2015; Dagan *et al.*, 2019; Epp *et al.*, 2020) and matching individuals based on commonalities (Li *et al.*, 2020; Chen and Abouzied, 2016; Dagan *et al.*, 2018; Olsson *et al.*, 2020; Kirkham *et al.*, 2013) with the aim of enhancing in-person or 'co-located' interactions. Wearables might also be public facing with watch faces generally being visible by those around an individual (Pearson *et al.*, 2015). Therefore, there has been the idea to display this information not just for a wearer but a gazer. One of the earliest examples of this being BubbleBadge (Falk and Björk, 1999) which displayed quotes and information at a conference as a way of starting conversations. A more recent example (Pearson *et al.*, 2015) displays information about others through an individual's display (Figure 9A) i.e., if someone is on a train and someone is staring at their watch, it might become context-aware showing the 'gazer's' emails or more public information such as the weather or news headlines, changing the purpose of wearables and how we view self-tracking information.

Many technology interventions aim to communicate data by focusing on the aesthetics of the wearable. Often through non-verbal feedback, earlier technologies encourage connecting with others through clothing items such as a jacket (Papadopoulos, 2005) or gloves (Figure 9B) (Carswell, 2009). Later work still uses prototypes to explore these themes but with a focus on wellbeing. This includes, taking regular breaks to socialise (Figure 9C) (Dagan *et al.*, 2020), receiving colours through a physical cloud prototype about a friend or partner's moods (Figure 9D) (Rodgers et al., 2019), live biofeedback from collective emotional states (Qin *et al.*, 2020) and the heartbeats of a loved one (Figure 9E) (Liu *et al.*, 2019).

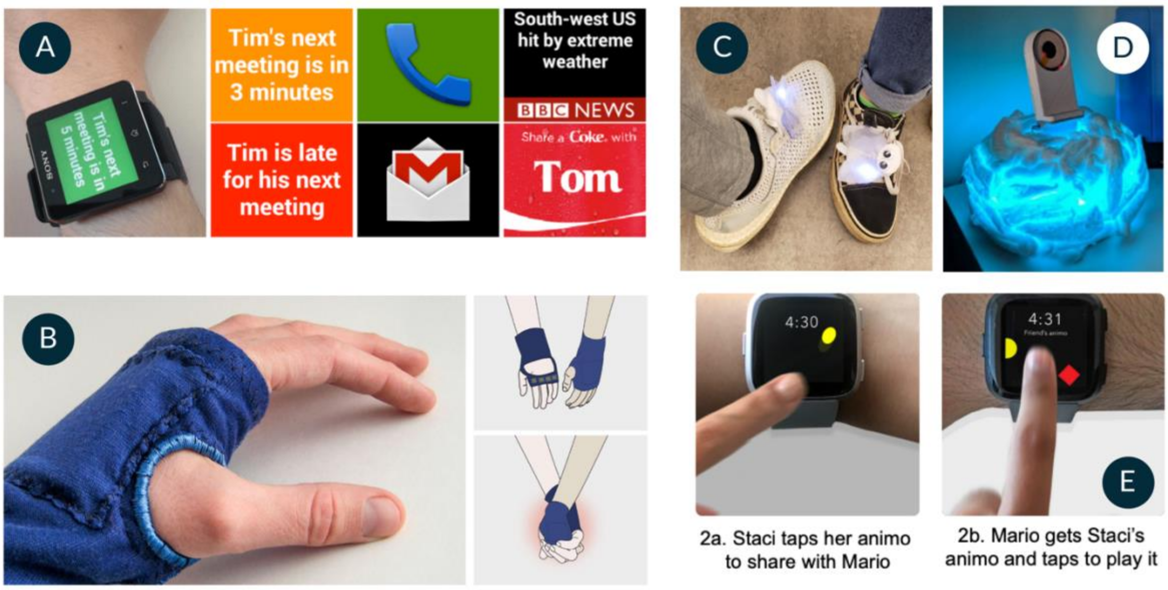


Figure 9 - Social self-tracking technologies and systems. A – Watch displaying public information about the watch wearer or the news etc. (Pearson *et al.*, 2015). B – Glove that connects to a loved one's glove (Carswell, 2009). C – Flippo the shoe fly encouraging person to take breaks and socialise (Dagan *et al.*, 2020). D – Cloud displaying mood (Rodgers et al., 2019), E – Watch that shows heart rate of a loved one (Liu *et al.*, 2019).

2.4.3 Associated impact from tracking those around us

Self-tracking systems that capture data about ourselves and multiple humans and non-humans can create new meanings for our relationships. Even through vague data about energy levels in a household, people's behaviours can be revealed. From the data itself as well as people being predisposed to see people in the data based on what they already know about each other (Tolmie *et al.*, 2016). Due to these assumptions, it means that previously hidden behaviours are made visible and therefore people can become accountable for their actions in a way they weren't before. This accountability might be as simple as being accused of leaving a light on or showering too long. This highlights behaviours that are considered morally acceptable or unacceptable within a social setting. When the accountability is about safety of another person, i.e., an infant, having metrics presented as vital for care of this person can result in obsession over the data and increased anxiety with the caregiver wanting to make sure their infant is ok (Wang et al., 2017). For older children, some expressed that parents having access to data about their activity levels, meant parents were able to monitor their actions that were previously inaccessible i.e., parents were aware if they walked the dog. This could change their relationship with their parents i.e., being reprimanded over low activity levels (Jørgensen *et al.*, 2016). Also having multiple family members data made available resulted in comparisons between family members. This was particularly problematic for divorced parents who did not want their whereabouts known by their former spouse (Pina *et al.*, 2017).

This also highlights how for certain people, using these systems can have consequences for who can view or monitor intimate details about our bodies. For example, menstrual health apps used in the workplace to collect regular reports about employee's activity which encouraged female employees to use family planning apps (Mahdawi, 2019). Hong (2020) argues that this is one problem with using technological solutions for knowledge about ourselves and those around us. Using masses of data results in systems that benefit some people more than others. This leads to what Hong describes as a *quantified society* which increases inequalities. This can already be seen through some of the voices raising awareness around biases within our systems including societal biases (O'Neil, 2016), gender biases (Broussard, 2018; Criado-Perez, 2019), racial biases (Benjamin, 2019) and class biases (Eubanks, 2018).

Most of these examples show potential harms in a system design that were only revealed after the systems were implemented fully and social dynamics came into play. Without design processes and contexts where this data might be used, it may never become clear what harms could develop. All these examples note problems with a purely quantitative approach to measuring multiple bodies. Therefore, exploring implications of introducing new considerations of contextualised information through different perspectives is important before these self-tracking systems are implemented with the potential to cause harm.

2.5 Moving beyond the current design of self-tracking technologies (considering more-than-human theory)

As noted throughout this literature review, a single perspective of what it means to be 'healthy' and 'well' creates a one size fits all design to cater to a collection of bodies (both human and non-human) rather than acknowledging different health and wellbeing experiences. However, what if self-tracking systems introduced different perspectives of contextualised general wellness information? What might these perspectives include that are different from this single perspective included in current self-tracking system design? Exploring this, first involves looking at how these different perceptions of the world have already been considered within HCI and design. The following section explains the differing waves of HCI acknowledging that there are different ways of perceiving the world and how we interact with it.

2.5.1 The waves of HCI

Frauenberger (2020) argues that HCI has gone through a few paradigm shifts. Popularised by Kuhn (1962), knowledge comes into existence through theories, concepts and methods within a paradigm believed by scientists to be true which are then adopted or accepted (normal science). When doubt forms, that is when new ideas are adapted and our understanding of the world changes within a paradigm causing a shift i.e., Darwin's discovery of evolution in Biology. Frauenberger (2020) outlines these shifts in HCI through emerging waves. The first wave acknowledges that interaction forms part of HCI and the second builds on a metaphor around merging human and machines ways of processing information. The third and fourth wave forming the most relevance for this thesis.

2.5.1.1 The third wave of HCI

The third paradigm or wave of HCI focuses on "interaction that is situated in the social and bodily complexities of a messy, real world" (ibid, p. 2). Harrison et al., also refer to it as the *situated perspectives* paradigm (2007). Situatedness has been used as a term within HCI to explain how our differing perceptions of the world change how we navigate and live within it. One of the first instances being Suchman's (1987) explanation of situated action. This describes how a person's actions can change in a particular situation tied to a place or environment. Suchman focuses on our actions with machines, arguing there is a significant difference between where an object is designed and made. This creates a separate relationship with where this object is placed and how we relate to it in practice. Equally, as described by Fischer (2016) our interactions are also situated. We cannot make sense of a situation unless something is known or assumed about a conversation taking place.

This can be seen to follow current approaches to context-awareness, determining where someone is and what they are doing to provide different information, or 'context-aware' insights based on that particular situation. However, this ignores situated knowledge (Haraway, 1988), with our background altering how we understand the world. We can partially share knowledge, but people do not necessarily perceive knowledge and therefore process knowledge in the same way changing how we understand information about our health and wellbeing. Crabtree and Mortier (2015) explain how social factors are involved as information can be interpreted differently across communities. This means even if one viewpoint is considered true by some, this does not mean everyone follows this same understanding.

Bertel et al., (2019) explains how situated knowledge should also consider the knowledge of the researcher, designer or developer has about the world as this will shape the systems that are created. They argue while situatedness has been included in this wave, the "complexity of social identities" is not addressed and if they are it is viewed as "an aspect to be corrected" rather than "an essential part of the scientific process" (ibid, p. 3). This raises questions about whose knowledge, actions and interactions are prioritised in self-tracking system design and how this shapes who can understand and interact with these systems. Bardzell discusses how acknowledging cultural differences through pluralist design can embrace the "margins" (2010, p. 1306). Acknowledging that multiple voices help to support our understanding of data as everyone has unique and varied viewpoints is important for this research. This thesis will argue that these multiple voices can be included through more-than-human perspectives (see section 2.5.2).

2.5.1.2 The fourth wave of HCI

Frauenberger explains how the emerging fourth wave of HCI responds to advances in technology such as IoT devices (i.e., self-tracking devices) and artificial intelligence which have blurred the line of "where the human ends and technology starts" (Frauenberger, 2020, p. 2). He refers to this fourth wave as entanglement HCI aiming to bring humans and non-humans onto the same level. Despite the epistemology side of more-than-human discussed within this wave, the main relevance to this research is what this would mean for future self-tracking design.

There has been an argument to move beyond creating 'user friendly' experiences to expand to the other complexities that arise from the integrated world we live in. This is in response to a problematic human centered approach by referring to people as users, described by Baumer and Brubaker (2017) as “user-fying” people. They advocate for a move to post-userism as the term *user* generalises people down to their relationship with technology, forgetting these are real people with real lives. Grouping individuals into a collective term whether to speed up or simplify the design process, shows how focus on the human can remove needed context i.e., who a person is and ignore other actors involved in the system. Frauenberger builds on this concept to argue for a move beyond user-experiences considering the "political mattering of things through which we make sense of us in the world" (2020, p. 19).

This has been explored through HCI and design disciplines. Animistic design (Marenko and van Allen, 2016) focuses on conversations *with* things rather than *about* things using more-than-human theories to respond to the unpredictable network of IoT devices. In data visualisation, Morton's characterisation of object-oriented ontology (OOO), can be used to define data in a way that "doesn't privilege any single body or way of knowing about the world" (Ploehn *et al.*, 2020, p. 3). OOO can be applied to more-than-human HDI for considering how the design of our systems impacts the planet (Stead *et al.*, 2022). Additionally, more-than-human centered design focuses on how devices can form constellations. That is devices rely on multiple actors and these constellations can change depending on cultural views, environments etc. (Coulton and Lindley, 2019). These approaches acknowledge how we construct and experience the world, as well as how we relate to each other, which can differ depending on who we are and how we view the world.

2.5.2 Posthumanism and more-than-human theory

Posthumanist theories are a vast area, exploring the different ways of constructing and experiencing the world. While there is not space within this thesis to discuss the many varying types of posthumanism, here a brief overview is explored.

The definition of posthumanism is tricky, with many terms overlapping and used interchangeably including posthuman, transhuman, posthumous and more-than-human (Lupton, 2020). Braidotti (2016) advocates for the term critical posthumanism to consider our connection to the environment and acknowledging racism, sexism, colonialism, classism etc. as part of this approach. For Haraway, a term that doesn't include the human at all is more appropriate for dismantling power hierarchies, coining the term compost-ist (2016). Forlano describes posthuman as resisting binary categories to "integrate the human and the nonhuman" and that this viewpoint rejects "the rational, autonomous individual and, rather, emphasize[s] the partial, situated, and socially-constructed self" (2017, p. 5) . While this definition aligns with the way this thesis frames the concept of the self in self-tracking (see Chapter 5), the term more-than-human is used in this research. This is following Lupton's (2020) argument that more-than-human is better at "encapsulating the inextricable entanglement of humans with nonhumans" (ibid, pg. 23).

As will be explained, more-than-human theory takes many different approaches. It can be used to explain the complexity of the world focusing on the entanglement of beings to help address social inequalities and sustainability issues. It can also advocate for a focus on those considered more-than-human i.e., plants, non-human animals, bacteria, etc. As explained by Coulton and Lindley, more-than-human theories are becoming increasingly relevant for design (2019). They argue that for design practice, more-than-human approaches are helpful for informing and creating the design i.e., artefacts, but the subtleties between the approaches are inconsequential. While it is important to discuss different more-than-human theories and their relevance to this research, it is not necessary to be wrapped up in the "nuance" between these different approaches. This is because people will respond to the artefacts themselves, rather than the theory and ideas that helped influence the design.

This research wishes to introduce different perspectives of contextualised general wellness information into self-tracking design. What particularly can more-than-human perspectives reveal about experiences of the world beyond bodily metrics and what does this mean for self-tracking system design?

2.5.3 More-than-human perspectives

Within this research, it is acknowledged that other actors are particularly important in the types of self-tracking systems that track non-humans as well as humans (van der Linden, 2021). Additionally, these self-tracking systems are starting to overlap with social features, for example encouraging competition between human bodies but also comparing the step count of our dog to our own. Therefore, considering different perspectives of information requires understanding that these perspectives can be more-than-human.

As explained by Stead et al., (2022) in Figure 10, the flora, fauna, climate, humans as well as data, IoT, AI and machine learning all have a different perspective on the way we view the world. This means that technologies, animals and nature can all play a part of the design process. This is considered in this research by taking different more-than-human perspectives and exploring how might they provide different considerations for contextualised information through their viewpoint of the world.

Following more-than-human theory also means implementing a *flat* ontology where "humans are no longer monarchs of being, but are instead among beings, entangled in beings, and implicated in other beings" (Bryant, 2011, p. 44). Therefore, humans are not always the central focus of the world. Even if these applications are made to be used by humans, they may not necessarily benefit multiple beings' wellbeing, as discussed in later chapters. While this is the overarching more-than-human theory that influences this research, different more-than-human theory will help consider general wellness experiences beyond metrics in self-tracking system design.

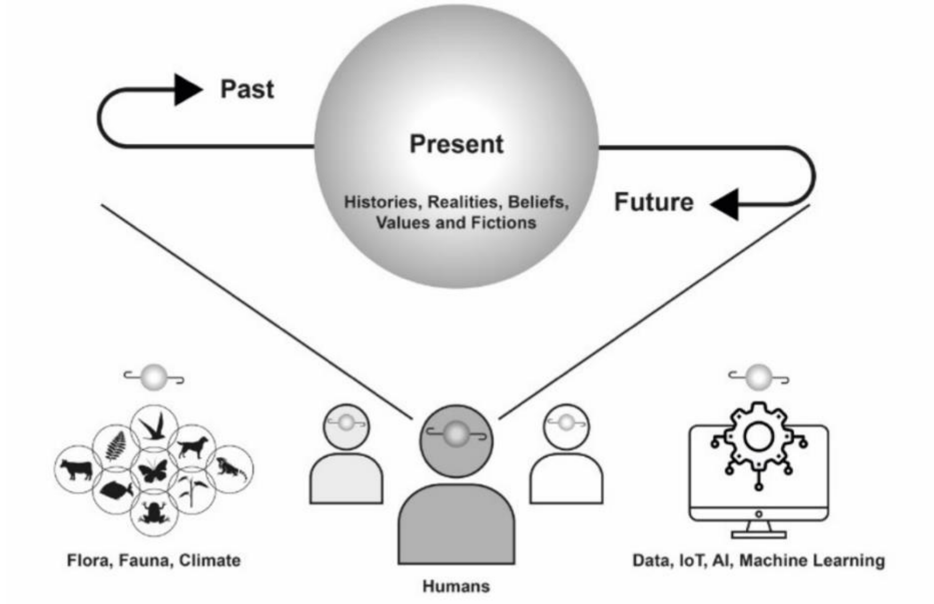


Figure 10 - More-than-human HDI diagram where different perspectives influence the world around us. Image from the paper Stead et al., (2022)

2.5.3.1 More-than-human theory to understand our connection to technology (and things)

According to Bogost (2012) objected oriented ontology (OOO) means taking into account things at all scales, these things can be anything from a living being like a gecko to food such as cake and even an idea can be a thing (ibid, p. 24). As explained by Wakkary et al., (2017) this means looking at our relationships with 'things', where a human "mutually shapes the other [the thing] through mediations that form the human subjectivity and objectivity of any given situation". This can be seen in the IoT space Figure 11 where OOO acknowledges our connection to visible IoT *things* i.e., IoT devices like a smart speaker and can extend to include invisible connections to *things* such as algorithms, humans, data, business models, etc. as well as acknowledging the impact this has on both the environment and resources (Lindley *et al.*, 2020a). As self-tracking technologies fall under this area, acknowledging how algorithms and non-human actors can also be viewed as *things* within our systems shapes considerations for system design.

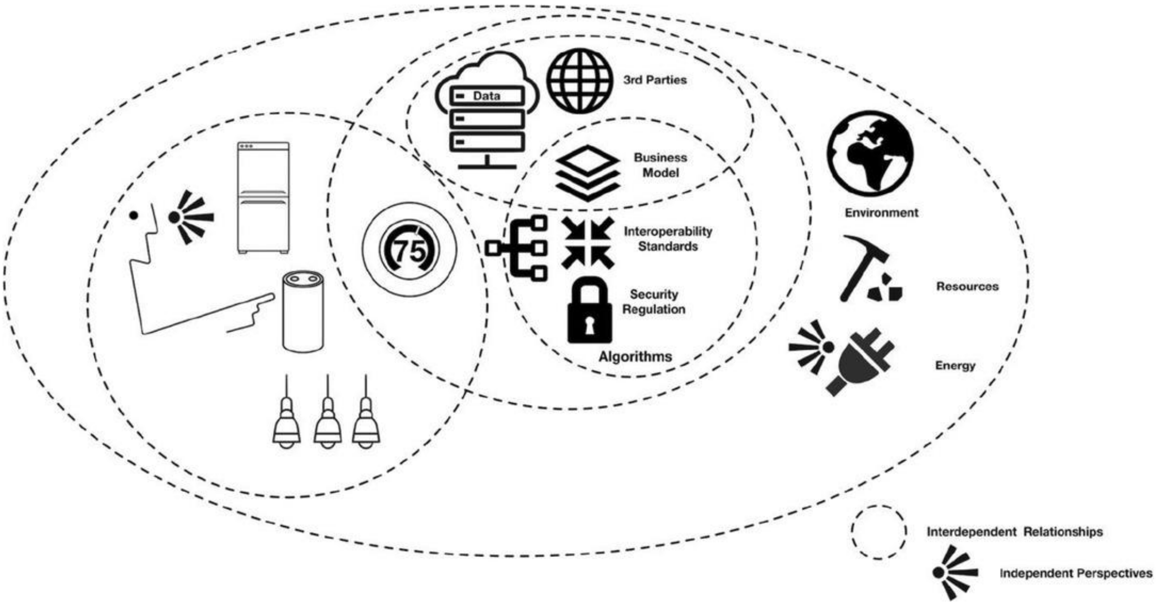


Figure 11 - IoT constellations representing our visible and invisible connections to various IoT things. Image source from (Lindley et al., 2020a).

This more-than-human concept falls under speculative realism asking, “why would you, a human, be able to shed light on a teapot?” stating that everything might have its own reality “not necessarily resembling, reflecting, or correlating with our own experiences” (Lindley *et al.*, 2019b, p. 7). This is important to consider for introducing these different perspectives as we are not actually experiencing these realities. However, as Bogost (2012) highlights by exploring these ideas practically we can begin to understand and design as well as critique better IoT devices.

2.5.3.2 More-than-human theory to acknowledge companion animals' entanglement in society and what their experiences can bring to self-tracking systems

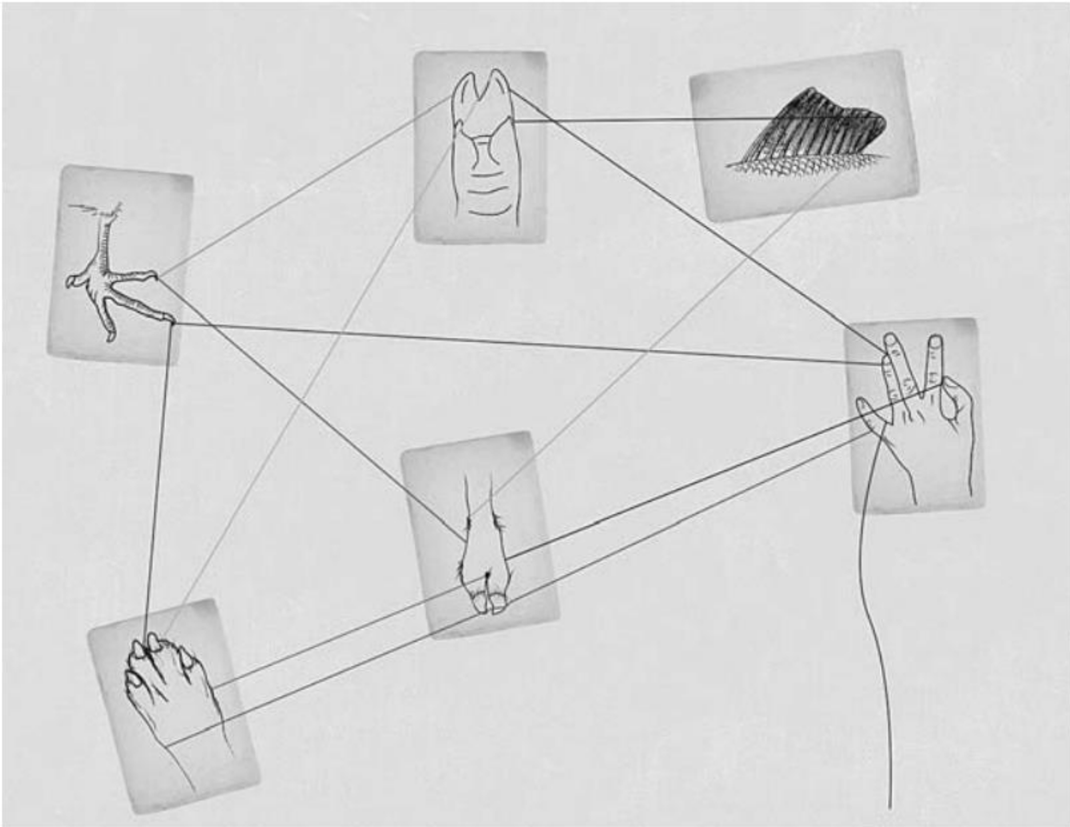


Figure 12 - Multispecies Cat's Cradle. Drawing by Nasser Mufti, 2011. From Staying with the trouble (Haraway, 2016)

In a similar way to how IoT networks shows our connections to things, Haraway (2016) discusses a multispecies cat's cradle (see Figure 12) showing our visible connections to multi-species. This shows how our narratives are woven into each other's lives. In self-tracking systems, introducing these narratives through more-than-human perspectives could involve representing the more authentic relationship with our companion animals as this relationship is full of "waste, cruelty" etc. (Haraway, 2003, p. 12). Representing relationships in this way are not present in current 'social self-tracking' features. There is a focus on positive aspects of our relationships but representing authentic connections could better show varying social links between things. While non-human animals' social skills differ to our own, as described by Jain et al "they have successfully become part of human social groups” (2023, p. 2). Therefore, considering our connections to all social links could provide considerations for self-tracking system design. Relating to companion animals, these perspectives can be generated by noting that companion animals:

Are considered commodities in capitalist structures: Acknowledging that self-tracking system design has been less about supporting our relationships with companion animals and their experiences of the world and more about creating a “value-added” (ibid, p. 47) dog, cat etc. that can sell more products. This is because just like humans, multi-species are seen as commodities in a capitalist market (Haraway, 2008).

Are entangled in our lives and spaces: Non-human animals (companion species) have been “becoming-with” humans for several thousand years. Because of this they intra/interact in our spaces through our houses, labs, zoos, city streets etc. entangled within our lives but not experiencing the same world with “natures, cultures, subject, and objects” not pre-existing in their “worldings” (2016, p. 13).

Have been involved in ‘human’ society across time: Historically companion animals have been involved in working roles i.e., carrier pigeons during World War 2 and service dogs (ibid). Equally while the word social might imply human connection, they are social with other companion animals such as cats looking after and grooming each other. Including their perspectives of the world in future self-tracking systems starts to break down these embedded values in our systems and could better consider all involved.

To include these perspectives, Tsaknaki et al., (2022, p. 4) refers to Bennett and Roser’s similar term of “being-with”, acknowledging respectful encounters with non-humans rather than using empathy techniques that can erase their experiences of the world. As companion species can go into unfamiliar spaces, such as pigeons navigating the world from the sky, we can learn from their different world experiences. By introducing the ability to respond (Barad’s concept of response-ability) to these experiences i.e., through companion animal perspectives in self-tracking system design, means considering our relation to animals is not an "obligation" but could help "inviting, welcoming and enabling the response of the Other" (Lupton, 2020, p. 28; Barad and Kleinman, 2012). Thinking with and respecting different humans and non-humans, could provide new opportunities for design to support multiple actors that are entangled in our lives.

2.5.3.3 More-than-human theory to explore multisensory experiences beyond the human

By considering the non-living or nonhuman i.e., "rocks, rivers, plants, technologies, houses and so on" (Lupton, 2020, p. 23), animism is a more-than-human concept that involves attributing life to things and valuing the world around us. This blurs the binary boundaries embedded in western cultures such as the "self and other, subject and object, humans and animals, culture and nature" acknowledging how we are connected to these things via multisensory properties. This can be seen through different cultural practices. Japan's Shinto philosophies spirits contributing to collective life through statues, creating a sense of relationship to a place (Hozumi, 2020) (see Figure 13A). The Whanganui River that has been given protected legal status and rights, giving the river a voice (Evans, 2020) (see Figure 13B). As well as sweet grass (see Figure 13C) considered sacred by native Americans with the grass creating a "more-than representational level" through our "connectedness via sensory properties such as its scent, texture and literal rootedness in the earth" creating "sensory embodied experiences" (Lupton, 2020, p. 24).

Figure 13 - Examples of animism. A – statue in Japan source: https://www.tadahozumi.org/somatic-pathways-for-animist-connection-to-place-and-body/. B – Whanganui River in New Zealand source: https://www.bbc.com/travel/article/20200319-the-new-zealand-river-that-became-a-legal-person#:~:text=The%20Whanganui%20River%20is%20not,recognised%20as%20a%20legal%20person. cited above. C – Sweet Grass source: https://www.bbc.co.uk/news/science-environment-33984044

This can also be applied to animal's multisensory experiences through Nagel's essay about What it's Like to Be a Bat (1974). While not directly accessible to us, non-human's perspectives are more about our relationships with non-humans. This includes looking at how multi species help shape our experiences while also acknowledging how design could potentially impact their experiences. He explains that bats do have an experience of the world, but because their "range of activity and a sensory apparatus so different from ours" (Nagel, 1974, p. 438) such as sonar or echolocation differing completely from our own senses, it is hard to imagine and experience. As imaging what this would be like is limited from our view of the world and our own physicality, we may "ascribe general types of experience on the basis of the animal's structure and behaviour". But each bat is different and so this subjective character is "beyond our ability to conceive" (1974, p. 439). However, we can believe they have this experience even if we can't access it and use this to influence considerations for what their perspective of the world might provide in self-tracking system design. Therefore, we can use these non-human experiences that aren't directly accessible to us as humans, to understand our relationships with those around us.

2.5.3.4 Drawing on plurality to explore multiple human perspectives

When looking at our relationship with things, it is clear how human perspectives can also alter how these things are interpreted by us. As explained by Hallam, how bones are placed in ossuaries alters their meaning, for example, the bones history and the location of where the bones are placed. Hallam explains how the intentions of the human's interpreting the bones changes the “diverse narratives and social relations” (Lupton, 2020, p. 35; Hallam, 2010) surrounding these interpretations. Therefore, the human's perspective changes how we view, remember and relate to things around us. This is further supported by D’Ignazio and Klein (2020) who encourage people to embrace plurality because “when people make knowledge, they do so from a particular standpoint: from a situated, embodied location in the world. More than that, by pooling our standpoints—or positionalities— together, we can arrive at a richer and more robust understanding of the world” (chapter 5, p.14). Acknowledging how our interpretations of a thing changes how it is viewed, highlights how multiple human perspectives could help make sense of the world.

Plurality can also help promote unequal voices addressing inequalities such as decolonisation, feminism, queer theory, acknowledging power relations and how we relate to the world. As part of this promoting traditional and indigenous knowledges means this approach can incorporate more-than-human values. This means acknowledging not just humans left out of system design but non-humans as well. Benefits for both humans and non-humans within our design practices can lead to what Haraway calls multi-species flourishing (2016). While more-than-human theory can apply to anything from plants and rocks to food and voice assistants, this thesis focuses on Haraway’s term companion species (2003) with a focus on a cat’s perspective and how they shape our world. Reasoning for a focus on cats over other companion species such as canines will be explained in later chapters. As it is difficult to apply more-than-human theory into design practice, Rolighed uses theory to “reconfigure the posthuman relationship between human and plant” (2022, p. 6). Through design practices, this can be explored by introducing different more-than-human perspectives of contextualised general wellness information into self-tracking system design.

2.5.3.5 How can these perspectives be used in design research?

A critique of the post-human approach is that ignoring this focus on the human mind and body assumes “that we have all had a chance to be human” (Benjamin, 2019, p. 17). However, post-human does not have to mean “after the human” (Tarcan *et al.*, 2022, p. 6). This research critiques current self-tracking system design highlighting how a single perspective has led to bias and certain represented selves over others. By using more-than-human theory as part of design practice, different perspectives of contextualised general wellness information can be introduced into future self-tracking systems to explore what this might mean beyond theory-based research. Using more-than-human theory acknowledges that companion animals wrapped up in self-tracking applications (either through pet tracking applications or comparison of steps in human activity trackers) can ignore many aspects of the animal’s life (van der Linden, 2021) which might be vital to their wellbeing.

Therefore, an approach is required that acknowledges how systems might better support non-humans even when it might be humans using the system i.e., cat owners. Some creative approaches have explored these multiple perspectives such as a series of books written from the perspective of bread (Shershow *et al.*, 2016), an egg (Walker *et al.*, 2017), and dust (Marder *et al.*, 2016), which show the hidden lives of ordinary objects. This could radically change our thinking and question how we design. However, as argued by Nagel exploration into these perspectives will only ever remain speculative (Tarcan *et al.*, 2022) allowing speculative design methods to be in a perfect position to approach multiple perspectives in new ways. The speculative methods and research through design methodology used to approach the introduction of these new perspectives will be discussed in the following chapter.

2.6 Summary

The main gaps throughout this chapter highlight a need for other considerations of contextualised general wellness information to consider all involved in self-tracking systems. This research argues that introducing different perspectives of this information could help understand implications for future self-tracking system design. The gaps found are summarised below:

Context is misrepresented – People are lacking contextualised information about their lived experiences which is becoming more complex as these self-tracking systems gather data about their relationships and environment. It can be argued that this is because context is viewed as a technical rather than an interaction problem. Designers can focus on these interaction problems to provide new considerations for including contextualised information in self-tracking systems.

Design decisions can cause harm –Without this needed contextualised information, self-tracking systems can hinder wellbeing i.e., obsession over the metrics provided. Solutions to reducing harm focus on user's excessive use and self-awareness, rather than acknowledging the design decisions that have led to these unintended consequences. Design methods like speculative design (see Chapter 3) can explore implications of self-tracking systems before they are implemented and able to cause harm. This research will explore these implications by introducing new perspectives of contextualised general wellness information in self-tracking systems.

System capabilities versus user expectations – Design decisions focus on one single perspective of what health and wellbeing is, viewing us as a collective. Through this approach these decisions follow a system's capabilities rather than what people want from self-tracking systems.

Understanding and interpreting data – Self-tracking systems require adapting or customising a system to provide people with information that they want but also that they can make sense of. How we interpret data might differ depending on our background and context. Visualisations are used to help ease our cognitive load and support understanding of complex information. However, it's important to note that adding more contextualised information might not be beneficial for future self-tracking system design. Providing more adaptable or ‘contextualised’ information could be detrimental for wellbeing according to literature. Therefore, it is important to understand the implications of introducing more than one perspective of what it means to be healthy and well.

More-than-human considerations – More-than-human could help inform context-aware self-tracking design by considering different ways non-human animals and things live. This means considering parts of health and wellbeing experiences aside from bodily metrics. This might include representing authentic connections/relationships, acknowledging our entanglement with different natures and cultures, deconstructing social structures, considering multi-sensory experiences and the concept of plurality.

These challenges outline a difference between where self-tracking design research currently is and where this research positions the future design of these systems. Figure 14 visualises that literature in Personal Informatics currently falls into two phases: physiological and psychological measurements about our own and multiple bodies. Phase 1 acknowledges that most of the literature in the field focuses on individual tracking (tracking the self) which focuses on quantitative metrics and comparisons about our own bodies with different human and non-human bodies. Phase 2 acknowledges more recent literature including psychological measurements, maybe about a person’s mood and emotions, mental health or general wellbeing as well as a move towards more ‘social’ tracking. However, there is still a focus here on bodily metrics and a single perspective of what it means to be healthy and well. Phase 3 is where this research positions the future of self-tracking technologies, moving beyond the first two phases to consider the complexities involved in general wellness experiences. This also means acknowledging that humans are no longer the sole focus of these systems with non-humans wrapped up in our complex systems.

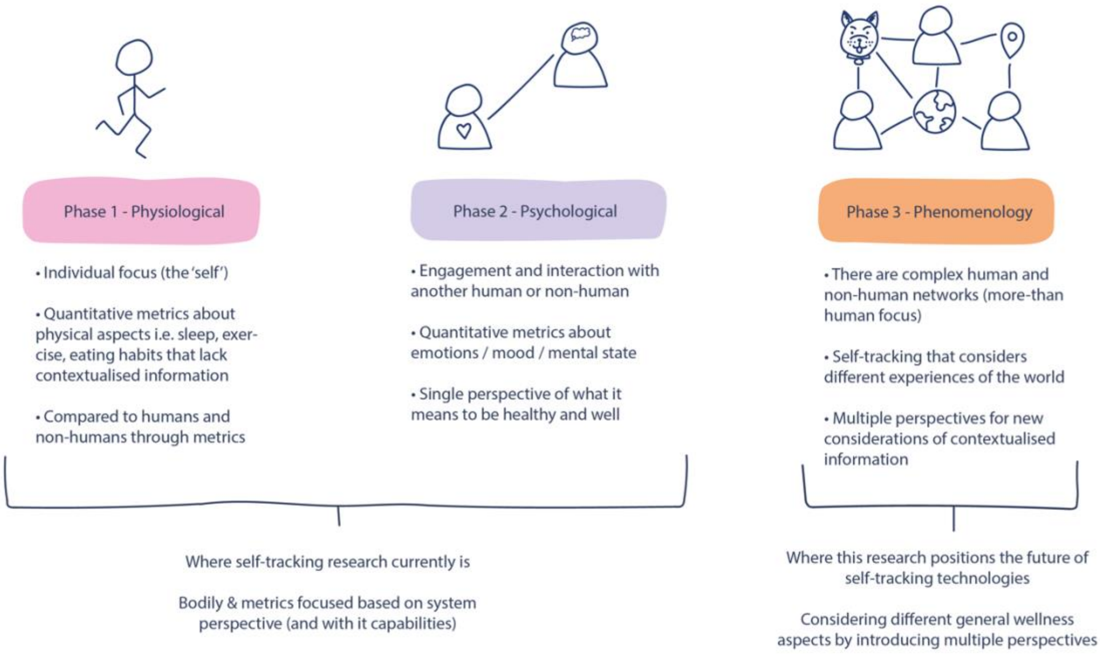


Figure 14 – Current focus in self-tracking systems vs where this research sits

This also raises a question about language used within this thesis. As non-human animals are discussed whether they can be discussed under terminology such as personal informatics and self-tracking is debatable. This is because they are neither a person nor a "self". However, these non-human entities are already involved in self-tracking systems. This can be seen either through activity comparisons i.e., step counts between a dog and their owner or similarly designed tracking systems that track the companion animal's whereabouts and health and wellbeing. Using the terminology personal informatics/self-tracking reflects language used in this space and the overwhelming focus on the people using these systems. Even if not acknowledged, non-human animals are encompassed under these human-centric ontologies. This shows that current terminology is not inclusively representative of all involved in self-tracking systems. In later chapters, this framing of self-tracking helps to add critique around current design and how changes are needed to consider the complexities of all those involved in these systems.

In this chapter, it is acknowledged how self-tracking systems present information about our general wellness through a single perspective of what it means to be healthy and well. Through this perspective, people miss needed contextualised information about their general wellness which can result in harm. As these self-tracking systems are tracking information not just about ourselves but those around us, an understanding of contextualised information is needed about all involved in self-tracking systems. Therefore, more-than-human approaches are considered as part of this work focusing on moving past this single perspective of health and wellbeing that is filled with preconceptions about the world around us. This thesis aims to explore how introducing different perspectives of contextualised general wellness information might reveal implications (whether these are opportunities or challenges) for future self-tracking system design. The rest of this thesis will explore these different perspectives through a series of projects. This will explain the implications of introducing these different perspectives for considerations of contextualised information in future self-tracking system design. The next chapter will discuss the research methodology chosen for this body of work and discuss the methods chosen to explore these different perspectives of health and wellbeing information.

Chapter 3 The Research Process

3.1 Introduction

According to Crotty (1998), conducting research involves understanding what methodologies and methods should be chosen to answer the research questions and justifying why they help answer these questions. This can be addressed through the following four questions posed by Crotty (1998, p. 2):

- What *methods* do we propose to use? - These are the procedures, resources, tools, used to gather data related to the developed research questions.
- What *methodology* governs our choice and use of methods? – This being the overall process, strategy or approach used to conduct research. The methodology influences the decisions made about which methods will help address the research questions.
- What *theoretical perspective* lies behind the methodology in question? – The philosophical viewpoint or stance that has helped inform the methodology.
- What *epistemology* informs this theoretical perspective? – The theory of knowledge that is embedded in the theoretical perspective (and also the methodology).

This chapter will answer these questions, following the structure presented in Crotty's diagram, adapted in Figure 15. This shows how each of these elements relate to each other and influence the research process. Given the structure of this diagram, the questions above will be answered in the reverse order. This is because theoretical perspectives are discussed within the methodology and methods used (to justify their use), so it is important to understand what these theories are first. Therefore, to begin, the most relevant epistemology and theoretical perspectives that underpin the research developed will be explained. Here it will be argued how epistemological stances and theoretical perspectives have influenced personal informatics literature which has led to the critique of self-tracking system design presented in this research (section 3.2.1). The theoretical perspectives and epistemology that are used in this research will follow, countering these dominant viewpoints in the personal informatics literature (section 3.2.2). Following this the methodology (section 3.3) and methods (section 3.4) chosen for this research helps to highlight why this research was conducted in a particular way.

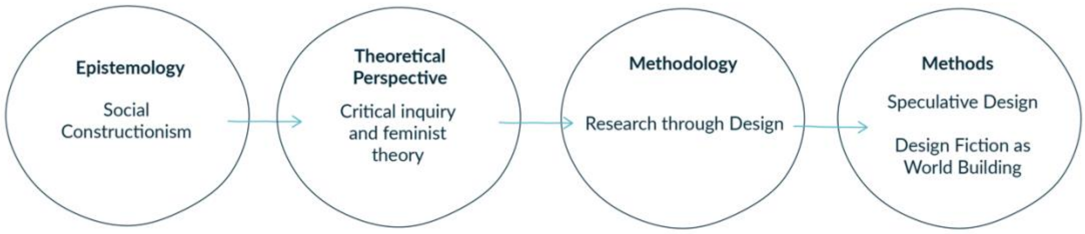


Figure 15 - Epistemological alignment to the methodology and methods used within this research

3.2 Epistemological and theoretical perspectives

Epistemology is about knowledge; it suggests theories for what is possible to know and how knowledge might be produced from these theories. Ontology is about existence and what reality is, theorising what exists and is real. Braun and Clarke summarise this in a simplified way, ontology is "*what* it is that we think we can know" and epistemology is "*how* we think we can know it" (2021, p. 166). Crotty explains that it is often hard to separate the two as each theoretical perspective embodies "a certain way of understanding *what* is (ontology) as well as a certain way of understanding *what it means to know* (epistemology)" (1998, p. 10). Therefore, while ontology might not be mentioned, it forms part of the epistemology and theoretical perspectives discussed. As the epistemological theories influence the theoretical perspectives taken, these are discussed together to explain why this research is conducted in a particular way.

3.2.1 Epistemology and theoretical perspectives in personal informatics literature

As explained in the literature review (Chapter 2), this research takes a critical look at self-tracking systems which take a purely quantitative approach to tracking general wellness. This does not mean this research does not see the value in metrics within these systems, but only using metrics to explain complex behaviour has been shown to be problematic (as explained in section 2.3.3 & 2.4.2). Given these gaps that have been revealed in the literature review, it can be argued that personal informatics largely follow an objectivist epistemology. This viewpoint suggests that there is an objective reality somewhere and research is "about discovering this objective truth" (Gray, 2021, p. 24). This aligns with the argument presented in this research, critiquing this approach, as it suggests there is only one perspective of what it means to be healthy and well. The theoretical viewpoints aligning with this epistemology include positivism and early concepts of realism (i.e., naïve realism) (Bryman, 2016; Gray, 2021). These viewpoints are reliant on scientific ways of producing knowledge and empirical approaches following methodologies that deal with facts. This means that even though people's subjective experiences and ways of viewing the world can be considered, they would not be viewed as truthful compared with more scientific methods and established facts (Crotty, 1998). Positivism views reality as what is available to the senses such as what can be seen, smelt, touched etc. (Robson and McCartan, 1993). This aligns with naïve realism which assumes that the "world is as it appears to be". This implies that non-human's experiences of the world cannot form part of research because their reality is not available to us. This contradicts the more-than-human theory discussed in the literature review that aligns with this research. Given this argument, this suggests that a large amount of personal informatics research aligns with the positivist paradigm that is outlined below in Figure 16.

	Positivist paradigm	Phenomenological paradigm
Basic beliefs	The world is external and objective The observer is independent Science is value-free	The world is socially constructed and subjective The observer is a party to what is being observed Science is driven by human interests
The researcher should	Focus on facts Locate causality between variables Formulate and test hypotheses (deductive approach)	Focus on meanings Try to understand what is happening Construct theories and models from the data (inductive approach)
Methods include	Operationalising concepts so that they can be measured Using large samples from which to generalise to the population Quantitative methods	Using multiple methods to establish different views of a phenomenon Using small samples researched in depth or over time Qualitative methods

Figure 16 – Summary of positivist vs phenomenological paradigm. Remade from David Gray's Doing Research in the Real World page 26 (which is adapted from Easterby-Smith et al. 2002)

The following section will explain how this research aligns itself with the phenomenological paradigm.

3.2.2 Epistemology and theoretical perspectives taken in this research

This thesis frames different considerations of contextualised information through introducing new perspectives of health and wellbeing to explore the implications in self-tracking systems. Therefore, any epistemological stance, and with it theoretical perspectives, focusing on one viewpoint or a 'single perspective', not acknowledging that people can experience reality differently, contradicts the underlying motivation for this research. Therefore, within this research multiple realities do exist, as everyone's way of viewing the world is situated and partial and so there are multiple truths based on everyone's unique reality (Braun and Clarke, 2021). In this work this also acknowledges non-human's experiences of the world, even if they are not accessible to us directly. By including their perspectives of the world, it helps to highlight normative values embedded in self-tracking system design that have led to bias and harm. Given this alignment, the work in this thesis seems to fall under the phenomenological paradigm as explained in the table above (see Figure 16) cited from (Gray, 2021).

This paradigm links closely with social constructionism, which is argued here to be the epistemology that this research is most aligned with. Social constructionism takes the position that truth and reality is created through social agreement i.e., a collection of people agreeing that an apple is an apple. This has also been explained by Gergen as "what we take to be the truth about the world importantly depends on the social relationships of which we are a part" (2015, p. 3). This means that our understanding of the world differs through these social relationships, so reality can be viewed as a human construction with our culture and history changing what we believe to be true. This also means that there are multiple realities and what is considered meaningful to us differs, so our understanding of the world is subjective.

Constructionism is often used interchangeably with constructivism as can be seen in this definition by Bryman "constructionism is an ontological position (often also referred to as constructivism) that asserts that social phenomena and their meanings are continually being accomplished by social actors" (2016, p. 29). This work uses the term constructionism based on Robson et al's (1993) way of distinguishing between the two with "nism" focused more on a social or collective view of sense making about the world with "vism" focusing more on an individual's viewpoint.

While this research does value individual's experience of reality i.e., what we understand from data, this is considered collectively, focusing on how social structures present in self-tracking system design has led us to prioritise certain individuals over others. Social constructionism can be seen to help interpret these ways of viewing the world and that through doing this "we might be more tolerant and curious about those from whom we differ" (Gergen, 2015, p. 3). This includes understanding how non-human animal's ways of experiencing the world differ from our own, which could provide different considerations for self-tracking design i.e., acknowledging their different multisensory experiences. Social constructionism does argue that there is "no reality outside of human practices (that we can access)" and through human practices "this is the reality that is taken to *matter*" (Braun and Clarke, 2021, p. 180). This in some ways contradicts this research, considering non-human's perspectives to understand the implications of including multiple viewpoints on contextualised health and wellbeing information in self-tracking system design. However, as it will be a human using the self-tracking system, it is their practices that will shape how information is understood about multiple beings. Equally, it is this view about what matters that has resulted in current self-tracking system design practices i.e., designing for a collective and generalised approaches to self-tracking system design to support system capabilities. Social constructionism differs to other types of constructionism because as Crotty explains, knowledge is constructed based on institutions and culture which "brings things into view for us and endows them with meaning and, by the same token, leads us to ignore other things" (1998, p. 54). In other words, people are designing systems not because of how they themselves as individuals experience the world but because of collective knowledge/consensus around health guidelines have been agreed upon as the correct way to approach general wellness. This is in accordance with what society deems an acceptable way to live.

Social constructionism is influenced from critical inquiry and feminist theoretical perspectives, aligning with the more-than-human theory discussed in Chapter 2. Both these theories focus on power relations within society and how privileged groups use their power to create reality, which can "exert an oppressive force" (Gray, 2021, p. 30) on certain identities i.e., someone's race, class, gender or sexuality, disability etc. Feminist social constructionism focuses specifically on people's social positions in the society, looking at "who is doing the asking and from what social location(s)" which leads to certain knowledge being created. This acknowledges things such as plurality (discussed in section 2.5) to note multiple truths and reality related to a particular "time, space and place" (Wigginton and Lafrance, 2019, p. 5). Critical realism is also influenced by critical and feminist theory and while this epistemology has much in common with constructionism, it doesn't acknowledge multiple realities (Braun and Clarke, 2021). Therefore, social constructionism is better aligned with the goals of this research, acknowledging how a single perspective (one truth or reality) of health and wellbeing has led to bias and harm in current self-tracking system design.

This viewpoint has influenced the methodological approaches taken in this research to answer the research questions. Given this research's views that align with a phenomenological paradigm, the following section outlines how the methodology and methods construct theories based on the data (in this case the data being created artefacts). The methodology uses multiple qualitative methods to introduce different perspectives of contextualised general wellness information and understand the implications around this.

3.3 Methodology

This section outlines the methodology adopted for this research, this being research through design. In this section, research through design theory is discussed (section 3.3.1.1). This is to explain what this approach is, before comparing it to other traditional methodologies used for similar types of research (section 3.3.1.2). This justifies why this approach was necessary to answer the research questions and how this helped influence the methods chosen (section 3.3.1.3).

3.3.1 Research through Design

3.3.1.1 What is Research through Design?

Research through Design (RtD) acknowledges that research and design have been considered separate and interrogates what it means to do both research and design. In his paper Frayling (1993) described this through a difference between research with a little and big R. (r)esearch has a strong association with practise in the arts and humanities meaning to search for something which is defined in advanced i.e., searching for tea in the kitchen. However, research with a little r doesn't follow procedures such as guidelines or rules and isn't about ‘professionalism’ like (R)esearch. This is used more in design and often associated with development and innovation reflected in the academic sector.

Additionally, Frayling explained how this relationship between research and design differs between research *into*, *for* and *through* design. While art is also explained in his paper, as this thesis focuses on design research, art will be omitted from this explanation. The differences between these types of design research are as follows:

- Research *into* design - Focuses on the scientific way to study design looking at the way we design and have designed in the past allowing us to reflect on existing design practices.
- Research *for* design - Uses designers and their practices as a focal point of study with the aim of developing design practice, whether this be suggesting new tools or methods or ways to improve how we design.
- Research *through* design - Focuses on practice through the creation of new artefacts, products etc. to document the design process in some way and communicate the results to others.

However, as noted by Gaver (2012) this does not necessarily mean that an RtD approach is verifiable, as these processes are often addressing complex wicked problems (Rittel and Webber, 1973) which might not provide a solution. Especially as described by Zimmerman and Forlizzi, an RtD approach changes depending on the researchers carrying out the research and what “intention that design researchers bring to bear on a problematic situation” (Zimmerman and Forlizzi, 2014, p. 168). This intention is an important aspect of this research, the way we view the world impacts the way we research, design, analyse and evaluate, changing how research might be conducted and therefore what knowledge is produced as a result. As described by Gaver “Design, and research through design, is *generative*. Rather than making statements about *what is*, design is concerned with creating *what might be*, and moreover, in Zimmerman et al’s formulation, on making the *‘right thing’*” (2012, p. 940). This approach aligns well with the epistemological and ontological standpoints taken in this research. As described by Godin and Zahedi, RtD follows constructionism using Papert to explain how RtD can be considered “learning by design” (Godin and Zahedi, 2014, p. 7). This research uses RtD to learn and think about future-system design but also reflects and critiques whether the insights developed about these self-tracking systems are the ‘right thing’ for future system design.

3.3.1.2 Why is Research through Design used in this research over other approaches?

Phenomenological research wishes to understand the world from an individual’s perspective (Gray, 2021). This relies on researchers ignoring their own preconceptions about a subject as well as using people’s experiences, interpretations of the world and their context for analysis. Many aspects of this thesis cross over with phenomenological research with emphasis on how individual’s contexts and perspectives are unique, providing multiple understandings of the world around us. However, this is because the phenomenological paradigm, which phenomenological research expands from, overlaps with the social constructionism stance this research takes. Equally, feminism and critical inquiry (ibid), also crossover with views this research takes about the role of society in the way things are designed. Using Research through Design, the theory from this epistemology and theoretical perspectives could be fed into this research while concentrating on more design focused approaches i.e., practice-based and speculative design methods. Therefore, RtD helps prioritise the role of design within this sociological and philosophical space.

Action research focuses on creating some kind of change through working with people in a particular environment i.e., working closely with teachers in a school to improve test scores (Gray, 2021). Similar to RtD, action research has strong links with practice, with the research being carried out by the practitioner, meaning it is often referred to as practice-based research (McNiff, 2013). However, in action research, participants themselves are seen as researchers as they help generate data from their own experiences of the world and help to create change (Robson and McCartan, 1993). That is where this research diverges from action research with artefacts helping to produce knowledge and people adding different perspectives on what these artefacts could mean, but not as researchers. Additionally, action research projects can take years looking at whether change occurs over a long period of time. This means that more in depth data can be gathered. However, given the length of this PhD, short scale projects were conducted that built on each other and adapted dependent on the knowledge produced, meaning RtD worked well in this instance.

Grounded theory is another approach like research through design that is appropriate when there is little known about a phenomenon being studied. It acknowledges that qualitative research is capable of generating theory and that the purpose of a research project can change drastically during the research process (Gray, 2021). Godin and Zahedi (2014), reference Bryant's view of grounded theory as overlapping with the ontology of RtD as both consider "reality as multiple and subject to redefinition" (2014, p. 8). This means that in a certain context, data might show one thing given a person's life experiences and the literature the researchers have read. However, if new theory emerges maybe because of additional life experiences included in the research, the data could be seen in a different way resulting in a need to adapt the developed theory.

Equally grounded theory is influenced by social constructionism (Bryant and Charmaz, 2019) aligning with the stances taken in this research. This assumes that people perceive the world based on their own situatedness which according to interpretivism (a "proto-constructionist 'theorem'" (2019, p. 7) used in grounded theory) is influenced by cultural, historical and geopolitical practices. Given all these similarities, why was research through design chosen over this approach? As explained by Partington, the literature from grounded theory can be "bewilderingly complex" (Gray, 2021, p. 761). When looking at grounded theory, in practice these seemed to follow with more constructivist approaches used primarily in psychology studies and much more focused on using qualitative data in an empirical way. The popular approach to grounded theory, as outlined by Strauss and Corbin, using coding practices, did not seem to align with the more experimental methods which are argued as the best approach for this type of work i.e., speculative. Focusing on mixed methods can make it hard to analyse data, but reflexive thematic analysis (RTA) is much more flexible in its approach than grounded theory. Therefore, while elements of grounded theory worked, as an overall methodology it was concluded that it was not the best fit for this type of research.

3.3.1.3 How is Research through Design used in this research?

Research through Design has been used in this research through speculative methods such as design fiction for world building (see section 3.4.2.1). The building of one world helped to create insights which helped shape the PhD process and influence the directions taken, further expanding on the created world. This is explained in this section (illustrated in Figure 18) using a space metaphor to better explain how world building formed part of the RtD process. This diagram helps to distinguish the different worlds developed from other parts of the RtD process that emerged based on the insights from these worlds. This is shown in Figure 18 through the presentation of two worlds as separate planets representing the projects explained in CoCo (Chapter 4) and the Cat Study (Chapter 6). In between these worlds is a gas cloud presenting an argument which emerged from insights developed from CoCo which could be tested in the following world presented in the Cat Study. The surrounding stars symbolise additional insights that helped influence research directions taken. This approach was taken to help answer part of the overarching research question: What if self-tracking systems considered different (more-than-human) perspectives of contextualised general wellness information? And a sub question what would this mean for future self-tracking system design? Including interacting with these perspectives and potential implications with introducing these new perspectives in self-tracking systems.

The first world or planet is a project called CoCo (Chapter 4) based around the implications of only using the system perspective for contextualised health and wellbeing information. As RtD allows reflection through practice i.e., creating an artefact and iteratively adapting and critiquing the design approach, speculative design can help to develop answers to the research questions through an RtD approach. As explained by Lindley & Green "it seems that rarely—if ever—does Speculative Design take place without the underlying aim...to produce new knowledge or insight" (2022, p. 4). This new knowledge and insights are explained here through the stars, following Lindley (2018) and Pollastri's (2017) diagram, as shown in Figure 17. It explains how an RtD approach can contribute to the research process through domain insights, design fiction insights, material engagements (making and interacting with things). For this project, speculative methods helped create these insights, finding that social consequences were running theme based on the artefacts developed. These fictional and domain insights helped to inform research directions.

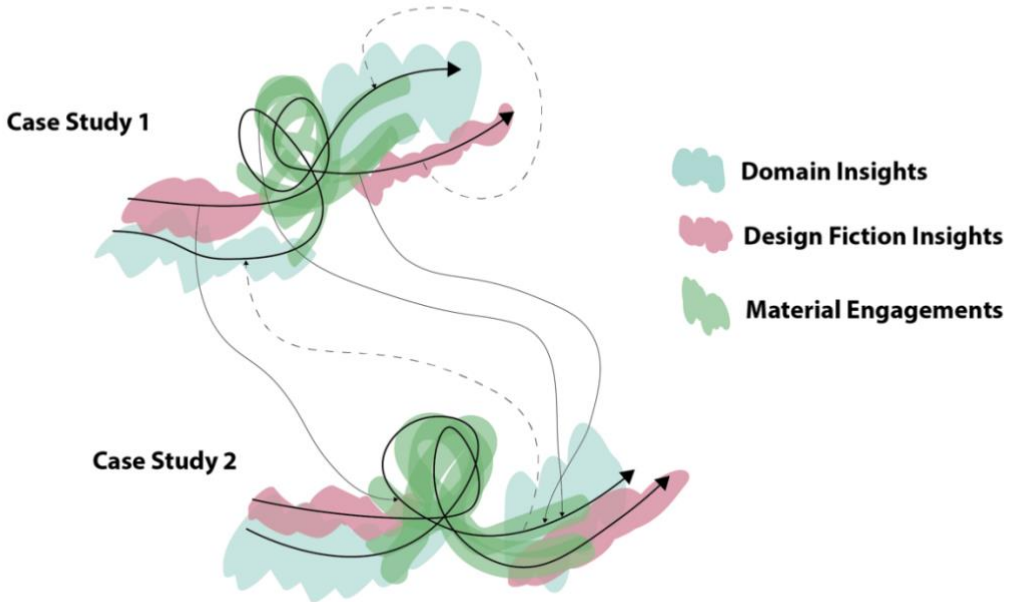


Figure 17 – Lindley's (2018) Phases of Research Through Design Diagram, based on Pollastri's (2017) Diagram

Selves and Beings (Chapter 5) is represented as a gas cloud between the two planets reflecting that world building was not used as part of Selves and Beings but was developed based on insights from the world building process in CoCo. Within this chapter, these insights highlight specific problems with a system perspective (that it focuses on our bodies and purely metrics through one perspective of what health and wellbeing is). This helps present an argument for introducing different perspectives in self-tracking systems to provide insights for contextualised health and wellbeing information. These ideas could then be tested in the second world. This is to understand whether introducing these perspectives is the right thing to do for self-tracking system design before these systems exist with the potential to cause harm.

The second world or planet outlines the project presented in the Cat Study (Chapter 6). This tests out the argument presented in Selves and Beings, answering part of the research questions around how people interact with new more-than-human perspectives of contextualised general wellness information. The insights from this project help to answer whether there would be implications with designing systems in this way. At this stage of the Research through Design process, insights gathered across the thesis can be collated to provide insights about more-than-human context-aware self-tracking systems (as shown in the sun). A Research through Design approach was particularly necessary for this research to answer these questions. This was because it was not known what introducing these new perspectives might mean for how people interact or react to having different contextualised general wellness information. Through making and reflecting on possible implications of self-tracking systems, it was possible to develop knowledge about this unknown area without implementing these ideas into a working system where they could potentially hinder someone’s own or multiple being’s wellbeing.

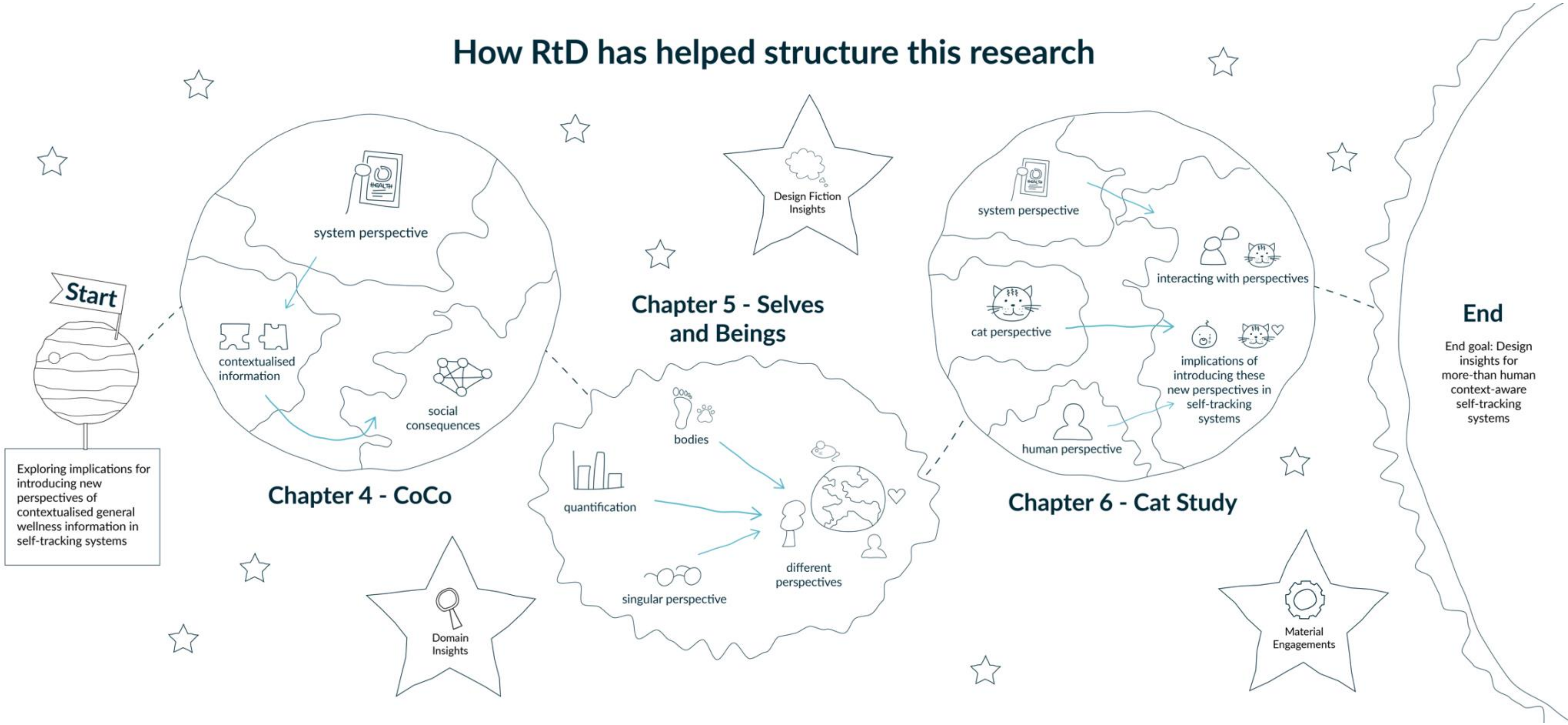


Figure 18 - The Research through Design structure of this research. How RtD process helps address the research question

3.4 Methods

This section outlines the methods used across the various projects in this research. Using research through design, speculative methods were chosen given their approach to ethical issues and focus on future thinking (section 3.4.1). Various techniques such as world-building (section 3.4.2.1) were used depending on the intended audiences i.e., academic audiences for fictional papers (section 3.4.3) versus new approaches (section 3.4.3.4), used later on to test speculative approaches with different groups of people. Reflexive thematic analysis (section 3.6) was used to analyse the later stages of this research. In this section it will be explained why this analysis was used over other analysis approaches (section 3.6.1).

3.4.1 Critical and Speculative Design

"To be human is to refuse to accept the given as given"

- Dunne & Raby in Speculative Everything (2013, p. 33)

This is the quote used by Dunne and Raby to begin their chapter *Design as a Critique* perfectly describing the essence of critical design; to critique, to challenge accepted reality or normality and question the role products play in our day to day lives. Rather than accepting the way an object is presented to us (including the expected ways to interact with it) it is up to us to question why something is designed the way that it is and critically examine what it could become. What started as an attitude grew into a design approach, with the first use of the term appearing in Dunne's Hertzian Tales (Dunne, 2008). This type of design helps create artefacts, not necessarily existing ones, that spark conversations and debate about various topics including health tracking anxieties (Lee, 2014), sedentary behaviour (Menheere *et al.*, 2020), overpopulation (Dunne and Raby, 2009) and body augmentation (Loizeau and Auger, 2002). However, it has been noted that critical design can be hard to follow, with confusion about what it is and a lack of clear pointers about how it could be used (Bardzell and Bardzell, 2013). While work has been done to create a better grounding of critical design as a practice in the HCI space (Ferri *et al.*, 2014), practices such as speculative design help reflect the ideas critical design outlines.

Speculative design focuses on examining possible futures in order to redesign the present and help understand what others would like the future to be. Speculative design does not predict the future but uses the future as a topic of discussion to change current design processes (Dunne and Raby, 2013). Speculative design has been used to create sketches of conceptual IoT devices for new data roles around the home (Desjardins *et al.*, 2020) as well as isometric drawings to show futures at different scales (Overdijk *et al.*, 2022). Additionally, plausible prototypes both digital i.e., diagrams and websites, as well as physical i.e., a smart pet collar have been used to critique many topics such as our perception of the world (Li *et al.*, 2018), privacy issues with IoT devices (Karmann and Knudsen, 2018) and reactions to future technologies such as quantified pet technologies (Lawson *et al.*, 2015a). These prototypes can also be used for interactions with participants to understand how future products might be used (D'Arcey *et al.*, 2019). Even fully illustrated, 'what if' scenario books have been published such as the In Vitro Meat Cookbook (Van Mensvoort, 2014). With speculative recipes from chefs, designers and artists, the book aims to get people discussing food futures. In more recent applications, speculative design has been used to generate conversations and insights from non-human objects and devices for future research applications (Reddy *et al.*, 2021).

Putting speculative design into practice has resulted in many using a cone as a starting point to explore potential futures. Dunne & Raby (2013) adapted the Voros cone for their own purposes calling it the Taxonomy of Futures (see Figure 19) using different cones to represent questions about the future. Cone 1: Probable - what is likely to happen? Cone 2: Plausible - what could happen? Cone 3: Possible - what are the links between our world and the fictional world? Cone 4: Preferable (in between probable and plausible) - what are the issues with the future?

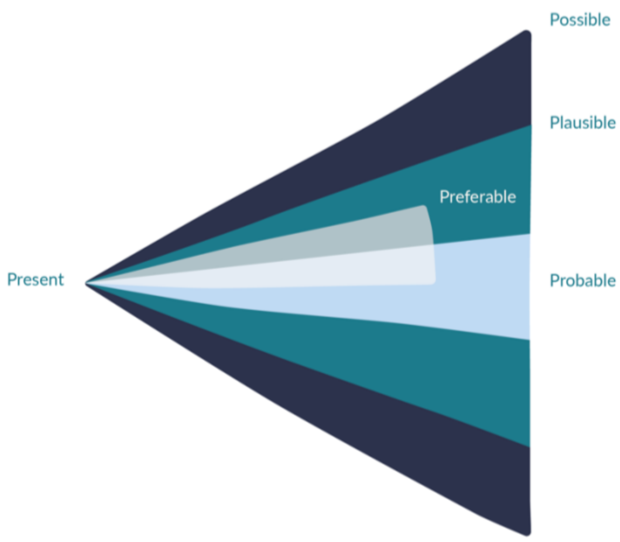


Figure 19 - Dunne and Raby's Taxonomy of Futures cone, remade from Speculative Everything Chapter 1 - Beyond Radical Design? Page 5

However, this model has been critiqued allowing assumptions to arise about one singular shared experience of both the present and the future, without acknowledging the "plurality of lived experiences" (Hillary et al., 2021, p. 4). Coulton & Lindley refer to this as driving "a single preferable future" (2017, p. 8) that doesn't acknowledge the future's history and the beliefs and values embedded within this presented reality. The authors suggest using design fiction worlds counters the lack of plurality in the cone's approach to speculating about future worlds. Given that theory like plurality helped shape this thesis, this argument for using design fiction worlds supports reasoning for this method forming part of this research. Equally as speculative designs have been criticised for not moving "beyond the realm of the museum exhibit" (Forlano and Anijo, 2014, p. 11) alternative design methods such as design fiction could help provide more applications for design research around future technologies.

3.4.2 Design Fiction

Design fiction is often described as a form of speculative design, coined by Sterling in his book Shaping Things as a "more practical, more hands-on" approach (2005, p. 30) compared with science fiction (sci-fi). Later Sterling stated that design fiction is the "deliberate use of diegetic prototypes to suspend disbelief about change" (2013).

Bleecker refers to diegetic prototypes in relation to design fiction based on Kirby's take on diegesis (Kirby, 2010) as a way of prototyping in a fictional world. This is explained in relation to science fiction films and television with an emphasis on "the circulation of knowledge and ideas" (Bleecker, 2009, p. 39). Showing technologies in media that do not currently exist but are working systems in a fictional world can help play out how these technologies might be used when integrated in people's lives. For example, in the satirical sci-fi show Black Mirror, the episode Arkangel helps tell a story about a potential reality of living with social tracking devices i.e., tracking children under the guise of safety.

Following a brief scare where Marie temporarily loses her daughter Sara, Marie has a device implanted in her daughter's brain allowing an app on the Arkangel tablet to show Marie where Sara is. The app can also track Sara's vitals and filter what she sees and hears in the real world through 'content limitations'. For example, in Figure 20 Marie sees a dog barking so she activates a filter on the tablet meaning the dog is blurred from the child's vision and the barking is distorted. These interactions show how a person's life can be altered through technology and how these devices can change behaviour. This can be seen across the episode where the implant interferes with Sara's ability to see someone in need of medical attention. As she ages, this impacts on Sara's relationships with other people as well her mother, as Marie is able to see everything Sara does. In this episode through the use of diegetic prototypes (the Arkangel app on a tablet and the brain implant) the creators were able to show issues with future technologies reflecting issues within the self-tracking field including privacy and control, agency, social exclusion and social tension from different character's perspectives.

Figure 20 - Black Mirror: Season 4 Episode 2 Arkangel example of diegetic prototype. Connected to a brain implant in a child's brain, this scene shows an interface with an option to filter out distressing content in the real world, when the filter is turned on the barking dog is blurred out from the child's vision and the bark is distorted source: https://www.framerated.co.uk/black-mirror-4x2-arkangel/.

While this shows how diegetic prototypes can engage audiences through narratives, design fiction can also be applied to design practice. Design fiction in this sense can be used as an approach for understanding what could happen if a created prototype did exist, what it might be like to live with that created prototype and what might prevent it from becoming a reality. As Bleecker describes designed objects, or multiple artefacts in a design fiction, can show "different kinds of near future worlds" (2009, p. 7). This is how design fiction is defined within this work focusing on technology in near futures i.e., tracking devices with new sensing capabilities which are likely to exist in our lifetimes. There are many different ways people have implemented design fiction into their design practices, both in academia and independently i.e. The Near Future Laboratory (2023) and Superflux (2023). Some have created design fiction prototypes which helped to think about the future of companies (The Near Future Laboratory, 2015), add realism to a scenario (Tiberio and Imbesi, 2017), explore potential sensing technologies (Wong *et al.*, 2017) and enabled discussions with a company (Colombo *et al.*, 2018). Blythe (2014) used design fiction approaches, reconsidering research through the use of imaginary abstracts. These abstracts summarise fictional research of fictional prototypes to critique and help develop potential projects. Another storytelling aspect in research outputs, Sturdee et al., (2020) used the perspective of a deteriorating phone with the aim of encouraging readers to reflect on e-waste and our relationship with technology. Film has also been popular in the design fiction space, with short videos being used to demonstrate prototypes related to issues including machine learning (Lindley and Potts, 2014), algorithms (Rebaudengo, 2015), IoT devices (Lindley *et al.*, 2020b) and self-tracking devices (Jain *et al.*, 2015). In one instance, animated scenarios were created for prompts with older adults as a method for co-creating future wearable devices (Ahmadpour *et al.*, 2019).

Some of these works helped influence the design fiction methods used in this research. For example, as explained in section 3.4.2.1, a fictional trailer for a fictional app was created for a conference as an entry point to the fictional world created. However, world building draws on some of these design fiction methods while ensuring design is at the forefront of this approach; as this can be misunderstood by some where emphasis on the word 'fiction' implies creating narratives without involving design at all (Coulton *et al.*, 2017).

3.4.2.1 World Building & making

World building is explained by Coulton et al., (2017) as a design fiction activity, helping to understand both what design fiction is and providing a more concrete approach to using design fiction as part of design research. In this framing of world building, a diagram is used to describe what it means to create design fiction worlds. However, as it uses examples from the paper to explain this concept, Coulton et al's (2018)'s depiction is used in Figure 21 as a general outline. This diagram demonstrates how these worlds are developed through a variety of artefacts that access the world at different scales, referred to as entry points. These entry points allow ethical and social questions to emerge and provoke conversation about the fictional world created.

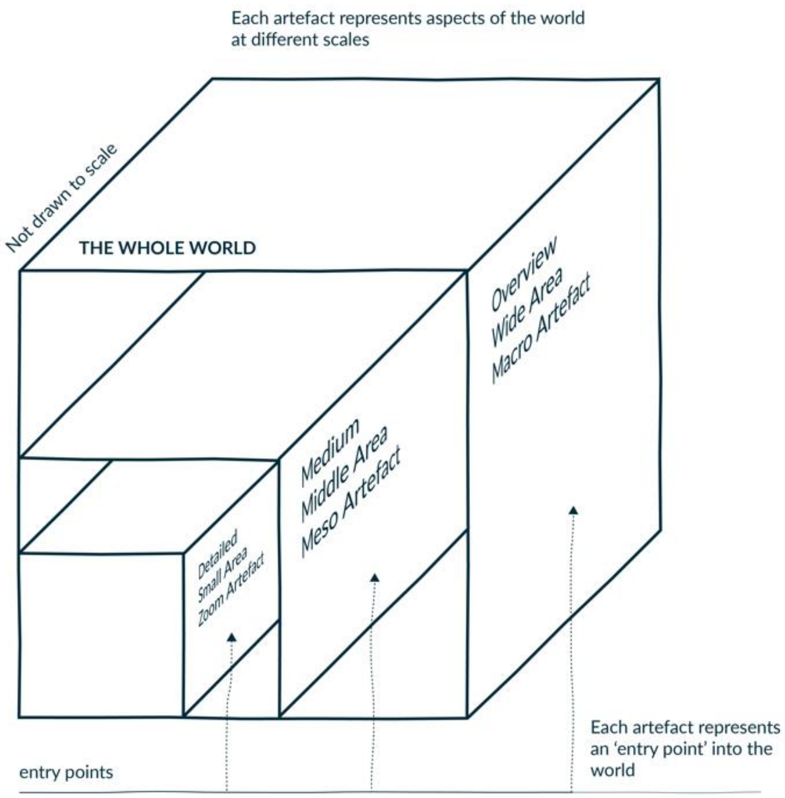


Figure 21 - Design Fiction Worldbuilding diagram to show artefacts created at different scales providing different entry points to the fictional world. Remade from The Little Book of Design Fiction for the IoT (Coulton *et al.*, 2018)

To apply this concept of entry points at different scales to an example, when learning about what design fiction was at the start of this PhD, it coincided with discussions about contact tracing applications related to the spread of COVID-19. There was debate at the time around using a centralised approach rather than an anonymised approach that big tech companies offered. This suggested people were more trusting of companies who have access to huge amounts of data about us, compared with the government that is supposed to be there to protect us. Wishing to explore the concept of worldbuilding, I created some fictional applications based on the idea that if Google had access, the API they created might be available to third party developers resulting in different apps having access to extremely personal data. They would also have the potential to use this data to profit from a health crisis which resulted in the loss of many lives. Figure 22 showed a gamification aspect of this technology through the popular app Pokémon go, which pre-pandemic encouraged users to go out and interact with others in the real world. This was turned into a diagram explaining to users how to activate the feature and what an alert might look like when indicating possible exposure to the virus. Another was based on the Google Maps app (Figure 23), allowing you to see how close you were to other people on your intended route and reroute, if possible, to less congested paths. This was made into a series of short explanations in the advertising style Google might use to promote new features in their apps. These both provided different entry points to the fictional world of contact tracing exploring exposure applications and social distancing features, reflecting potential uses of this technology by various parties. While these were not used anywhere, they helped me understand how design fiction could provoke conversation around current issues and near future applications through the creation of plausible artefacts.

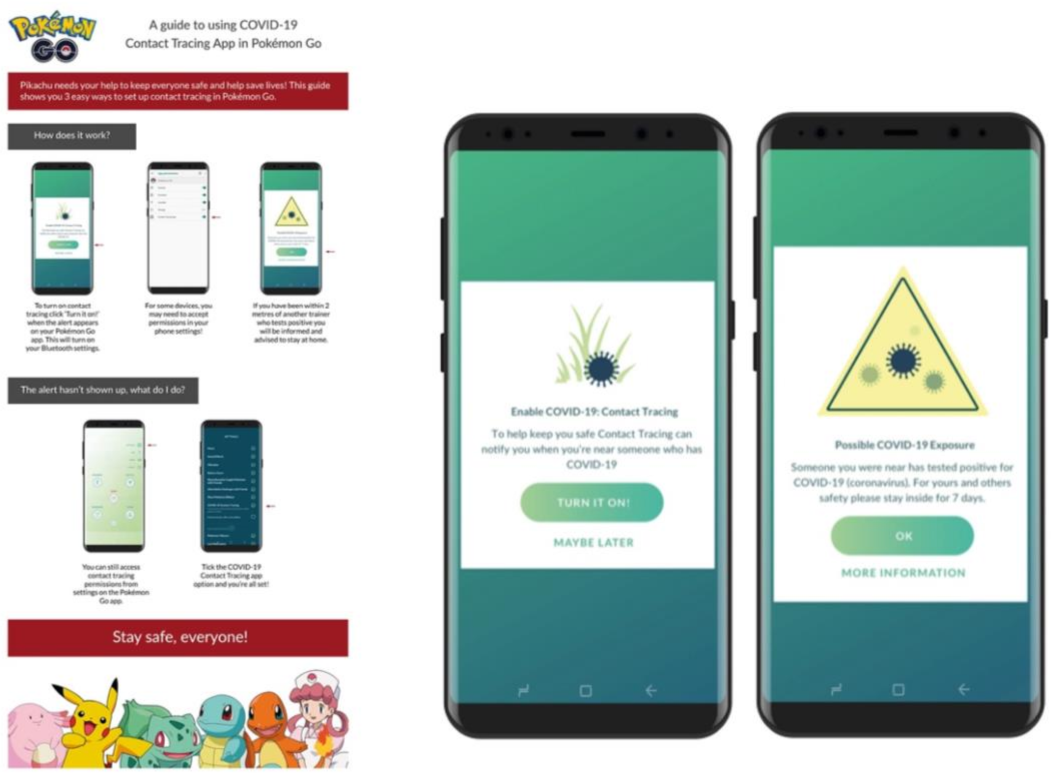


Figure 22 - Pokémon Go Contact Tracing Design Fiction Application - Left shows a diagram explaining to users how the app works and the right shows two of the app screens developed related to tracking exposure to COVID-19.

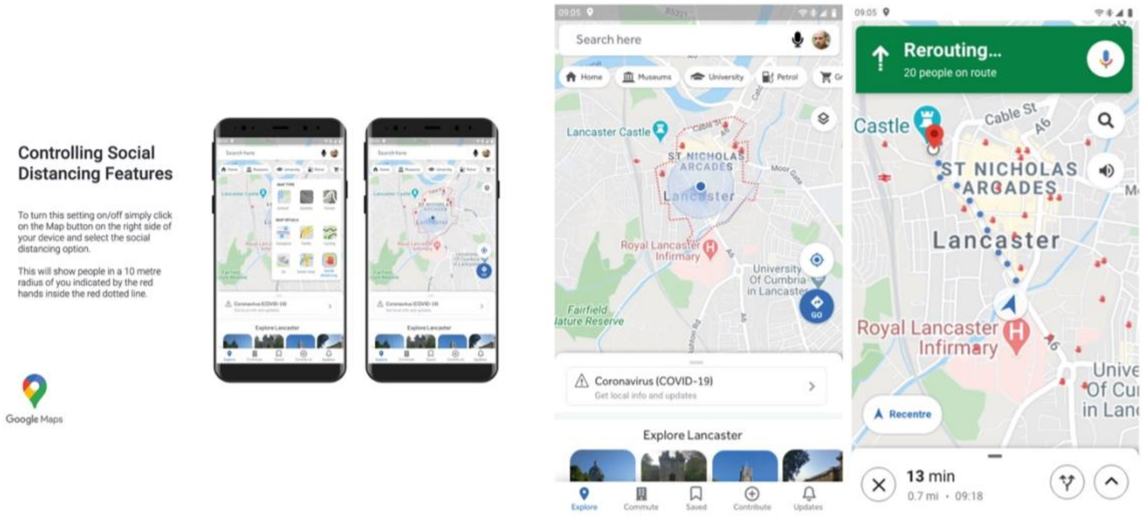


Figure 23 - Google Maps Design Fiction Contact Tracing App - left shows an advertisement of some of the social distancing features the app offers with the right showing two app screens indicating where people (the red hands) are in relation to you & an alternative route to follow.

In the literature, world building has been used for a variety of debates and thought-provoking topics. Icons have been created to research legibility around AI technology (Lindley *et al.*, 2020c) which has been applied to specific parts of a fictional world. For example, where AI iconography might be used in the real world (Pilling *et al.*, 2020) i.e., a public space, could be shown through artefacts such as signs in a city square and third-party applications in apps like Spotify. Equally world building can be used to test more-than-human theory as well, provoking questions around human centered design (Akmal & Coulton, 2020). While these examples show different types of plausible artefacts, this can cause issues with deception with some of these prototypes (even when based on technology seen in sci-fi movies! (Sturdee *et al.*, 2016)) being so realistic, actual news sites (Livesey, 2016) reported on them as real and existing technologies. This deception issue was also found with some of the design fiction techniques used as part of this research.

3.4.3 How is design fiction used in this research?

Throughout the course of this research mixed methods were used depending on what method worked best for the research conducted. The methods used were specific to particular projects and so will be explained in relation to those projects in later chapters. However, here methods that people may not be familiar with are briefly explained to give an initial grasp on what design fiction methods could be. This is to make it clearer why these techniques were used for projects discussed in later chapters. Interviews and workshops were also used in this research, but as these are usual methods for design researchers, these will be discussed in later chapters in relation to the particular project. Firstly, these various design fiction methods will be discussed (section 3.4.3.1-3.4.3.3). Following this a couple of other methods that were necessary for the creation of some artefacts will be outlined (section 3.4.3.4) before ethical implications of the methods are discussed (section 3.5).

3.4.3.1 Fictional papers

Expanding on Blythe's work around imaginary abstracts (2014), fictional papers present fictional research within published papers to explore potential value and critique of new HCI concepts and means "disbelief can be suspended" (Lindley & Coulton, 2016). These papers, while fictional, still require a lot of work to think through how these systems could be created in this particular world. This includes critique around this potential future and helps start discussions around whether this is a world we want to exist. This is instead of providing a solution with the assumption that technology will be able to solve any issue. Game of drones (Lindley and Coulton, 2015) is an example of a fictional paper. The paper is written in its entirety as if it is ongoing existing research. In the final part of the paper, it is revealed that the research is in fact fictional and therefore showing a plausible future rather than an actual work in progress. As well as a fictional user trial, fictional artefacts are presented to support discussion around drone legislation i.e., screenshots of videos, diagrams of a docking station and signage of drone trials all helping to create a believable existing project. This approach values design fiction as a method, provoking questions not just about HCI issues raised in the fictional paper but also about how design fiction practices can be used in design research.

As explained in Lindley and Coulton's (2016) paper advocating for fictional papers, this approach is similar to past HCI techniques like Wizard-of-OZ techniques (Buxton, 2007). Wizard-of-Oz asks people to interact with a fabricated system which is simulated to appear as real working system. This aims to produce more accurate reactions to interacting with the technology without having to fully implement it. Both approaches suspend disbelief, and have their reasons for doing so, but can also be critiqued for getting in the way of transparent or ethical research as they can be seen to deceive the participants. In relation to this, fictional papers pose little ethical risk to an academic audience, especially as it is made clear that deception has occurred within the fictional paper. Coulton et al.,(2016) describe deception in a fictional paper as a friction between making a plausible design and a fiction, causing a tension between truth and untruth. It is concluded that deceit comes from deciding to use design fiction as an approach and how researchers choose to present their design, rather than the use of fictional papers themselves.

3.4.3.2 Fictional trailer

A fictional trailer is an example of a type of video that could be created as part of the world building process. Lindley et al (2015) use a short design fiction video linked to their fictional paper to help suspend disbelief about drones. By presenting fictional artefacts in a fictional trailer, fictional worlds can be demonstrated quickly to a large range of audiences. They can make it clearer to these audiences that the world is in fact fictional and provide a preview to other outputs from a design fiction such as a fictional paper. At the same time, a fictional trailer can act as an additional entry point to the design fiction world.

3.4.3.3 Fictional artefacts

Fictional artefacts are objects or prototypes developed as part of the world building process. This can be anything from fictional legislation documents to social media posts, and physical catalogues. While already briefly touched upon, fictional artefacts are a common aspect of world building and can help create a variety of entry points to the world to access it at different scales. Here a couple of examples are shown to provide concrete examples of what these fictional artefacts can look like. The Near Future Laboratory (2019) created a physical map (Figure 24) outlining the network of autonomous vehicles across Geneva. Rather than asking higher level questions around future cities, the map provoked immediate debate around autonomous transport's impact on traffic levels and urban infrastructure. Through the process of creating this fictional world, developing the map allowed new considerations to arise about employment opportunities and drop off areas. Through making, new knowledge was produced and could be used to generate further discussions.

Figure 24 - Map of autonomous vehicles from the Near Future Laboratory. Source: https://blog.nearfuturelaboratory.com/2019/10/

Stead et al., (2018) created a modular HealthBand with various artefacts such as legislation documents (Figure 25), a device certification guide and a permit for domestic fabrication authorisation to provoke conversations around digital fabrication and e-waste. Based on existing requirements from various health bodies such as the MHRA, the plausible artefacts created could help to start conversations with different stakeholders including various health practitioners, members of the public, medical ethics committees, manufacturers of health devices etc. It also provides prototypes for people to reflect on challenges adopting this technology before it is widespread and affecting people's lives.

Figure 25 - Device Certification Guide for modular HealthBand from Stead et al's paper Do-It-Yourself Medical Devices: exploring their potential futures through design fiction (2019). DOI: https://doi.org/10.21606/drs.2018.475

3.4.3.4 Developing artefacts from the perspective of multiple beings

This thesis aims to introduce different more-than-human perspectives of contextualised health and wellbeing information to explore implications for self-tracking design. Therefore, methods are required to develop these perspectives and allow people to interact with them. Artefacts can be used in a similar way to the fictional ones created but based on non-fictional techniques. For example, a similar approach to probes used in the HCI and design space can be followed (Gaver *et al.*, 1999). With cultural probes, participants are given a pack of materials which might include things like pencils, paper, scissors or even maps and a camera. These act as provocation and inspiration to help participants engage with research in a unique way. They are usually given some prompts and then they use the materials to respond to these prompts i.e., tell me about your favourite television show and then a participant might draw or take a photo, expressing their views on the prompt.

When applied to the critical and speculative design area, artefacts have been used as prompts to understand how people might interact with technologies as well as their thoughts around a particular topic. Gross et al (2017) made three tracking device prototypes to emphasise the relationship between tracking and experiences of anxiety which were placed in people's homes and allowed people to interact with them for 6 months. This was also done on a much shorter timescale with Lawson et al (2015b) using speculative artefacts to explore the quantified aspects of tracking technologies. These were presented to people through short focus groups, gaining initial thoughts on the technologies presented as well as human-animal relationships. With companion animals forming part of this research and their perspectives used later on, it seemed appropriate to create some kind of artefact that would help provoke discussion of complex topics. Noortman et al's (2019) description of a design fiction probe helped influence the created method used in this research. Their probe was called Hawkeye, allowing participants to play the role of a character in the fictional world and interact with a physical control panel across 3 weeks.

Speculative artefacts can be created to engage participants but non-fictional methods can also help create these artefacts, for example by observing companion animals. The lives of our companion animals have been documented across time, shedding light on the hidden lives of the non-humans amongst us (White, 1981). An example of this can be seen through White's diary entries about Timothy the tortoise's general wellness.

> *"1777 Sep. 11. Mrs Snooke's tortoise devours kidney-beans & cucumbers in a most voracious manner: swallows it's food almost whole. Foot note. Timothy the tortoise weighed six pounds 3 quarters, 2 oun: & an half: so is not at all increased in weight since this time last year. The scales were not very exact." From The Portrait of a Tortoise* (White, 1981, p. 29)

As can be seen in the above extract, Timothy's weight, preferences in diet and behavioural habits (eating style) are all noted. Further entries also highlight humans and non-humans wrapped up in the tortoise's life that impact his wellbeing. For example, the death of Mrs Snooke results in Timothy fasting between "7, or 8 months" breaking his fast on "the globe-thistle, & American willow-herb" (ibid, p.31).

These diary entries have provided inspiration for artists and illustrators to shed their perspective on the lifelong companion (Pallant, 2020). This technique can also be used to document a companion animal's activities, so the artefacts created are based on actual behaviour of that animal.

Equally, to explore these animal perspectives, cameras can be used to explore the world from the perspective of that being. Figure 26A explains how Critter Cams, placing a camera on an animal, can acts as a way to explore non-human subjectivity (Bell, 2016). This was also put into practice by documentary makers and scientists at the Open University (Figure 26B), attaching these cameras with sensors to cats seeing their 'secret' lives outside the homes of their owners (BBC, 2014). For ethical reasons, it might not necessarily be appropriate to attach a camera to an animal and therefore a robot could be used to mimic the animal's perspective. This can be seen in nature documentaries like BBC's Spy in the Wild (Figure 26C) where imitations of animals are created with cameras for eyes to obtain closer footage of animals in their natural habitats (BBC, 2017). This approach might be better for designers who might not necessarily have access to an animal but want to understand how people might perceive different views of the world.

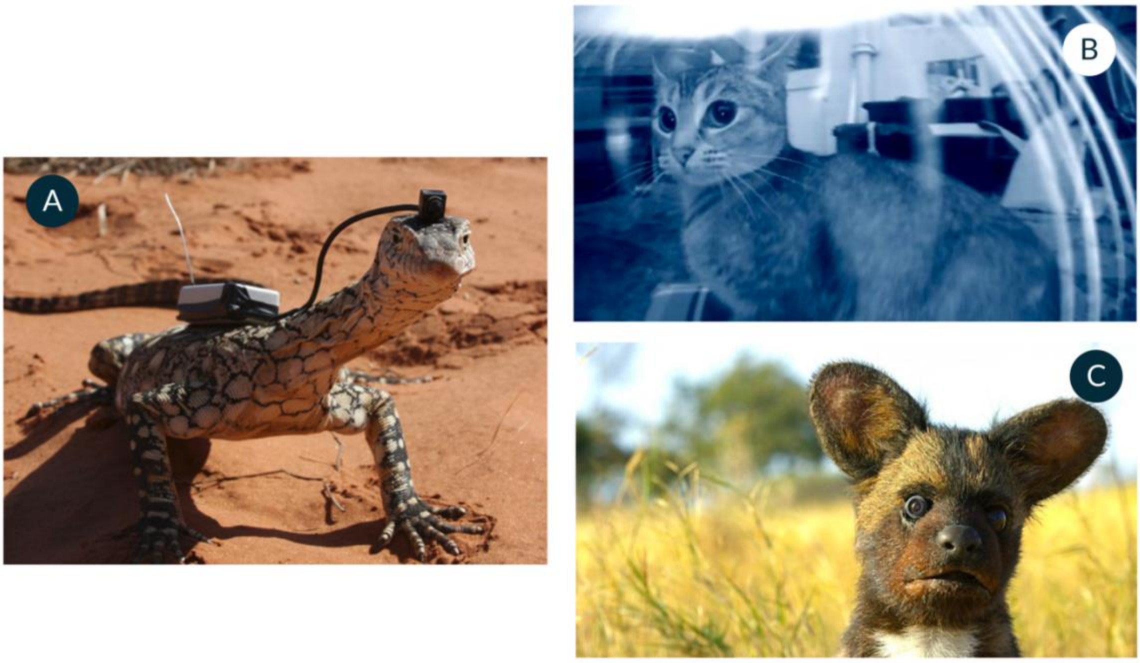


Figure 26 - Various cameras used to gather animal perspectives. A – CritterCam on lizards head source: https://www.kpbs.org/news/arts-culture/2009/10/15/nova-lizard-kings. B - A camera on a cat's collar source:

https://www.bbc.co.uk/programmes/b04lcqvq. C - A robot made to look like a hyena source: https://www.bbc.co.uk/programmes/b088s4fy

Including different types of artefacts for people to interact with allows people to properly experience a fictional technology or system. Using non-fictional artefacts with fictional artefacts helps enhance the creation and development of a fictional world that is more plausible when presented to participants to interact with.

3.5 Ethical implications of the methods discussed

For all research, ethical considerations are required to minimise harm. Therefore, this section will discuss potential ethical concerns that arose from conducting this type of research and how the risks were reduced. One way these risks can be reduced is by submitting the project for ethical approval to the University faculty. The documents submitted for this application can be seen in Appendix B. However, with the exception of the Cat Study, discussed in chapter 6, the research conducted in this thesis did not involve any participants so this process was not required. Even if small, the potential risks from conducting fictional research are also discussed here.

3.5.1 Recruiting participants

Recruiting from our own networks and advertising across campus and social media could have ethical considerations. For example, if anyone was gathered from a researcher’s own networks, it needs to be clear that there is no pressure or expectation to take part in the study. To make sure participants are informed at all stages, they will need to be given information sheets and consent forms and informed that they can withdraw at any time. The exception to this is where responses might be gathered during a workshop and due to the anonymous nature of gathering responses i.e., post it notes, responses could not be removed from data collection.

3.5.2 Identifying information

To ensure people cannot be identified, any identifying factors such as names, descriptions, locations and occupations need to be removed from transcripts. Where necessary these can be replaced with pseudonyms or fictional jobs to protect the identities of individuals. This is in case data from the interviews are required in publication of the results.

3.5.3 Storing & Collecting data

Any data gathered will be stored on an encrypted and password protected computer and the University's secured OneDrive. Manual data such as activity responses from a workshop will be stored in a locked cupboard in the University building. The audio/video recordings from the interview stage will be deleted after transcriptions have been made anonymous and publications around this work have been accepted. After copies of the manual data are created, these will be destroyed. The copies as well as the anonymised transcripts and anonymised responses from participants will form a dataset which will be stored on an encrypted device and kept securely for 10 years on a University server after the end of the project.

3.5.4 Deception

For the fictional research conducted i.e., the fictional paper, deception could occur if people believe it is real. For example, the fictional paper is presented like actual research so people might believe it's an actual study that took place. Putting disclaimers at the start of the paper might ruin the plausibility of the paper and the suspended feelings of disbelief, which makes the fictional paper a powerful method. However, to make it clear to the reader, the fictional nature should be revealed at the end of the paper. This might explain why this method was used and explain that this type of study was not carried out with actual participants to ease concerns. This could also happen with people interacting with artefacts. If it is necessary for them to believe it is real at the start, debriefing them to make it clear these artefacts do not exist helps with minimising deception.

3.5.5 Potential for harm

As explained under the animal perspective methods, placing a camera on a cat could be unethical without proper processes in place. To ensure animal welfare, not gathering any data from the cat i.e., via sensors or sending messages to participants that could change the cat's safety, routine or daily life in any way will help protect the companion animals potentially involved in the data or artefacts gathered and created.

3.6 Analysing participant responses

For the methods discussed, the inclusion of participants to interact with and react to the created fictional artefacts requires reflection. To thoroughly analyse people's responses to the artefacts developed and created, within this research reflexive thematic analysis was chosen. What this process is, what it entails and why this was used when analysing this research is discussed here.

3.6.1 Reflexive Thematic Analysis (RTA)

Thematic analysis (TA) is a way of creating codes and themes from a dataset to find, analyse and interpret relevant patterns to produce meaning about the data (Braun and Clarke, 2021). Reflexive thematic analysis (RTA) is a form of TA which, as the name suggests, puts reflection at the core of the analysis (ibid). It acknowledges how researchers play an active role in the development of codes and themes. Additionally, that we have a situated and subjective way of analysing data which means we should be aware of theoretical assumptions when conducting research. While RTA acts as guidelines for researchers rather than strict rules, these guidelines follow a few phases:

- **Familiarisation** (phase 1) – Broadly speaking, this is about getting familiar with the whole dataset, beginning to form questions and potential meanings from the data set. This includes noting anything of value either through memos or doodles or other practices that work for the researcher.
- **Doing coding** (phase 2) – Going through the dataset again, codes are created to capture meanings within the dataset with relevance to the research questions. These are not set so they can be altered as researchers begin to understand their dataset. This might require several rounds going through and refining the created codes.

- **Generating initial themes** (phase 3) – From the codes created patterns that emerge around a central 'organising concept' form themes. These themes are some kind of shared meaning within the dataset.
- **Developing and reviewing themes** (phase 4) – As the name suggests, this is about going through the initial themes to make sure they are all built around a singular central idea or argument. Linked to the research questions, they should tell a story about the researcher's dataset.
- **Refining, defining and naming themes** (phase 5) – Making sure the names represent the researcher's themes correctly, as well as encouraging people to want to know more about the analysis. With this in mind, also not misleading them about what the theme is about.
- **Writing matters for analysis** (phase 6) – Writing up the analysis also means producing analysis in the process. As this process continues to refine the analysis, it will not be fully developed until the writing is completed and published. This is different than other approaches where findings are written up after the analysis is complete.

These phases do not have to be linear and can be carried out as many times as needed across the course of the analysis. Within RTA there are also variations to carrying out this kind of analysis. Figure 27 explains the differences between these variations describing how data is interrogated and the focus that is taken from the dataset. This includes the theoretical underpinnings that influence the approach taken.

Orientation to data	**More inductive:** where the analysis is located within and coding and theme development are driven by, the data content	⟷	**More deductive:** where the analysis is shaped by existing theoretical constructs which to read and code the data and develop themes
Focus of meaning	**Semantic:** where the analysis explores meaning at the more surface, explicit or manifest level	⟷	**Latent:** where the analysis explores meaning at the more underlying or implicit level
Qualitative framework	**Experiential:** where the analysis aims to capture and explore people's own perspectives and understandings	⟷	**Critical:** where the analysis focuses on interrogating and unpacking meaning around the topic or issue
Theoretical frameworks	**Realist, essentialist:** where analysis aims to capture truth and reality as expressed within the dataset	⟷	**Relativist, constructionist:** where analysis aims to interrogate and unpack the realities that are expressed within the dataset

Figure 27 – Table showing variations of reflexive TA. Remade from Braun and Clarke's Thematic Analysis: A Practical Guide page 10.

Participant responses can be gathered via qualitative analysis software like NVivo. NVivo can increase the speed of the analysis process and allows easy comparison between codes and patterns across a large dataset. RTA offers guidelines for how to carry out analysis rather than setting rules to follow, acknowledging the flexibility in this approach. Everyone’s process will differ dependent on their interpretation and reflection of the data. However, this will not change conducting meaningful and useful analysis. It allows reflection on our own biases and subjectivity which may change how data is interpreted from the participant’s responses, as well as methodological choices made, interpreted, coded, and reflected upon based on how we view the world. Reflexive thematic analysis allows the generation of codes and themes while exploring the data, to reflect on whether themes are relevant and iteratively adapt them to make sure they continue to remain relevant in response to the research questions.

Other approaches also use coding approaches to qualitative data sets such as content analysis and grounded theory. It has been suggested that thematic analysis was developed from content analysis meaning the approach overlaps a lot. However, instead of interpreting the dataset, content analysis “provides a direct representation of participant’s responses” (Gray, 2021, p. 759). Whereas this research used participants responses to uncover additional meaning. Additionally, content analysis does not prioritise reflection on the analysis approach. Reflection is important in this work given that there is a focus on critiquing current system design that includes bias and inequalities, therefore it's important that this thesis also reflects on assumptions made within this research. There has been criticism from (post)positivists that if thematic analysis is used over other qualitative methods, there needs to be multiple coders to increase the accuracy of this approach because there is no focus on an objective truth. As explained by Braun and Clarke this implies that "themes are *in* the data, waiting to be found by the researcher" (2021, p. 239). This thesis agrees with the view that different researchers could look at exactly the same data and take completely different meanings from it. Collective coding will still have subjectivity even if the researchers don't notice it. Equally there's no single 'truth' in the data that can be uncovered by taking one set approach, but this doesn't weaken the approach. Awareness of our situatedness and subjectivity and including this awareness in reporting of analysis, rather than attempting to reduce and control "bias" (2021, p. 273) helps readers to understand the values that underpin the analysis conducted. It highlights that we are humans that think differently and that these unique views can help add to a body of knowledge compared with posing these views as a "threat" (ibid) to research.

3.7 Summary

This chapter begins by explaining how my views about knowledge and reality (phenomenological paradigm following a largely social constructionist approach) differ to how knowledge and reality is represented in current self-tracking research (following a positivist paradigm linked with realist and objectivist approaches). The methodology used in this research, research through design is then outlined and compared with other approaches. This was chosen because of the focus on creating artefacts to produce knowledge while allowing for iteration and critique of the design process. Additionally, RTD works well with speculative methods because of the concern with creating what 'might be' and the 'right thing' relating to future thinking and ethical issues. These speculative approaches included design fiction, particularly focusing on world-building, providing a concrete approach for using these methods in design research. World-building highlights how there can be multiple futures and worlds rather than one shared future that we all experience in the same way, aligning with the theoretical standpoints and theory outlined in this research. The mixed methods used in this research are then explained in further depth, providing an overview of what these methods are. Lastly, reflexive thematic analysis is explained as the form of analysis for the qualitative data produced from this research. Acknowledging the active role the researcher plays in the analysis process, allowed reflection on the particular stance taken in this work and how that influenced the patterns of meaning produced.

In the following three chapters, the projects developed across this research will be explained individually. Each project shaped the proceeding project to help discuss the implications of introducing new perspectives of contextualised health information. These chapters will discuss details about the project themselves, including the process for producing artefacts and other outputs, as well as any answers these specific projects provided. These will then be collated and discussed in relation to the overarching research area in the discussion and conclusion chapters.

Chapter 4 Connected Companion (CoCo)

Viewing context from a system perspective

4.1 Introduction

This chapter presents the first published paper from this research titled Context-Aware Wearables – The Last Thing We Need is a Pandemic of Stray Cats (Snooks *et al.*, 2021), presented at Alt.CHI 2021. The goal with this paper was to explore people's experiences interacting with context-aware information about their health and wellbeing. This was to understand problems with a system perspective and considerations for new contextualised information. This paper was fictional, meaning it presented fictional research in a published paper. This was necessary for understanding the implications of introducing new sensor features in self-tracking systems, following a system perspective's approach to implementing more contextualised information. Using a non-existent system to explore this meant this could be done without hindering people's wellbeing in the process. By submitting fictional research to a real conference, it provided provocations on current approaches to designing context and helped develop an understanding of existing concerns from experts in the human-computer interaction (HCI) space. The development of this fictional paper was the result of a world building process which involved understanding what context was from a system perspective. This involved exploring how contextualised information is presented in current self-tracking systems and how insights from this process led to the creation of several artefacts. These were presented at the Vis Futures: Design Fiction Methods for Envisioning Tomorrow's Visualisations at IEEE VIS 2020, expanding on the development of the world of CoCo. This section also discusses the creation of fictional user narratives as a process for combining and collating world building aspects into a fictional paper.

This chapter includes the published fictional paper (section 4.2) before explaining the world building process (section 4.3) and how this helped to reflect upon this process, understand the aims of this research and the challenges that it raised (section 4.4).

4.2 Fictional Paper

4.2.1 Connected Companion (CoCo) Overview

We present Connected Companion (CoCo), a health tracking wearable that provides users with timely, context-relevant notifications aimed at improving wellness. Traditionally, self-tracking wearables report basic health data such as resting heart rate; these data are visualised and positive behaviours (e.g., exercising often) are encouraged with rudimentary gamification (e.g., award badges) and notification systems. CoCo is the first wearable to combine caffeine, alcohol and cortisol sensors, a context network (which predicts user context), and a wellness model (which establishes per-user wellness measures). Working in tandem these provide users with notifications that encourage discrete behaviours intended to optimise user-wellness per very specific biological and social contexts. The paper describes the (sometimes unexpected) results of a user-study intended to evaluate CoCo's efficacy and we conclude with a discussion about the power and responsibility that comes with attempts to build context-aware computing systems.

4.2.2 LOTUS, IVY, and BLOOM: Data Driven Wellness and Context Modelling

CoCo is the first wearable to combine caffeine, alcohol and cortisol sensors, external data streams, and machine learning to implement context-aware sensing for providing timely and relevant notifications for users intended to help them optimise their wellness[4]. CoCo's software is built around three interlinked components a context-network (IVY), a wellness model (LOTUS), and a management layer (BLOOM). In terms of hardware, the CoCo wearable uniquely combines multiple biosensors into a single device providing the software components with the data necessary to create and maintain bespoke wellbeing and context models. These include a cortisol

[4] A formal definition of wellness is beyond the scope of this paper and incorporates aspects of mental and physical health alongside subjective accounts of happiness and emotional well-being (Simon et al., 2022)

(potentiostatic circuit and chronoamperometry (Rice *et al.*, 2019)) sensor; caffeine (electro-chemical differential pulse voltammetry sensing (Tai *et al.*, 2018)); and alcohol sensor (using proprietary ION sensor cartridges (ION, n.d.)). Alongside these specialised biosensors, data pertaining to heartrate, blood oxygen, movement, ambient sound, and temperature are also captured. CoCo users are required to give permission for CoCo to access additional 3rd party data in order to provide the IVY context-network with sufficient data to reach reasonably confident context assessments. These data include location, content and meta-data of calendar entries and messaging apps (compatible with various Email Clients, WhatsApp, Facebook Messenger, iOS/Android SMS apps). To support the functions of the LOTUS wellness model, CoCo prompts users to generate wellness labels at regular intervals (Figure 28C 'Wellness Check').

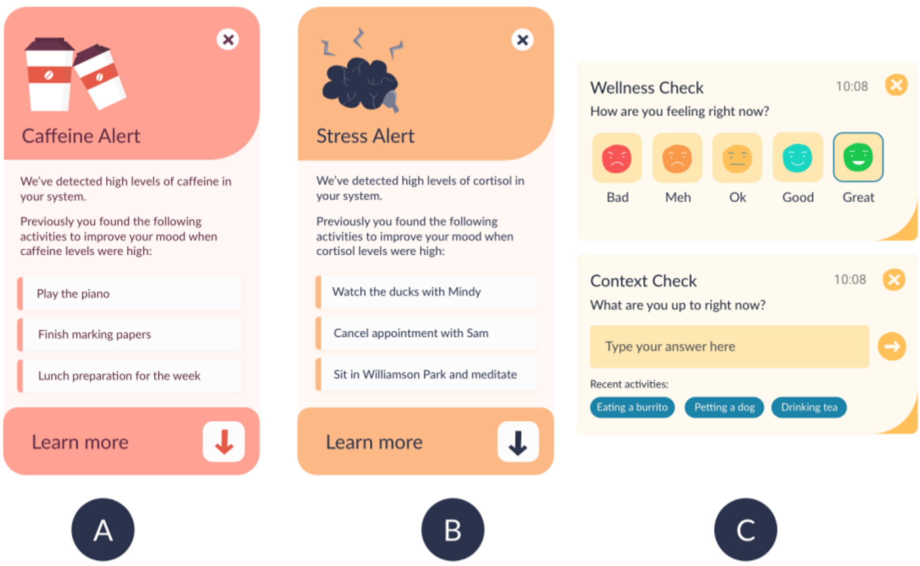


Figure 28 – CoCo notifications sent to users during the user study

The IVY context network (Figure 29) correlates live sensor data and 3rd party data (e.g., calendar, location) in order to create robust labels which can describe context to a high level of accuracy. For, example calendar and messenger entries may suggest a 'coffee shop meeting' which will be reinforced by relevant sensor data such as location, sound signature (e.g., the sound signature of a coffee shop), and increased caffeine. Using supervised learning, the model increases confidence via manual interventions with the user (Figure 28C, 'Context Check'). The result is a bespoke model which can take partial datapoints to infer context to a high level of certainty on a per-user basis.

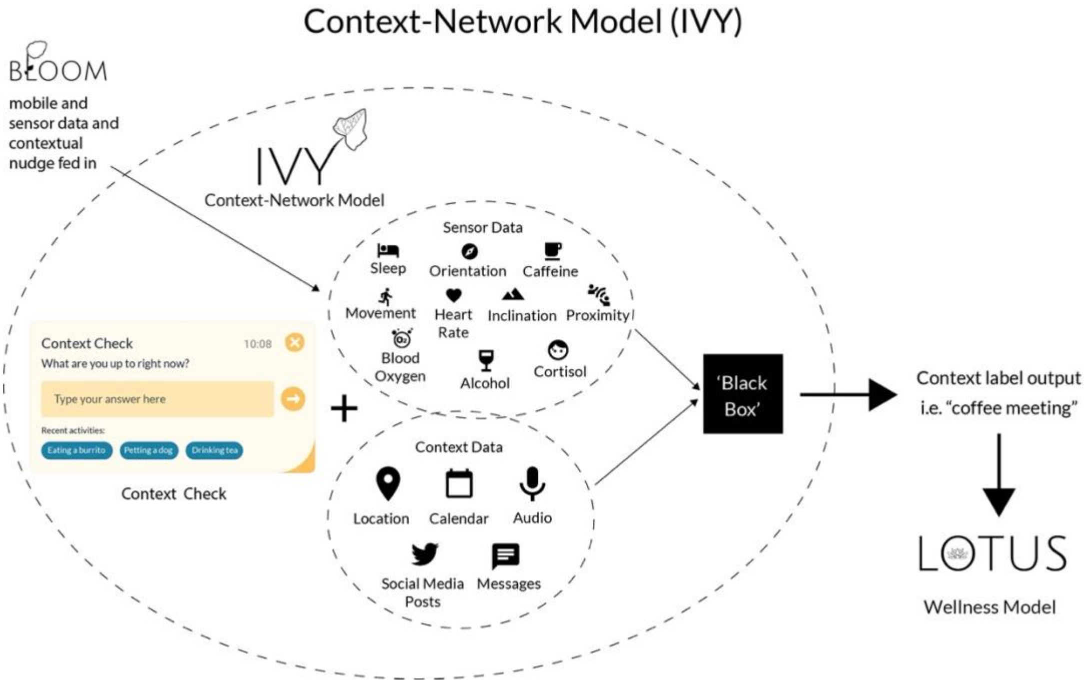


Figure 29 - Context-Network Model (IVY)

The wellness model LOTUS (Figure 30) correlates labels from the IVY context network (e.g., 'having a coffee meeting with a colleague') with user-generated wellness tags and relevant sensor data[5] (Figure 30). In contrast to traditional health-related wearables that assume an average or standard interpretation of wellness for all users, through LOTUS, CoCo learns what wellness means for each individual user. The result is an architecture which has the capability to adapt to nuances of both context and perceived wellness, and to do so for each user uniquely.

[5] Notably, sensor data (e.g., high caffeine level) is processed by the LOTUS model *independently* of IVY, this means that biosensor data exert influence on CoCo's understanding context and wellness independently of each other.

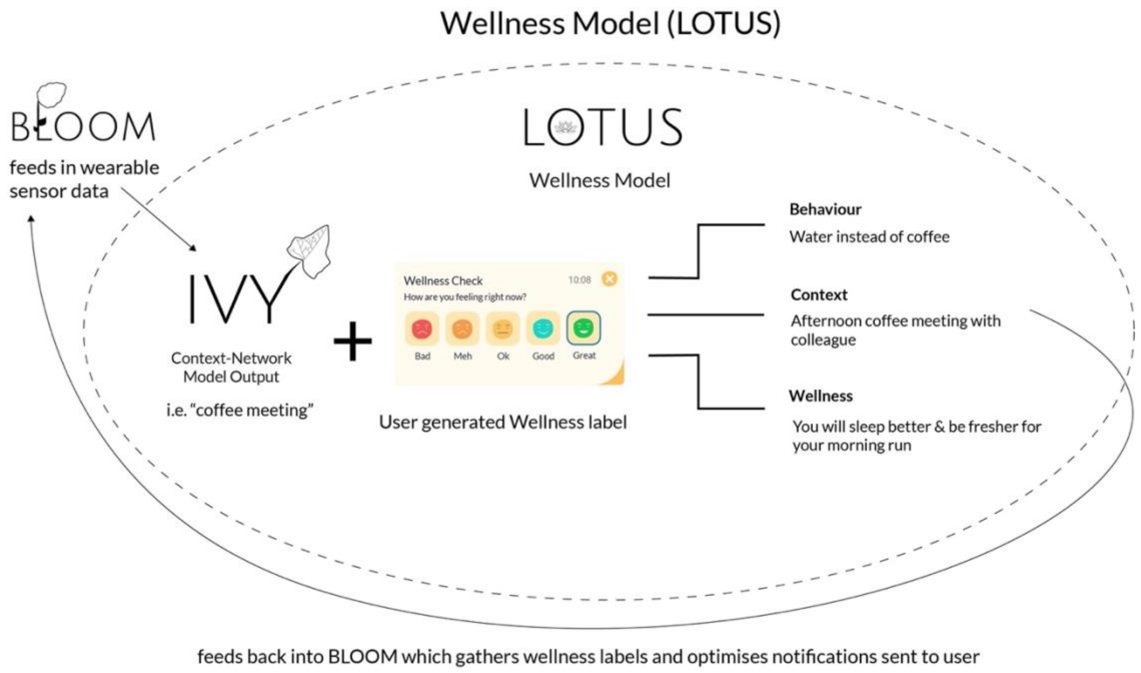


Figure 30 - Wellness Model (LOTUS)

BLOOM is CoCo's management layer (Figure 31). BLOOM can query both IVY and LOTUS models in order to highlight and promote correlations between established context and wellness baselines. Until the model meets a pre-determined confidence threshold BLOOM runs in a training mode, allowing IVY and LOTUS models to learn based on each user's data. Once baselines are in place BLOOM provides notifications (these are referred to as Welltexts—a portmanteau of wellness and context) to users. Welltexts are notifications designed to encourage users to adopt specific behaviours (e.g., reduce caffeine intake or get more sleep) which, at particular times or depending on context, may increase their predicted wellness. In addition to managing Welltexts, BLOOM is also responsible for enhancing the confidence that each model has by prompting users to generate further training data to label what they are doing and how they feel about it at key inflection points (see Figure 28). Figure 31 shows the system architecture: BLOOM manages notifications; sensor data from the wearable feed both IVY context network and LOTUS wellness model independently; 3rd party data (location, messaging, audio, etc) are fed into IVY; IVY's outputs (i.e., computed contexts) are utilised by LOTUS; both models are continually reinforced by additional user labelling, managed by BLOOM. The components are configured to encourage users towards behaviours which will increase their reported wellness as much as possible.

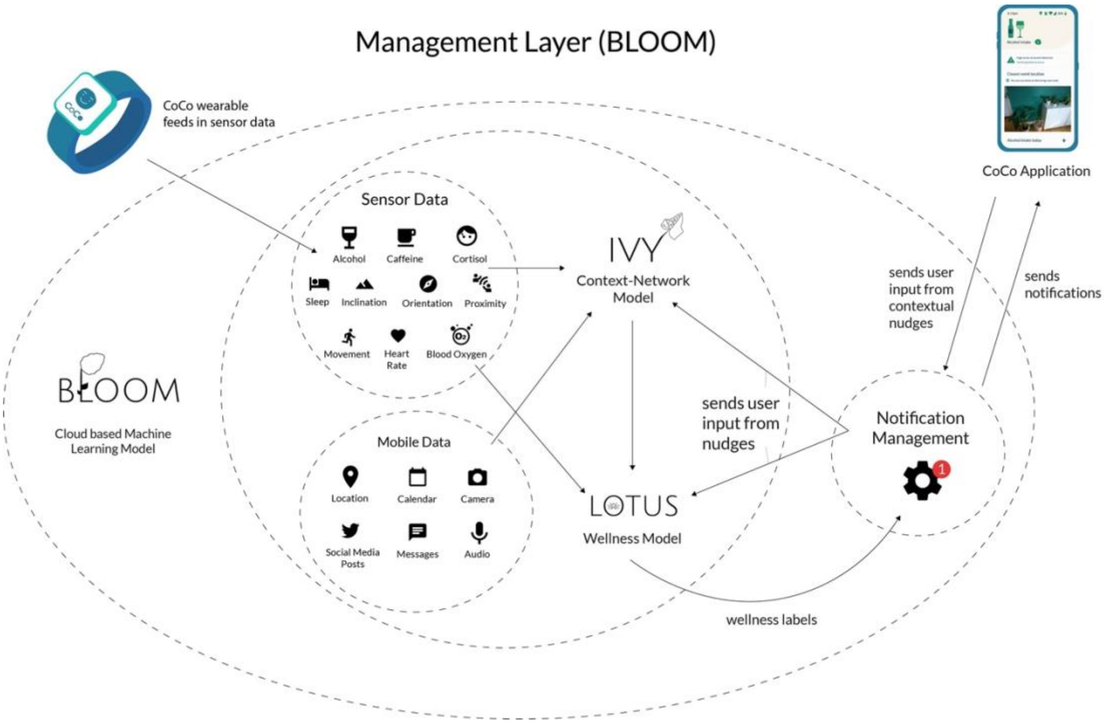


Figure 31 - Diagram showing how CoCo's software and hardware components function together.

4.2.3 Background and related work

Historically, health trackers embed sensors such as ambient light sensors and accelerometers to infer basic facts about a user's life, e.g., step count, sleep cycles, heart rate. Miniaturisation has allowed the current generation to combine biosensors which can detect not only heart rate but, alcohol, caffeine and cortisol levels into a single device. Moreover, while self-tracking devices provide users with a plethora of visual means to interpret data, users struggle to derive meaning from the information (Dulaud *et al.*, 2020). This is, in part, due to a separation of data and context (Li *et al.*, 2011)). The upshot is that users find it very difficult to make meaningful decisions based on their tracking data (Heyen, 2020; Choe *et al.*, 2014).

Context-aware computing (Theimer and Schilit, 1994; Dey, 2001; Dourish, 2004) focuses on detecting movements, routines and actions to provide relevant contextual information to a user. Whilst contextual computing has been a long-term aspiration of HCI and Ubiquitous Computing it has struggled with transitions between states

(Musumba and Nyongesa, 2013), differentiating activities (Guo, 2016), human perception (Musumba and Nyongesa, 2013) and supporting specific goals (Bentley *et al.*, 2013). The crossover with affective computing, to recognise and interpret human emotion, further highlights the complexity and challenges in creating context-aware systems (Moore, 2017). However, improvements in machine learning (Nascimento *et al.*, 2018), increased availability of relevant data (Campana *et al.*, 2018), and enhanced battery and network performance mean that efficacious context models are increasingly practicable (Civitarese *et al.*, 2019). Although research has attempted to encourage behaviour change through recommendations (Yang *et al.*, 2019; Rabbi *et al.*, 2015; Ghandeharioun *et al.*, 2016; Musumba and Nyongesa, 2013; Gyrard and Sheth, 2020; Guo, 2016), machine learning models (Plarre *et al.*, 2011; Adams *et al.*, 2020; Kumar, 2020) and timely interventions (Liao *et al.*, 2020; Nascimento *et al.*, 2018; Lee *et al.*, 2017), CoCo is the first system, that we know of, which combines alcohol, caffeine and cortisol sensors with a functional context model in order to encourage specific user behaviours.

In the remainder of the paper, we describe preliminary findings of a user study. Specifically, we draw upon data from user interviews to evaluate user experience. Initial results show that CoCo elicits a high level of engagement with users and can encourage behaviour change. However, due to identifying several unintended consequences of the system, we suggest that further work is needed in order to define systems which can reliably support a positive user experience and minimise unanticipated negative outcomes.

4.2.4 User Study

We deployed CoCo wearables to 15 participants who were asked to use the system for 6 months (see Figure 32). The participant cohort comprised 3 co-habiting childless couples, 2 who lived alone, 1 family with children and 1 household of shared occupancy; in total there were 8 male and 7 were female participants; the median age was 28, mean age was 34, youngest 9 months and eldest 80 years old. Participants were given a CoCo wearable and instructions on how to download and use the mobile application. Participants have been pseudonymised throughout.

Household	Name	Age	Gender	Profession
1	Phillip T	50	Male	Doctor
1	Kat T	47	Female	Swimming Instructor
2	Euan C	30	Male	Veterinarian
2	Gina C	28	Female	Barista (part time)
2	Piper C	9 months	Female	n/a
2	Darlene C	5	Female	n/a
3	Ron G	80	Male	Retired
3	Doris G	76	Female	Retired
4	Kelsie B	55	Female	Botanist
5	Cecilia L	22	Female	Biology Student
5	Mohammed A	19	Male	Computing Student
5	Russell F	18	Male	Psychology Student
6	Gabriel A	33	Male	Author
7	Mark G	26	Male	Software Engineer
7	Jason G	27	Male	Teacher

Figure 32 - List of participants interviewed in the user study

We interviewed participants in their households at 3 and 6 months into the trial using an unstructured ethnographical interview approach[6]. The purpose of this data gathering exercise was to understand the user experience of the CoCo system. In particular we wished to identify different perspectives, motivations, attitudes of the participants, as well as highlighting any problematic aspects of the system or social tensions that arose due to participants' adoption of the technology. The data, we suggest, is relevant to this particular implementation of a data-driven context-awareness system but may offer other researcher insights into generalisable challenges associated with encoding context. In the following we present 7 themes which have emerged from our preliminary engagement with the data.

[6] Please note that the trial took place in the latter half of 2019 before the Covid-19 pandemic and social distancing restrictions were in place.

4.2.5 Exercising

CoCo routinely recommended exercise to participants who usually found those Welltexts to be useful: Kelsie said "I upped my training regime" because "it decreased my stress levels" whilst Philip noted that CoCo "would often remind me that I might relax more if I went for a run". Due to the unique sensor implementation Kelsie was also able to use CoCo with tattoos, which was previously a problem with other wearables (Nelson *et al.*, 2020). Euan also noted that the personalisation of Welltexts helped motivate him to exercise "because of running I'm destressing significantly". However, on numerous occasions the app's tendency to propose exercise was also problematic. For example, Philip's stress was often highest while he was engaged at work seeing patients (he is a doctor) and those were the occasions that CoCo suggested he exercise (it is likely the IVY context network couldn't determine context because Philip's work diary was private). Conversely, for some users, the correlation between wellness and exercise was lost due to per-user training. For example, Russel—a first year psychology student—experienced that "rather than telling me to exercise more and eat better, encouraged me to spend more time socialising (Figure 33A)". This short-term gain (which enhanced his reported wellness) became problematic "in the end I had to stop using it. The time spent making friends was great, but it also made the end of term very stressful".

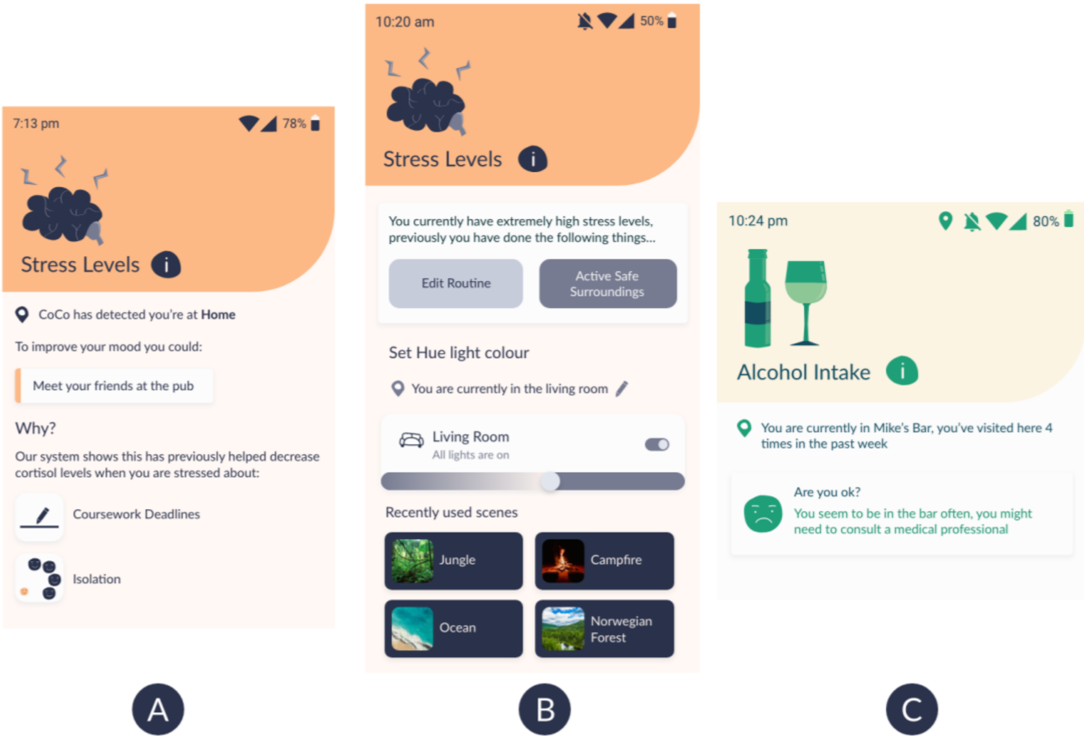


Figure 33 - Screenshots of users visualised health data in the CoCo app

4.2.6 Relationships

CoCo did help people become more social, Cecilia felt happier after using CoCo, catching up with “all the mates I hadn’t seen in forever” and Doris went to knitting club more often developing new skills like “finally learning how to cable knit”. However, whilst CoCo was learning, it suggested Doris—a 76-year-old with a knee problem—go mountain climbing. This suggestion was problematic in part because Doris wasn’t able to do it, but moreover by reminding her that she wasn’t able to CoCo inadvertently lowered her mood. These suggestions improved as users continued to interact with the system, but Philip suggested that maybe “technology is not the solution”. His friend only improved his health through “a combination of his wife nagging him, and me going around his house on my daily run to pick him up”. Others also found issues with the attention CoCo required, Cecilia finding that CoCo’s frequent notifications and requests for additional context information to be “annoying” and “needy” when she was trying to catch up with friends. Frustrated that she was unable to use her phone to read and respond to CoCo’s notifications during her work shift (she is a swimming pool lifeguard and phones in the pool room are banned), Kat eventually stopped taking part in the trial due to the “irritating” notification system. Ron found the constant "beeping and buzzing, asking what I'm doing, how I'm feeling" quite overwhelming, mentioning that the phone interfered with his day-to-day life; "I'm supposed to be retired, but this made looking after my phone a full-time job". Gina thought the app's recommendations were things she would enjoy, but that it repeatedly suggested things that were not possible at the given time "I can't choose mood lighting or listen to whale noises when the baby is crying" (Figure 33B). Euan (Gina's partner) also indicated that CoCo interfered with major life decisions; "seeing all the disruption that Darlene [their child] causes in a graph was quite startling [...] it made us think twice about a second child". Jason (a teacher) also mentioned CoCo was not able to distinguish between professional and social situations. After a successful parent's evening meeting which CoCo interpreted as a social occasion, the app later suggested that he go for a drink with the student and their parent; "It definitely needs some kind of filter so I can say do not under any circumstances suggest this again".

4.2.7 Alcohol

CoCo made people more aware of their alcohol consumption. Gina became more stressed after seeing the graph stating that "it looks like we spend half our lives pissed while looking after the kids" but later says that "I think we're just normal"; similarly, Cecila said "I don't think I drink more than a typical student". In both cases CoCo had learned that increased alcohol intake had a short-term positive impact on self-reported wellness, and hence suggested alcohol use more frequently. Perhaps unsurprisingly this was not a successful strategy (ultimately Cecilia needed to retake exams after following the app's advice, which she attributed to the increased alcohol use). Encouraged by CoCo, Gina and Euan began to drink to relax after putting their kids to bed, data which when it was presented back to the young parents caused a mild social anxiety. CoCo flagged Kelsie as a problem user of alcohol (Figure 33C) as it confused her working at a bar with social alcohol use, this decreased her confidence in the system; "I'm not sure I trust it now, to be honest". Algorithmic bias was also revealed as an issue after CoCo mistakenly suggested Mark cut down on his drinking; "I looked at the word cloud and noticed the slurred words [...] that's when it hit me, the system thinks I'm drunk because of my speech impediment! It gets worse when

I'm tired, and I've been working late recently" (Figure 34A). While Mark reported that "we had a good laugh about it" he went on to note that "others could be more sensitive, you should be careful about that kind of thing… it could really affect someone's confidence".

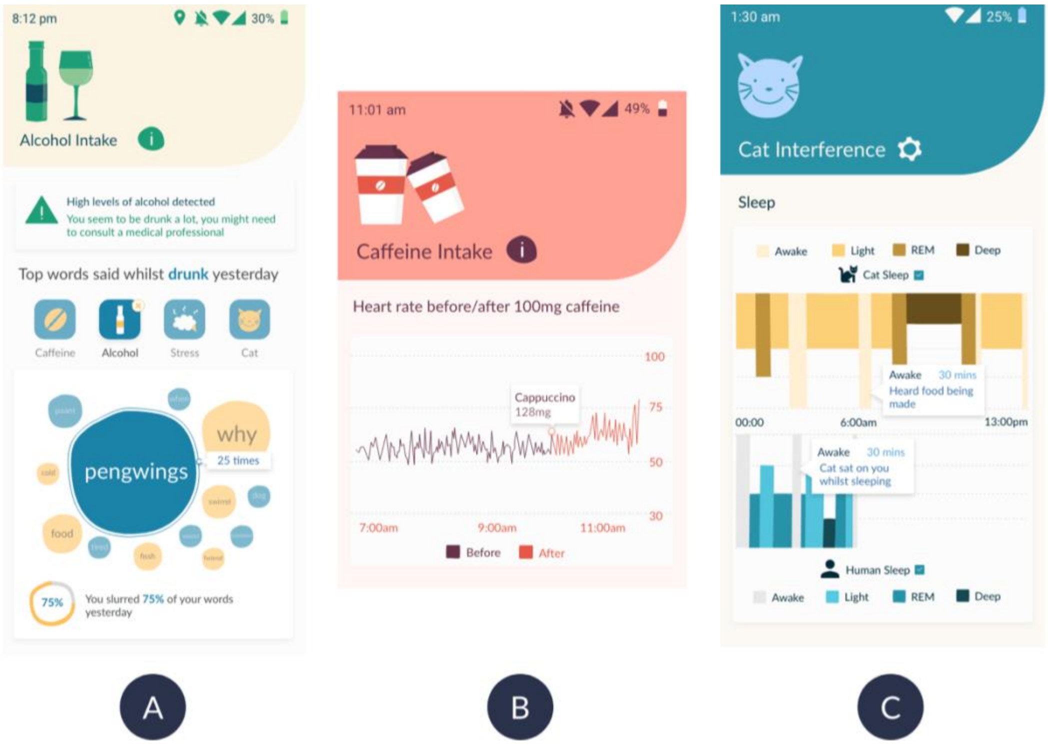


Figure 34 - Screenshots of users visualised health data in the CoCo app

4.2.8 Stress

CoCo was able to correctly identify activities that were causing people stress. For Jason a regular "all staff" meeting was one such cause that, based on calendar data, CoCo suggested he avoid. Adopting CoCo's suggestion meant that Jason ultimately had to explain this to the headteacher, which "increased my stress levels a lot more than attending the staff meeting". Moreover, because CoCo learns according to previous data it is unable to determine why a certain activity, might not be a possibility, Gina said it suggested "doing Darlene's medication after chatting with friends over a glass of wine". The medication which Darlene (Gina's child) is taking is time-sensitive, hence CoCo's suggestion—despite being based on relevant data—is an impossibility. Russel's account highlights "Hard work is necessary sometimes […] I need to feel some pressure in order to take on the challenge of University". However, because CoCo's wellness model is primarily driven by short-term self-reported wellness and the data gathered from the biosensors, it was more likely to encourage Russel to engage in social activities rather than study. Toward the end of the 6-month trial this resulted in a significant net increase in Russel's stress.

4.2.9 Caffeine

CoCo helped Gabriel to see how stressed his caffeine intake was making him (Figure 34B) but this also caused more problems; "the heating bills increased because CoCo kept telling me to turn the heating up […] when I saw the bill my heart sank […] Plus, I wasn't talking to anyone—I'm a social person, so that stressed me out […] And the bloody caffeine withdrawal…I had awful headaches". Whilst CoCo correctly correlated an increased caffeine level to some stress markers, the consequences of Gabriel following its suggestion decision led to new issues which were ultimately more significant. Kat noted that apps encouraging young people to decrease their caffeine intake could cause "a big downturn in footfall for local businesses, some cafés might struggle to survive". Based on this view, Kat ignored the suggestions provided by CoCo to decrease her coffee intake. Philip liked that the app made him think about his coffee consumption, but believes, like the app, that his caffeine consumption is making him stressed. During our interview it transpired that Philip was "trying to teach myself latte art, it's a bit of a hobby. I'm not very good, so, that winds me up as well". Whilst Philip's stress was associated with caffeine, a portion of the stress around the coffee intake was due to trying to learn latte art. However, as it has no data trace, the latte art activity was entirely absent from CoCo's reasoning.

4.2.10 Cats

Both Gabriel and Ron point out learning more about previously hidden behaviours of those around us can have an impact on our lives. Ron liked the sleep charts in CoCo (see Figure 34C) as it supported his own theories to the causes of his health problems, claiming that the cat (Muffin) was waking him up, "Muffin had to go, ten times she's woken me up in the past week". On the other hand, his wife Doris had a different theory "it was actually the TV waking him up. Every single day he'd refuse to go to bed saying he's not tired and then he falls asleep. Muffin likes to sit on him when he's sleeping in the chair". Based on Ron's (likely incorrect) conclusion about the cat, Muffin was rehomed. Gabriel also put his cat (Pickle) up for adoption after seeing that interactions with the cat increased his heart rate. With a recent hypertension diagnosis, Gabriel concluded that Pickle's presence was too much of a risk. The long-term data showed that Pickle's departure represented a significant decrease in Gabriel's wellness, and with the cat out of the equation, CoCo then began to cite coffee intake and house temperature as potential causes. "I really miss Pickle, that's my biggest regret about using the app [...] Imagine, if everyone used it, there'd be a pandemic of stray cats!".

4.2.11 Confidentiality

In order to even have a chance of working CoCo needs access to lots of data, often that data implicates 3rd parties in an unanticipated or hard to predict way. Mark had to stop using the app as "it suddenly started referring to a project that's currently under an NDA [non-disclosure agreement] [...] I can only imagine it picked up on that via the audio? Not cool, so I stopped using it immediately". These kinds of findings bring up questions to how the app warns users of the implications of using the app and whether the responsibility to solving these issues is on the user, the company, or the user's friends/client. Mohammed expressed similar concerns with the amount of data gathered, he felt that the app was trying to "control all my decisions" and that he didn't "feel comfortable giving it the power to change and dictate my life". The increasing ubiquity of sensing devices also presents causes for concern; Kat mentioned that "the pool is supposed to be a private space, even though it's shared physically phones are banned because people were worried about cameras and recording and stuff [...] I'm not sure what the rule would be with biosensors though, can they detect other people nearby?".

4.2.12 Conclusion

This paper discusses preliminary findings of a novel system which combines state of the art biosensors with machine learning to provide users with timely, context-relevant notifications intended to increase wellness. Whilst we can report that our system certainly has the potential to encourage positive behaviours, we are duty bound to report on the more problematic aspects of the system. CoCo was extremely effective at identifying causal relationships between specific activities and relative wellness, this did not represent a meaningful handling of context. The user study highlights the difficulty of distinguishing hedonistic (and enjoyable) behaviour from long-term positive behaviours. The attempt to implement context-awareness repeatedly failed to predict that changes in the understood part of the system (e.g., proposing a reduced caffeine intake) could have an impact on the non-understood part of the system (e.g., Gabriel's increased heating bill); this results in a form of context-awareness which is very naïve. Whilst every attempt was made to reduce algorithmic bias it arose in even the most unexpected places (e.g., interpreting Mark's speech impediment and late nights at work as an alcohol problem). Although CoCo encouraged exercise, this applied mostly to users who already exercised frequently and in the case of Doris, by suggesting a mountain climb, CoCo actually introduced a new barrier to wellness. In most cases, users followed their intuition and ignored CoCo's suggestions when they were nonsensical or dangerous (e.g., Gina ignored the suggestion to not give her baby its medication at the right time). However, in the case of Pickle and Muffin, the owners were convinced that the feline presence was causing them harm and the cats were rehomed. Whilst about cats and not humans, this supports similar findings to Tolmie et al., (2016) who point out the 'invasive step' of data with relationships.

While our context model utilises an unprecedented amount of data and biosensors and builds per-user models based on those data, clearly the approach is limited. While sophisticated the model is only ever aware of the datapoints and attributes which it is aware of. The reality of a human sense of context was significantly more sophisticated than our design assumptions. The aspiration of CoCo is to improve the wellness of users using data and wearable technology. Our study suggests that encouraging behaviour change based on data-driven models is possible, but that determining whether the behaviour change is positive reliably is an unsolved problem, which, in order to solve, we must involve users throughout the design process.

4.2.13 Discussion

Up until this point, and notwithstanding its viability, CoCo is a speculation. This paper is an example of Design Fiction as World Building (Coulton *et al.*, 2017) presented in the form of a fictional paper (Lindley and Coulton, 2015; Lindley *et al.*, 2020c; Akmal and Coulton, 2020). The aspiration for the paper is to provide enough detail for the speculation to appear plausible enough to engender a 'suspension of disbelief'. Whilst the logic of fictional papers is discussed elsewhere (Lindley and Coulton, 2016), it is important to discuss the significance of this specific paper, what its original contributions are, and how it represents a valid—but intentionally experimental—contribution to the (alt) HCI discourse.

The paper aims to contribute to a series of contemporary HCI concerns[7]. These include the potential applications of machine learning (Yang *et al.*, 2018); guidelines for implementing responsible, ethical and transparent AI systems (Jobin *et al.*, 2019; Larus *et al.*, 2018); and the emergence of Human-Data Interaction as a sub-discipline of HCI. Alongside the explosion of applications of AI (which, more often than not refers to variants of Machine Learning), recent years have seen a proliferation of frameworks, guidelines, and manifestos intended to support, encourage, or underpin ethical, transparent, and responsible system development (Bates *et al.*, 2019; ACM, n.d.; Jirotka *et al.*, 2017; ACM, 2017). While such initiatives are worthy and valuable endeavours until applied to specific applications or contexts, they remain abstract and are of limited use. Conversely, once systems are implemented, it is often too late to substantively change their design—an issue which is particularly salient in industry contexts where a minimum viable product may underpin a company's financial viability. To this end, we advocate for design-inspired research—in this case a Design Fiction/fictional paper—as a viable means to test proposed systems designs against guidelines and frameworks. For example, researchers may use fictional papers such as

[7] Notably, although they are overlapping concerns, we deliberately do *not* attempt to engage with the privacy and trust risks associated with such a system, this is a deliberate decision in order to maintain the central focus of the paper.

this one in order to check whether a proposed implementation would meet proposed design guidelines (Amershi *et al.*, 2019).

As it sits within a relatively small niche, we would like to draw attention to the paper's methodological contribution. Originally proposed as part of Design Fiction's maturation within the HCI community, fictional papers (a relative of Imaginary Abstracts (Blythe, 2014)) write up research which never actually happened. To date there are a handful of examples of fictional papers in the HCI canon, some of these are situated far into the future and are more irreverent (Kirman *et al.*, 2013), whilst others are more 'realistic' (so much so that they may even appear to be deceptive (Coulton *et al.*, 2016)). By providing an additional example to the body of published realistic fictional papers, we hope that this work will help contribute to the further maturation of the approach.

Lastly, looking back at first and second generation health sensors such as Fitbit Sense (So, 2020) and Withings ScanWatch (Gibbs, 2020) we can see how much the integrated context-aware capabilities of CoCo enable intelligent and timely interventions to improve wellness. The findings of this (fictional) study also show the need for greater context-awareness in systems seeking to shape behaviours relating to health but also show that this must be combined with facilities to maximise user autonomy and to support users in making informed decisions based on the transparent processing of their data. Whilst in computing, modelling context often comes down to measurable features such as location, time, activity (Dourish, 2004) etc., there are many uncertainties in human behaviour (Duhamel, 2014) which make it difficult to predetermine many situations in a computational system. Sociologists have considered how our actions (Suchman, 1987) and knowledge (Haraway, 1988) changes given a situation to help us understand something. We put to readers what is context? Perhaps the unintended consequences experienced by users in this study could have been addressed with better modelling of contextual factors and the intentions behind the actions users took. Conversely, perhaps the aspiration to fully model context is ill-advised, unattainable "Heffalump Trap" (Lindley *et al.*, 2019a). We suspect that the reality lies somewhere in between these extremes, and that attempts to model context may yield many benefits and come hand-in-hand with limitations. As such, we advocate for the use of future-focused and speculative research methods to concretise and explore the realities of these HCI challenges before such systems are implemented.

4.3 The world building process of CoCo

To produce the fictional paper presented in 4.2, a world building process was required to fully explore what it meant to understand context from a system's perspective. This process is presented in this section, outlining the steps taken to develop the world of CoCo and present the artefacts and development of this world through a fictional paper.

This includes influences from literature and self-exploration which helped to develop the CoCo app (section 4.3.1). These insights led to an expansion of the world of CoCo, these artefacts were presented at an IEEE VIS workshop (section 4.3.2). Collating these artefacts helped to develop user narratives which were essential for presenting a coherent story and argument throughout the fictional paper (section 4.3.4). This section shows how Research through Design helped to produce insights to the research questions and influence the directions taken in this thesis. Following this, the developed insights linked to the research questions will be outlined (section 4.4).

4.3.1 Developing the CoCo application

4.3.1.1 Understanding context from a system perspective

To understand how future sensing and tracking capabilities might add more contextualised information, I began to develop the world of CoCo by exploring various general wellness apps (activity & wellbeing tracking) by searching popular apps on Google's Play Store[8]. I also used a few different popular devices (FitBit

[8] Clear Fear, Daylio, Fabulous, FitBit, Forest, Headspace, Instant, Plant Nanny, Sleep Town, Super Better, Tide, Water Reminder, Withings

Charge 4 for activity levels, FitBit Aria scales for weight management and a Withings sleep mat for sleep quality) as shown in Figure 35A. This helped me to understand how contextualised information could be included through a system perspective and the challenges which might arise from these features (Figure 35B). For example, sometimes self-tracking systems gave reasons why behaviours were occurring e.g., getting to bed later usually leads to less deep sleep. However, this might have produced generic advice highlighting biases within the system design i.e., a suggestion like 'do 10 sit ups' is not possible for some people and reinforces ableist language. Therefore, the CoCo application included more personalised suggestions to explore how people interacted with less generic advice (Figure 35D). Additionally, it was not clear how decisions for 'good' behaviours were made i.e., no links provided to information sources, and it was unclear what was considered a flight of stairs or what counted as an activity. Therefore, buttons to find out information or learn more were added to the app. This helped to provide a sense that people could understand more about these sensors and potentially how decisions were made about what counted as being caffeinated, stressed etc.

At times current self-tracking applications also seemed to contradict health and wellbeing values. Manually logging food consumption only allowed people to select branded jars with higher salt intake, making it more complex to add food made from scratch. Equally, there were limitations to what could be logged e.g. certain sized cups or ability to log certain drinks like tea but not coffee. As a result, people might change their behaviours or habits to use the system rather than the application supporting their lifestyle. To explore more personalised or contextualised self-tracking systems, editing buttons were added so people could edit or correct the system. Additionally, the use of technology like ML would mean some features in future self-tracking systems would be automatic rather than manual, raising different questions about how context is captured in self-tracking systems.

I also tried manually tracking different behaviours not possible through current apps. This was to explore how different contextualised information might be mapped into self-tracking representations, following Lupi and Posavec's book 'Observe, Collect, Draw!' (2018). Figure 35C shows some examples of the visualisations made around my habits in the month of May 2020 including animals I saw during the week (at home and on walks) and different smells (food and nature etc) during the week. This helped me understand different ways visualisations might be included in self-tracking systems. This was explored in the CoCo application through alternative ways to explore qualitative information (Figure 35D). The following section explains how this process also helped to create an overall brand for CoCo, increasing the plausibility of this app.

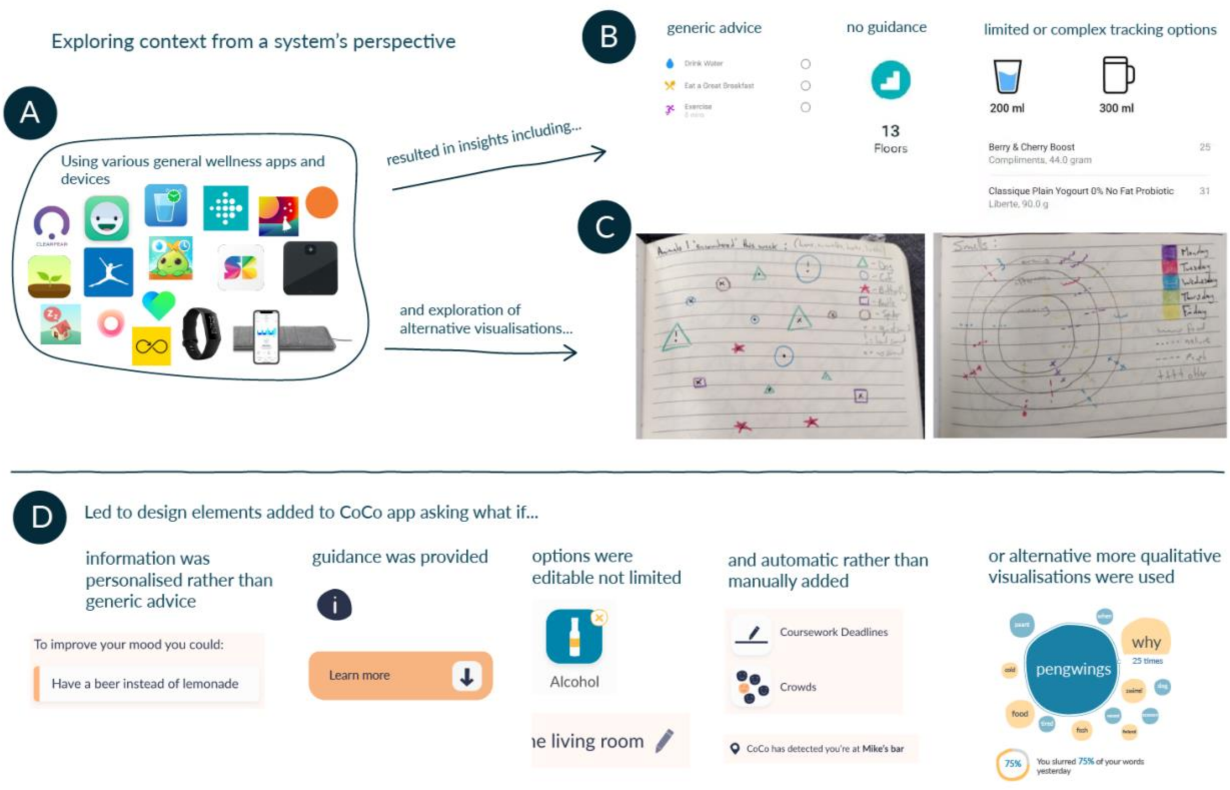


Figure 35 - Apps and Devices explored to understand how contextualised information is used in current self-tracking systems influencing elements of the CoCo app design. Generic advice: https://images.app.goo.gl/JgizfToYYArh7eoF6 No guidance: https://images.app.goo.gl/MibwyMHonvFpydZD8 Limited or complex tracking options: https://images.app.goo.gl/KZs4g8yaxLdKkguZ9 & https://images.app.goo.gl/Wr81VtmEiL1m65WM9

4.3.1.2 Brand Identity

As well as developing features based on elements present or non-existent in self-tracking apps, the visual style of CoCo was also influenced from self-tracking apps. To help add to the plausibility of the created artefacts, a company logo for CoCo was created and colour scheme chosen to establish an identity for the fictional organisation. A cartoon smiling face with a sweat drop (indicating someone exercising) was chosen as a logo symbolising 'well' and 'happy' individuals. The app style and colour scheme used was inspired by existing general wellness apps and features outlined in section 4.3.1.1. For example, IoT integrations such as Phillip's Hue linked to mood lighting replicated features from that app (Figure 36A). Graphs and charts created followed a similar style to those found in the Withings app and FitBit (Figure 36C&D). The pastels and graphic style chosen reflected current design trends in wellness apps at the time like Headspace (Figure 36B). This style could be replicated across all artefacts for consistency and give the illusion that this could be an existing tracking application.

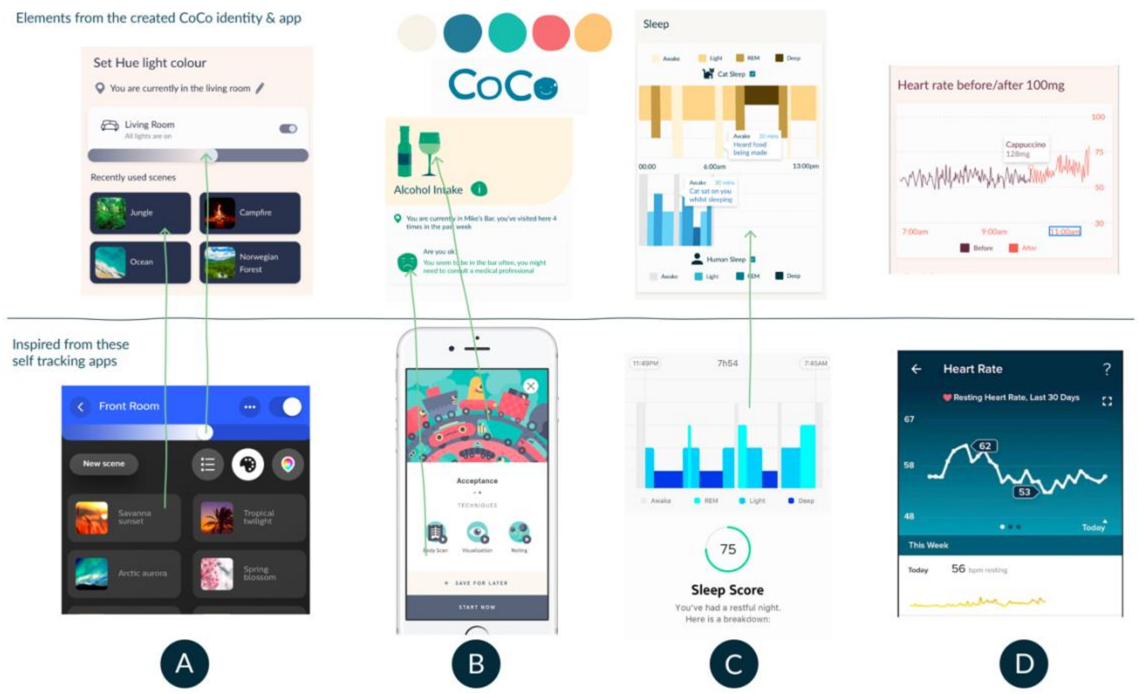


Figure 36 – Self-tracking app influences to help create CoCo. Image sources from left to right:
A – Phillips Hue App source: https://www.macstories.net/reviews/philips-hue-app-update-enhances-light-management-and-adds-30-new-designer-scenes/. B - Headspace App source: https://www.prevention.com/health/sleep-energy/g24736063/best-health-apps/. C - Withings App source: https://www.amazon.co.uk/Withings-Sleep-Sensing-Home-Automation/dp/B078Z1B34S. D – FitBit App source: https://9to5google.com/2022/07/21/fitbit-chart-redesign/

4.3.1.3 Sensors chosen for the CoCo application

The sensor features represented in CoCo reflect plausible advances in the self-tracking space. The features are based on a systems approach to including contextualised information. This is through using system capabilities from new sensor advancements to infer a person's context in a given state i.e., drunk, caffeinated or stressed. Additionally, exploring the shift towards more social features included in self-tracking applications i.e., comparing data with other users, the cat interference feature showed a potential way this relationship might be shown in future systems. The reasons for choosing each of these features for the CoCo application are discussed below. To see the developed CoCo app with an overview of each of these sensors please view the link in the footnote[9].

4.3.1.3.1 Caffeine

Water and other self-tracking apps are already allowing users to manually input their liquid intake (LIQUID, n.d.; waterllama, n.d.). Given that coffee is included in these logging practices but less prominent than water intake, even though it can be seen to link to our health and wellbeing (Harvard University, 2020) it was important to explore reactions to this being a main part of a self-tracking app. System capabilities only allow people to manually log their liquid intake in current self-tracking apps. Equally, with academic publications trying to monitor drug intake from sweat (Tai *et al.*, 2018), whether someone is caffeinated could be sensed in this way in more context-aware systems (Figure 36D).

4.3.1.3.2 Alcohol

Physiological links to alcoholism such as a change in walking and speech patterns allowed for more 'qualitative' aspects of the app to be explored through the quantified lens that a system perspective would take. This can be seen in the context of changes in gait to determine conditions like Parkinson's disease (Tucker *et al.*, 2015). Similar techniques could be applied to alcohol behaviours. Equally, in a similar way to the caffeine aspect of CoCo, tracking alcohol already has dedicated apps (drinkaware, n.d.; DrinkControl, n.d.). However, these apps again require manually logging of alcohol intake that could then be compared with other users in the app. Additionally, even if vapourware, alcohol sensors are marketed by different companies (ION, n.d.). Given that alcohol intake forms part of the NHS guidance on

[9] Walkthrough CoCo application: https://youtu.be/N46GwqrEqso

what it means to live well (NHS, n.d.), it seems to be an aspect missing from current self-tracking apps. The CoCo app included guidance by providing alerts when the system believes there is excessive use (Figure 36B).

4.3.1.3.3 Stress

Stress was one of the sensors that was closest to becoming a reality. As described in Chapter 2, there is a shift in personal informatics literature to analysing our psychological behaviours as well as physiological behaviours. There are many examples of people trying to measure stress (Plarre *et al.*, 2011; Swendeman *et al.*, 2018; Lee *et al.*, 2019; Gyrard and Sheth, 2020). These have also been noted in applications of other wearable technologies such as hearables (Crum, 2019). This can be seen through the release of commercial apps as well such as the FitBit Sense (Fitbit, 2022) a few months after the CoCo fictional paper which tracks stress levels. This gave the app a further level of plausibility making it seem that it could exist by grounding it in a very near reality. Also, given the shift noticed in the literature towards including psychological elements alongside the existing physiological features it was important to reflect this in a future context-aware application. Linking in IoT capabilities (Figure 36C) here helped to provoke discussion around third-party applications and data sharing.

4.3.1.3.4 Cat interference

Adding in the cat interference (Figure 36C) began to reflect beyond human-centric data points linked with more-than-human theory about complexity in IoT networks, discussed in the literature review (Chapter 2). For example, Tolmie et al's (2016) work points out the 'invasive step' of data within relationships, revealing behaviours that were previously hidden including the activities of cats wrapped up in this data. Therefore, acknowledging that sensor data gathered has the potential to impact not just ourselves but those around us as well. This helped to create narratives about our relationships with those around us and provoke conversation about how these dynamics are displayed within system design.

4.3.2 Visualisations for IEEE Workshop

Following the creation of the CoCo application, the world of CoCo was expanded for an IEEE workshop which aimed to explore visualisations from the future through design fiction methods. For the workshop I could create a few design fiction entry points to a fictional world (an early version of an app, a dashboard and tweets (Figure 37 & Figure 38) showing a general user interface for a backend system. This might be used by employees to analyse collective user metrics. The purpose was to explore third-party access for non-medical purposes, in this case television and film streaming provider Netflix. This exploration influenced the IoT integrated features presented in the stress section of the CoCo app. The focus on metrics started to explore how a system perspective of health and wellbeing could impact those interacting with this content. For example, if used for targeting content, these metrics could be used to alter people's behaviour i.e., the recommended for renewal section uses CoCo data to understand the most addictive content based on people not moving. This might then influence decision making about whether a show's contract is renewed. Equally it could be used for improved usability i.e., where users clicked in certain 'states' which might change how they navigate a website when drunk. Systems could use this data to enlarge certain features when drunk to make it easier to interact with. Elements such as navigating when drunk helped influence some features of the CoCo application such as the percentage of words slurred visualisation (Figure 34 of the fictional paper).

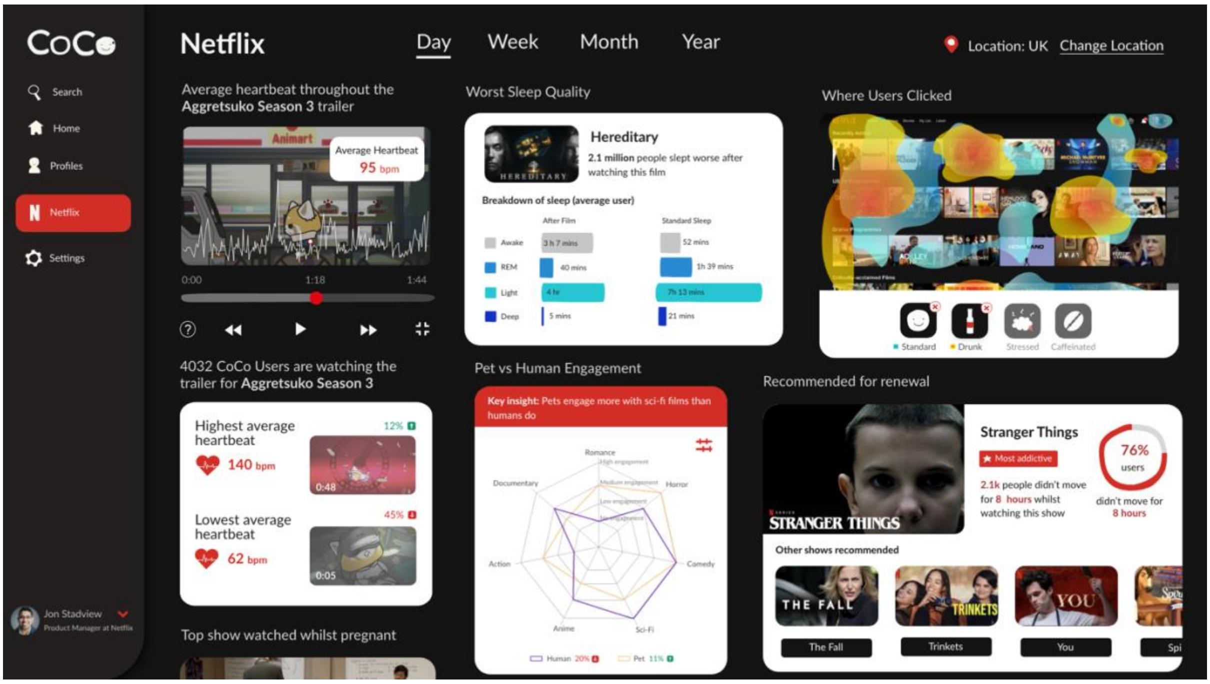


Figure 37 - CoCo Employee Dashboard Netflix version showing metrics of CoCo users linked to a third party application. The dashboard was created in Adobe XD with any pictures of real people taken from the plugin UI faces, all names given were fictional. Any other pictures of various shows were taken from Google images.

Figure 38 shows fictional tweets that respond to the fictional dashboard seen in Figure 37. These tweets show two different reactions to the leaked dashboard which was leaked via a news article shown in section 4.3.3.1. This dashboard reveals how health data is used for other purposes. One being the context-aware implications of adding emoticon reactions based on sensor data i.e., the stressed reaction in Facebook comments. Equally it could be how popups for premium subscriptions were offered only when the user was drunk, taking advantage of a user's state for monetary gains. These considerations all helped to map out considerations for the final elements included in the CoCo application.

The tweets read "We're all so stressed #netflixandspill had to happen before we realised the stress button only appears when stressed…" and "Now I know why I got a popup for account upgrade at 2am! Drunk me just wanted to be a good cat mother (cat emoji)".

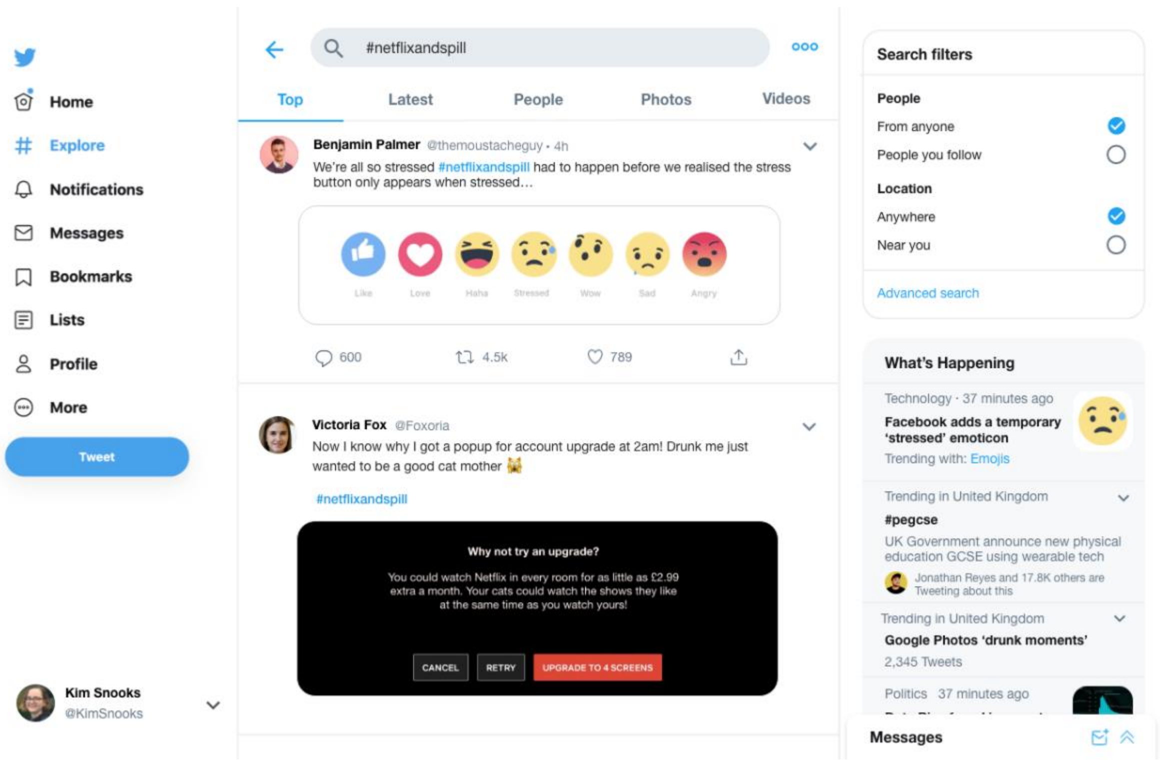


Figure 38 - Fictional tweets made reacting to leaked dashboard

These tweets also show CoCo's response to this leak, highlighting multiple perspectives on the incident as well as additional contexts where this data might have been sold to third parties.

The tweets read: CoCo "Our data is used only for user activity analysis and precision marketing. Users are able to opt out of collection under their profile settings". The Verge "Netflix and spill: Leaked dashboard shows how your health data is used by third parties". Nick Grand "want to know what my heart rate was like during the finale of Dark Season 8. I'm still scared #netflixandspill". Sara Mendoza "I've noticed @Spotify limiting my volume options and making buttons bigger during a night out…could be related? (thinking face emoji)"

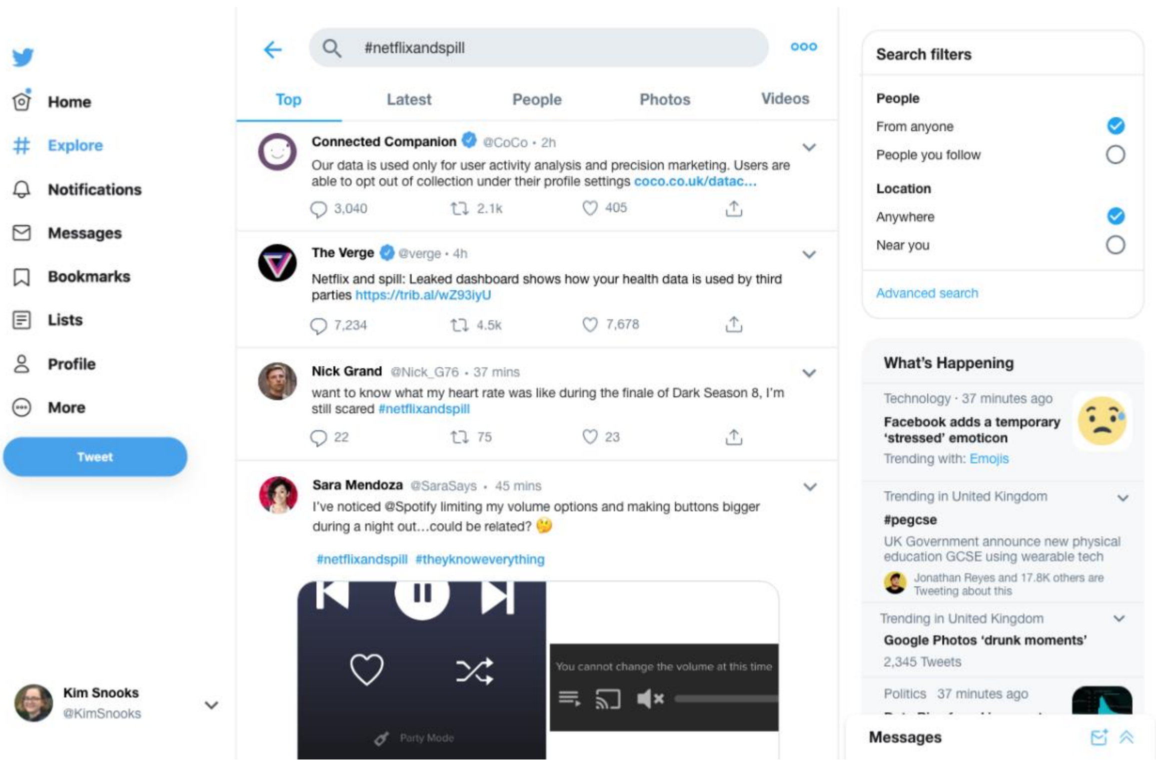


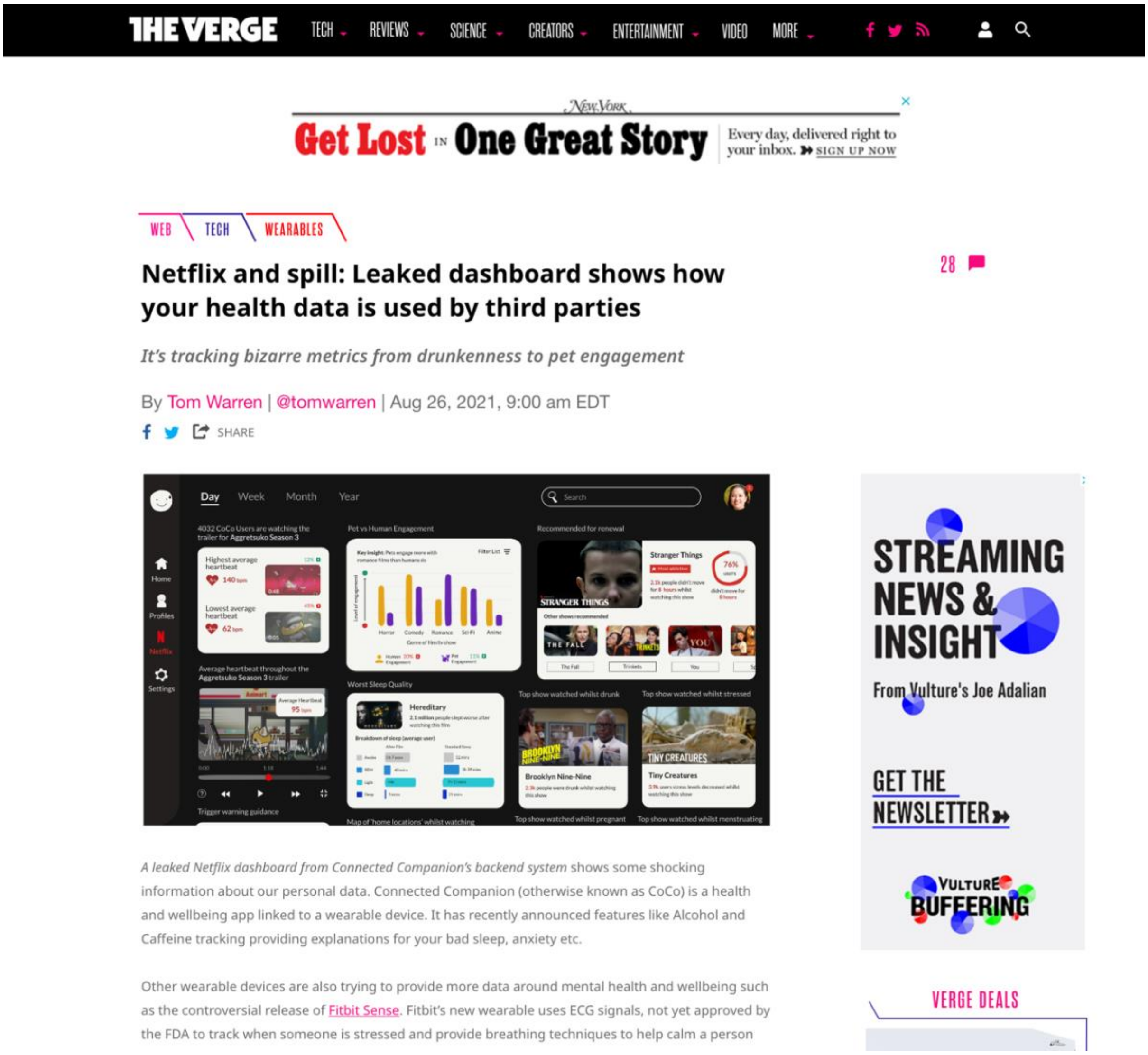
Figure 39 – Additional fictional tweets showing reactions to the leaked CoCo dashboard.

4.3.3 Additional influences for the world of CoCo

4.3.3.1 Fictional articles

While not submitted anywhere, fictional article created are included here as they helped to develop other artefacts in the world (e.g., tweets) as well as produce one of the narratives used in the final fictional paper.

Figure 40 shows the article exposing the dashboard CoCo used to share health data with third parties. The article explains what the dashboard is tracking including drunkenness to pet engagement in various tv shows and films, revealing that health data can be used for multiple reasons. This article was created to help create a narrative around the leaked dashboard. This article formed the entry point that allowed me to explore multiple perspectives on this news scandal and explore themes around self-tracking systems where more contextualised information is added.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Netflix and spill: Leaked dashboard shows how your health data is used by third parties

28

It's tracking bizarre metrics from drunkenness to pet engagement

By Tom Warren | @tomwarren | Aug 26, 2021, 9:00 am EDT

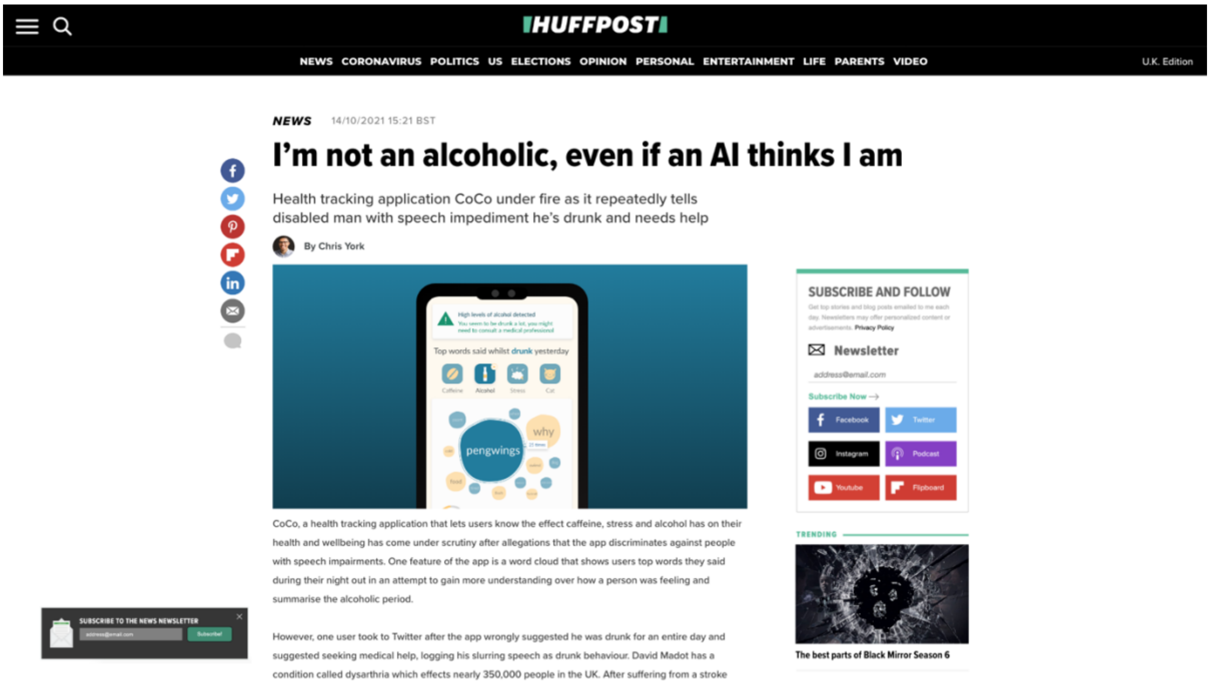
SHARE

A leaked Netflix dashboard from Connected Companion's backend system shows some shocking information about our personal data. Connected Companion (otherwise known as CoCo) is a health and wellbeing app linked to a wearable device. It has recently announced features like Alcohol and Caffeine tracking providing explanations for your bad sleep, anxiety etc.

Other wearable devices are also trying to provide more data around mental health and wellbeing such as the controversial release of Fitbit Sense. Fitbit's new wearable uses ECG signals, not yet approved by the FDA to track when someone is stressed and provide breathing techniques to help calm a person

Figure 40 - Fictional article showing reactions to a leaked dashboard from Coco's backend system

Figure 41 shows one article which features one of CoCo's app screens and detailing how a fictional user, David, interacted with the app and found a particular problem with using speech patterns to infer context. The article explains how the app assumed that David was drunk based on a percentage of words slurred throughout the previous day, suggesting David should seek medical attention. However, this was an incorrect assumption, as the slurred words are an everyday occurrence for David who has a speech disorder. This meant the insights were not only meaningless but also a reminder of David's condition and an implication that this behaviour was something that needed to be 'fixed' to help him be 'well'. This shows a potential implication of using 'contextualised' insights to assume a person's behaviour. It also highlights how limited measurable data which lacks needed contextual information can impact on people's lives.



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I'm not an alcoholic, even if an AI thinks I am

Health tracking application CoCo under fire as it repeatedly tells disabled man with speech impediment he's drunk and needs help

By Chris York

CoCo, a health tracking application that lets users know the effect caffeine, stress and alcohol has on their health and wellbeing has come under scrutiny after allegations that the app discriminates against people with speech impairments. One feature of the app is a word cloud that shows users top words they said during their night out in an attempt to gain more understanding over how a person was feeling and summarise the alcoholic period.

However, one user took to Twitter after the app wrongly suggested he was drunk for an entire day and suggested seeking medical help, logging his slurring speech as drunk behaviour. David Madot has a condition called dysarthria which effects nearly 350,000 people in the UK. After suffering from a stroke

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Figure 41 - Article about CoCo user implying he was drunk but actually has a speech condition

4.3.4 Collating artefacts and creating the fictional paper

Creating the fictional paper involved collating the artefacts discussed in the previous section to develop a coherent narrative for the paper. This also meant creating fictional narratives to explain different user experiences with the CoCo application, explained here in section 4.3.4.1. To make these narratives coherent, this also resulted in the creation of some new artefacts and further expansion of the world. For example, a fictional trailer (section 4.3.4.2) which was used to summarise and tease the contents of the paper.

4.3.4.1 Fictional narratives

The fictional narratives were central to the themes presented as part of the fictional user study included in the fictional paper. These were developed few a few steps; collating ideas from literature and the exploration explained in section 4.3.1.1, creating quotes, assigning these quotes to themes presented in the fictional paper. All quotes developed for the thesis can be found in Appendix A, A.2.

4.3.4.1.1 Creating quotes from ideas in literature

First a range of participants were created to reflecting a diverse range of backgrounds and perspectives including varied occupations, families versus individuals etc. Each participant was given a scenario and then quotes were created based on these scenarios. Some of these scenarios were expanding on the pre-existing artefacts created as part of the world building. For example, the character Mark Green, a software engineer, experienced algorithmic bias in the CoCo application due to his speech impediment. This was a pre-existing narrative that formed part of the worldbuilding of an article as explained in section 4.3.3.1. This resulted in creating a scenario based on this pre-existing narrative:

Mark has a speech impediment, in its decision-making BLOOM determined that Mark was drunk based on a few factors including time and detecting slurring as drunk related behaviour. However, this was just Mark working late and slurring his word due to his condition.

This scenario influenced the creation of quotes for his character which were also based on ideas presented in literature. For example, the problematic issues with designing for everyone as explained by Spiel et al., (2018) as well as including design ignoring certain conditions (Eikey and Reddy, 2017) which could impact on someone's mood.

> *"I didn't notice it at first but I've been working late the past couple of weeks, getting ready for the new website launch and I started getting notifications about alcohol problems. Initially I ignored it thinking it was just a glitch but they kept appearing. I looked at the word cloud and noticed the slurred words and that's when it hit me, the system thinks I'm drunk because of my speech impediment! I thought the system would have taken this into account but clearly not, it didn't bother me too much but that could really affect someone."*

Where pre-existing narratives were not present it meant that scenarios could be created based solely on mishaps present in literature. For example, two characters Gina and Euan's quote related to the problems with revealing information about another person. This included the tensions with comparing the bodies of family members (Pina *et al.*, 2017), as well as the impact revealing information can have on major life decisions (Tolmie *et al.*, 2016) . This also includes the feelings surrounding this i.e., making sure an infant is ok (Wang *et al.*, 2017).

> *"So much better than Fitbit, stopped using that thing after it compared me and my wife's stats even though I only wear it for runs, I could never compete! At least with this I have a chance of improving my health with simple things, I'm definitely going to use this more. FitBit was just about raw numbers, and Gina always had twice as much. But CoCo links the benefits to the activity, so I can see because of running I'm destressing significantly. On the other hand, I think it might have made Gina think twice about having another baby, seeing all the disruption that Darlene causes in a graph was quite startling."*

4.3.4.1.2 Fictional data analysis versus real data analysis

Analysing these developed quotes, emerging themes were found and then quotes that best described these themes were chosen to represent the final themes included in the fictional paper. Creating themes from fictional quotes results in a different approach from analysis real data approaches such as thematic analysis. Themes could only emerge from our own experiences using self-tracking systems and the literature read so could be limited in comparison to obtaining quotes from actual data and standard research approaches. However, creating quotes was essential to give the impression of multiple opinions around the contextualised metrics. This approach was needed because potential problematic elements with these systems could be explored without harming any actual people.

4.3.4.2 Fictional trailer

To present the fictional paper at Alt.CHI, a fictional trailer was made to tease the contents of the paper. This also helped to explain the concept of a fictional paper and design fiction for those not familiar with it. It also acted as an artefact as part of the fictional world, with the animation style matching the contents of the app. To watch the full trailer please view the link in the footnote[10], the contents of the trailer will be explained here.

Figure 42B shows a scene from the final trailer following one of the users of the fictional paper, Gabriel and his cat Pickle[11]. First the concept of CoCo is explained, following the same app screens shown in the fictional paper (a notification indicating a spike in caffeine levels and suggested activities to do in this state as well as associated metrics) as well as outlining the other sensor applications offered by the application. Then Gabriel is introduced, explaining to people that he downloaded the app to manage stress levels after a hypertension diagnosis. It is explained that he is an author and so spent a lot of his time writing. After the app suggested he was most stressed writing in the coffee shop, he followed advice to work from home. However, using additional app features i.e., IoT integration which increased heating to lower stress levels, resulted in higher energy bills and headaches from caffeine withdrawals. While working from home meant more time with his cat, the app made him aware of increases to his heart rate when Pickle brought uninvited guests (dead rodents) into the home. As a result, Gabriel puts Pickle up for adoption worrying about his own health. The trailer ends with Gabriel sweating, crying and with headaches leaving him "free to work on his book all thanks to CoCo". This satirical end scene is supposed to make it clear to anyone at this point that this is not a real working system but in fact a work of fiction.

[10] CoCo Fictional Trailer: https://youtu.be/VIW_P-zNfTQ

[11] To note, this is a fictional cat Pickle and an entirely different cat to real life Pickle discussed in later chapters!

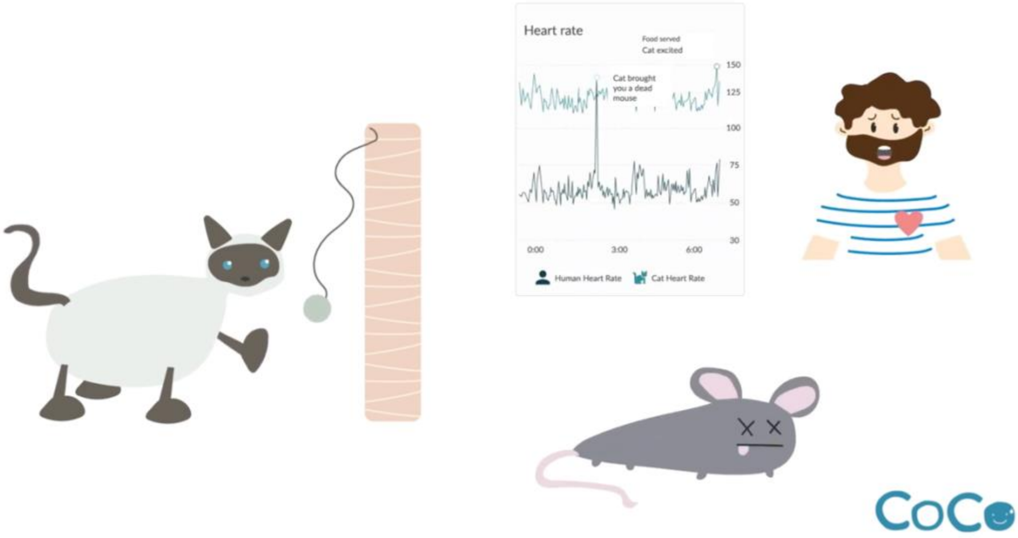

Figure 42 - Still from fictional trailer showing how Gabriel's cat Pickle increased his heart rate by bringing in unwanted guests. The trailer frames were made in Adobe Illustrator and then animated using Adobe After Effects.

4.4 Reflecting on CoCo

4.4.1 Personal insights from the fictional world

Exploring the fictional world through a fictional paper allowed the speculation of multiple different user experiences including associated challenges with using a system perspective for including context in self-tracking devices. This was beneficial in some instances, for example, personalised notifications increasing an individual's motivation to take care of their own health and wellbeing. Such as a doctor, Philip, who used the stress notifications to remind himself to relax by going for a run. However, we could also see the many dangers of using these systems, many relating to the complexities of context-aware computing such as CoCo mistaking one user for being constantly drunk when she actually works in a bar. Throughout there seemed to be a running theme that arose from this project: contextualised data can have social consequences when capturing information about our lives.

The fictional paper showed individuals' inability to act on recommendations given by CoCo because of misinterpreted context which resulted in inappropriate suggestions. However, this came down to problems with using a system perspective to consider or judge social situations and relationships. For example, a mother might be stressed because her baby is crying but dealing with the baby crying is a priority over the temporary increase in stress levels. This was not considered by the fictional app which just suggested using the integrated IoT features to put on whale noises to calm the mother. This links in with incorrect decision making, as the fictional app can only make suggestions on the data it has which might completely miss why someone behaves or does something in the way that they do. While for the most part people can logically follow their instincts around suggestions, if the app confirms incorrect beliefs because of a lack of context (which is a consequence of poor data quality as the data is incomplete altering the validity and accuracy of the data), it could have social consequences. For example, Ron putting his cat Muffin up for adoption believing Muffin was the cause for his bad sleep when it was actually the TV waking him up.

This also caused conflicts for several other fictional users, highlighting the difference between recommended actions from the app versus social expectations. For businesses who rely on people's routine visits to a coffee shop, collective behaviour advice to cut down on coffee could result in a decrease in business sales. For small independent shops this could be disastrous. At a smaller scale, CoCo gained an understanding of activities people like to do from user inputs, meaning there was a level of subjectivity about what puts someone in a good mood. This could have problematic long-term gains, even if the short-term gains were beneficial. For example, socialising put one of the students in a good mood but excessive socialising for a student could lead to a decrease in grades and decreased wellness i.e., increase in stress because of procrastination. The app's handling of context only considered if you do X then Y will improve which was considered a successful way to determine wellness, highlighting the complexities with designing context-aware self-tracking systems. Equally, this meant that suggested actions could result in unintended behaviour change by not providing guidelines for how often behaviours could be suggested or when they could turn problematic i.e., suggesting a wine late at night to decrease stress but not limiting how many times this could be suggested.

Additionally, social structures did not form part of the context considerations such as turning up to meetings a requirement of employment, even if these meetings did increase stress levels. Requiring access to several features also conflicted with determining context for some users because calendar access could be inaccessible due to company protocols. Audio data should not have been used in certain situations because of conflicts with NDA agreements. The design fiction insights from this project helped shape research directions and influence future projects developed. The design fiction insights produced, shifted the focus towards understanding of data not just about ourselves but other people and the world around us.

4.4.2 External insights from the fictional world

The peer review process came from submitting the fictional paper to a conference, helping to learn about the context-aware and self-tracking area from experts' opinions about the paper. This proved to be useful for a few different reasons, even when people did not understand it was fictional. In these instances, the paper was valued in a similar way to a traditional paper. One reviewer discussed how there needs to be more literature, data analysis and "numerical data" to help support "reliability" and "analysis". Another called for more explanation about how non-existent processes actually worked i.e., "how does the ML algorithm work?". These were not possible to include in the paper, as providing more details of non-existent systems through creating graphs and equations etc. would have broken the suspension of disbelief. Especially given my lack of maths skills which would most likely result in technically minded reviewers dismissing the paper as something that does not 'work'. Additionally, too much focus on technical elements would have shifted the focus away from interactional experiences with contextualised tracking data making it less useful for designers.

However, the technical focus did allow us to see what ethical concerns were considered by experts such as questions arising about data privacy issues around taking 'sensitive information' from users. This shows how this design fiction method could be used to highlight ethical considerations that were not thought about, helping to include alternative perspectives within the discussion. This was also seen through other entry points we could have included such as one reviewer discussing whether there's an 'admin page' to control different sensors and including discussion around transitioning between 'context states' with machine learning. These were things I was not familiar with from my own design perspective showing how different viewpoints could help adapt the fictional world.

For those that did understand the fictional style of this paper, they had good knowledge of the domain area. Links to theory helped highlight problem spaces I was not familiar with or aware of which helped to build my understanding of the field and influence directions taken in this research. The best example of this being a reviewer suggesting Paruthi et al's paper (2018) to consider a different view of what context is and show the "mismatch between technologist's understanding of context v. the general understanding". This mismatch is explained in the paper as a positivist view (technical understanding that predetermines specific attributes to determine context) and a phenomenological view (which acknowledges that context shapes actions and is therefore interactional) following Dourish's earlier approach that context is dynamic rather than static (2004). The paper aims to bridge the gap between the two highlighting how context-aware systems need to consider a combination of multiple contextual factors "weather, social factors, affect, time, other activities" that can dynamically change depending on the actions of an individual but can also change dependent on social factors "preferences, priorities" (Paruthi *et al.*, 2018, p. 10). Systems need to consider the importance of context in people's decision-making processes without predefining rigid contextual factors which removes these nuances of context. This framing of context became a fundamental part of this research and was vastly influential in helping critique a singular perspective for capturing health and wellbeing information. This was compared with my previous assumptions based on a couple of recent works, but mainly from highly cited papers in the late 90s and early 00s, which was not fully reflective of the challenges facing current system design. While the paper outlined used interviews to understand people's considerations of context, design methods could fulfil a gap in this space, moving past suggestions for system design to creating prototypes that could test whether these ideas would work in practice. As this was the approach taken for the third project

(Chapter 6) it shows how the outcomes from this world helped to find relevant gaps in this space that could be approached.

4.5 The importance of CoCo for this research

4.5.1 Reflecting on CoCo

Less than a year after CoCo was published in its fictional form, a similar app became a reality. The University introduced an app called Powrlife (2022) which offered wellbeing support for students, creating personalised plans to help people improve their mood or self-esteem. However well intentioned, the design of this app in my opinion (and most likely people at the University agree as it is no longer supported) is problematic. For those struggling, suggestions for how to improve wellbeing are shown through a traffic light scheme with a red circle and low percentage score indicating that they might be 'overwhelmed' or 'worrying'. When students start different plans, to improve these scores they are given generic activities intended to help them 'feel better' like donating blood or baking something for co-workers. Affirmation might be able to help in some cases, but generalised 'one-size fits all' solutions to a complex area like wellbeing replicates issues seen in many tracking applications. While the purpose of CoCo is to support general wellbeing through personalised suggestions rather than providing mental health support just like this app, this purpose is not made clear to users. Interfering with people trying to access help can cause real harm. This highlights the importance of critiquing these 'personalised/contextualised' health and wellbeing systems in the preliminary design phase before they are implemented in real world settings. This also shows that the way these systems are designed and developed still needs to be understood across different disciplines to explore different ways to explore general wellness experiences. This helped motivate the pursuit of different perspectives, to see what implications they might have for providing contextualised health and wellbeing information.

Another example linked to reviewers' responses to the fictional paper. These responses focused on technical measurements highlighted that stress was not an accurate measurement so wanted to know more about how stress was measured in CoCo. Shortly after, FitBit released Sense (2022) targeting stress management based on changes in sweat levels through an EDA sensor. This further acknowledges the advancement of wearable technologies relying on new sensor capabilities to market devices whether that is something people actually need in their self-tracking devices. While CoCo shows some potential applications with using contextual information in relation to stress, this made it clear that more work is needed to explore the implications of new considerations of contextualised information.

Based on insights from the fictional paper, it became clear that when discussing context, it is important to establish the role of context in relation to this work and how it differs from previous considerations of what context is. There is debate about how context is approached, with technical or positivist views seeming to dominate the self-tracking and context-aware literature. From the literature, it seems that a dichotomy between differing views of context can lead to information that is not considered useful or meaningful to individuals using a self-tracking system. In this work, context is more than creating additional 'features' to determine where someone is and what they are doing. Context cannot be predetermined in this way as it is constantly changing with people's preferences and priorities shaping the actions they take. Rather than focusing on how this is modelled within systems and considering alternative ways to model context, for designers it is more useful to see how more contextualised tracking systems changes how people interact with information about their health and wellbeing. This includes understanding the opportunities, challenges and insights that can be gained from introducing new considerations of context into self-tracking systems. This is acknowledging that this should be considered before these systems exist where they have the potential to cause harm to both direct and indirect users (i.e., cats being adopted!).

4.5.2 Gaps left to answer

This chapter has helped to understand implications with using a singular perspective, in this case a system perspective to including contextualised information about someone's general wellness. However, combining the design fiction insights with personal and external insights from the fictional world has highlighted a couple of gaps that have been left unanswered from this chapter, these will be discussed below. The following project chapters will help address the gaps not answered in this project. Selves and Beings (Chapter 5) will outline social considerations for self-tracking beyond individual metrics about our body. It will present an argument for different perspectives that could be considered in relation to health and wellbeing information. The Cat Study (Chapter 6) will introduce these new perspectives into a self-tracking experience with participants. It will discuss the implications of introducing these new perspectives.

4.5.2.1 Exploring social implications

The system perspective did not take into account people's preferences and priorities, such as the fictional users Gina and Euan's baby crying taking priority over reducing lighting to decrease their own stress. This highlights that information isn't just about one person, it involves a network of humans and non-humans (i.e., cats) involved in the data produced from self-tracking systems. Therefore, this network of social connections provides considerations for introducing new perspectives that could capture other parts of health and wellbeing experiences. Equally, through this social lens there might be information that should not be captured for example it might be inappropriate such as CoCo suggesting Jason having a drink with his student and their mother. It also might not be socially acceptable to gather i.e., the swimming pool Kat worked at was considered a private space. Introducing different perspectives might reveal aspects of private spaces that could be more problematic than what is already captured through sensors and metricised insights.

4.5.2.2 Information considerations

In some cases, the way the information is perceived changes their behaviour which can have social implications i.e., Gabriel having his cat adopted after seeing the increase in his heart rate. Therefore, through introducing new perspectives it needs to be considered what the impact is from displaying these new types of information in a particular way. The system perspective approached context as cause equalling effect i.e., if you sleep earlier, you'll sleep better without considering the wider picture i.e., caffeine drank before bed. This reveals interesting questions for exploring through the information produced from different perspectives, what would different perspectives reveal about potential causes of behaviour & what would the implications be when this is beyond information about ourselves? Additionally, CoCo revealed problems with people following the information provided i.e., student's exams grades decreased following the short-term recommendations. Would there also be concerns with introducing different perspectives? Or would these different considerations of contextualised health and wellbeing information help to aid understanding?

4.6 Summary

In this chapter, the fictional paper introducing CoCo, a health tracking application and wearable is outlined. Following this, the creation of the fictional world for CoCo is discussed explaining how various artefacts created and exploration of self-tracking systems helped develop the world of CoCo. These were collated to expand this world developing fictional user narratives and additional artefacts included in a fictional paper. This approach resulted in several insights both from my own perspective and others who reviewed the fictional paper. This changed the framing of context within this work and helped to outline two gaps that need to be addressed through the introduction of new perspectives in self-tracking systems. This chapter began to answer the research questions by exploring implications of a system perspective, or singular perspective for exploring contextualised general wellness information. To explore these implications, the fictional process taken was also important. Critiquing and testing context-aware systems through fictional means in a safe environment means these systems could be explored in a preliminary design phase before they were implemented in real people's lives which could result in harm. The following chapters will outline some new perspectives of health and wellbeing information and these will be tested with participants to explore the implications for self-tracking system design.

Chapter 5 Selves and Beings

5.1 Introduction - Moving beyond the metricised bodily goal

In Chapter 4, CoCo highlighted that a single (system) perspective of what it means to be healthy and well is missing contextualised information about someone's general wellness. Assuming context can be known and designed in the same way for everyone can result in harm for both direct and indirect users of a self-tracking system. This was revealed through the social implications involved in self-tracking information, with these self-tracking systems potentially harming the wellbeing of multiple humans and non-humans represented in this information.

Therefore, acknowledging self-tracking systems are capturing data about the world around us, the next step in this research involved understanding the problems with relying on a system perspective to represent the general wellness information of different selves (referred to in this research as *multiple beings*). Therefore, what parts of wellbeing are represented through a singular perspective of what healthy and well is? And what could different (more-than-human) perspectives of contextualised information consider about self-tracking health and wellbeing experiences?

In this chapter it is argued that relying on a system perspective to include contextualised general wellness information means a focus on metricised insights. These insights produce goals which focus on comparing human and non-human bodies and viewing these bodies as a collective. It is this focus on the bodily metricised goal through one perspective which only represents one part of who a self is and only represents certain selves experiences. This is explained in a few parts. Firstly, what a body is in this research and how self-tracking systems focus on them (section 5.2), how that body forms part of a self and how the self (section 5.3) and multiple beings (section 5.4) have been conceptualised in self-tracking design. It is suggested there are right and wrong ways to be a self, based on the self being socially constructed. Therefore, this chapter will deconstruct these notions of how a self is conceptualised and advocate for a move beyond metricised bodily goals, referred to in this chapter as moving *beyond the body*. This chapter will argue for an introduction of more-than-human perspectives of contextualised health and wellbeing information that consider other parts of multiple beings' health and wellbeing experiences aside from metrics about our bodies (section 5.5). Therefore, it will ask, what if we moved beyond this metricised bodily goal based on a system perspective of what it means to be healthy and well? What if we introduced different perspectives of contextualised general wellness information to consider other parts of health and wellbeing experiences?

Given that we know past design has caused harm, this chapter does not suggest that adding new contextualised information from different (more-than-human) perspectives will be good for future self-tracking system design. Instead, it is argued that we can explore the implications of these different perspectives for new considerations in self-tracking design. A few of these implications are presented at the end of this chapter, exploring potential challenges with introducing more-than-human perspectives that capture general wellness information not just about ourselves but our relationships with multiple beings (section 5.5.3). This chapter concludes with justifying why speculative methods, explored in the Cat Study, can be used to test how people interact with information from different perspectives, before these are implemented in self-tracking systems with the potential to cause harm (section 5.6).

The argument presented in this chapter is based on two published papers submitted to the DRS 2022 track "Valuing the qualitative in design and data". This includes one first author paper titled "Beyond the body: Moving past the metricised bodily goal in self-tracking" and a co-authored paper titled "Multitudes: Widening the research agenda for personal informatics design".

5.1.1 Varying terminology

It should be noted here that the beyond the body paper uses different terminology than the terminology used within this thesis. The framing of the self remains the same, as humans are the ones using and interacting with systems intending to learn more about ourselves (hence the term self-tracking). However, multiple entities are involved in these systems and so terminology was needed to reflect this. In the original paper, those compared to 'the self' were originally referred to as 'the other' or 'others'. The new terminology used in this chapter refers to those compared to a self, as a being or multiple beings. This change reflects further reading into feminist and social constructionist research that recognises the associated problems with 'othering' or referring to people as others. As Crotty explains, feminism has discussed this divide between 'self' and 'other' where "we each constitute the Other as an object and perceive it as a threat" (1998, p. 167). Here he discusses Simone de Beauvoir's distinction between binary representations of gender through a man and woman. The woman is viewed in comparison to a man and viewed as an 'other' who is a threat and needs to be controlled or oppressed in some way. This comparison has helped to create narratives across time that reinforce roles within society. This also crosses over with more recent examples, such as Tsaknaki et al., (2022) who explore how biodata might be shared beyond individuals in relation to multispecies bodies. The authors emphasise how current views of the other can enforce power relations, help erase multiple experiences and further impose comparisons "where comparison can risk denigrating or even effacing the 'lesser' category" (ibid, p. 4). This shows how comparisons are problematic for reinforcing normative values. Comparisons are still included in this work but only to explain how the self and multiple beings are represented in current system design. As this work aims to include more-than-human perspectives, those compared to the self are equally as important and valid. Therefore, language that reinforces the idea that these multiple beings are lesser than the self needs to be adapted. Given that language can be used to shape particular narratives and reinforce structures that contradict the values of the thesis, it felt necessary to change the terminology used in the original paper.

5.2 Bodies

When it comes to discussing the ways to move *beyond the body* in future self-tracking systems, it is first important to define the term *body*. Following the dictionary definition, a body is "the whole physical structure that forms a person or animal"

(Cambridge University Press, n.d.). However, when it comes to self-tracking or viewing the body from a digital perspective, the body can include any biometrics about an individual both physiologically and psychologically i.e., heart rate, step count, stress levels. While there is a focus on tracking human bodies, this work acknowledges tracking of multispecies bodies through pet tracking applications. These applications capture what a companion animal does and how these activities relate to their general wellness (Jayawardene *et al.*, 2021; Lawson *et al.*, 2015c; Zamansky *et al.*, 2019). Shifting towards social aspects of tracking beyond the body, means whether the relation is human or non-human is insignificant. It is still important to consider our connection to that being and why they relate to our wellbeing. Our body helps us sense and communicate with the world around us, and therefore our sensory responses also form part of what makes a body and how the body is tracked (Lupton, 2017). These metrics are easier for technology to detect, react and analyse in order to generate personalised insights. The data underpinning this approach reduces people to a collection of bodies that can be judged and compared based on societal norms to what a body should be (Gross *et al.*, 2017). Within digital systems, data documented about a body may, in some instances, mean that data about a body is living even if the physical body no longer is (Elsden and Kirk, 2014). Nevertheless, when discussing bodies this paper focuses on alive bodies in the physical world. To conclude, in this chapter a body is defined as an alive physical form, either human or non-human, that allows us to sense and communicate with the world around us. Data captured from these bodies allows self-tracking systems to analyse our behaviours, routines and reactions.

5.3 The Self

5.3.1 Why expand the definition of the self?

Despite personal informatics referring to the self through different terminology: self-tracking, self-reflection, self-knowledge, self-understanding, there has been little work done around who the self is that these systems are designed for. It is argued in this chapter that focusing on the bodily metricised goal through one perspective only represents one part of who a self is and only represents certain selves experiences.

Therefore, introducing different perspectives of contextualised general wellness information means it is important to understand who the self is that is conceptualised within self-tracking system design. This means considering the inclusion of different selves, experiences who have been excluded or misrepresented through system design which reinforces normative ideas about who a self is. This section will first explore who the self is (section 5.3.2), how notions of the self are currently represented (section 5.3.3) and considering the self in self-tracking system design (section 5.3.4). But first, has this been discussed before in personal informatics literature?

Within sociology literature there has been critique about how the self is conceptualised (Lupton, 2020; Turkle, 2005; Foucault, 1988), but little in the personal informatics field. One notable example within the personal informatics field is Rapp and Tirassa's (2017) theory of the self. This acknowledges phenomenological perspectives stressing how the self is subjective. This perspective has been followed by other researchers such as Homewood and Vallgårda's design of a menstrual cycle tracker (2020). This perspective overlaps with more-than-human considerations taken within this research. However, this theory is more about what is a self rather than ideas about the self demonstrated in personal informatics literature. Equally, drawing on sociology research, it is argued in this chapter that the self is socially constructed based on social attitudes. That is there are expectations within society about what is considered 'normal' and there are assumptions made about what makes a right and wrong version of a self i.e., cultural attitudes towards menstruation. This focus on a socially constructed self has influenced the research presented in the following section.

5.3.2 Who is the self in self-tracking?

The body is one part that makes us who we are, that is our 'self'. However, how the self is represented in self-tracking is a matter of debate. Gallagher (2000) discusses the minimal self which includes who we are (past thoughts and actions) and the narrative self which views the self across time considering memories and "intentions toward the future" (2000, p. 15). Lupton also discusses the self in relation to time through "human-data assemblages" (2020, p. 12), the idea that pieces of data represent a frozen measurable moment of someone's life specific to that time and context. Gross et al., (2017) critiques self-tracking's representation of the self as they promote hegemonic norms, that is society's expectations for people to look or behave in a certain way. They state that people often perform for the system, the self or for each other to have agency over the system. People also create multiple versions of the self, not only to aspire to (Boyd, 2001) but to reflect on who they are now (Foucault, 1988) and to help grow and shape themselves over time (Turkle, 2005). This suggests that people have set views of what they consider the self to be, causing conflict when these views don't match up with current representations of the self. It could be said that AI could offer a different way to represent the self by including personalised insights based on information gained about the self. But relying on quantitative data patterns, even if specific to a person, may lack meaning as these insights are shaped by design decisions, goals and norms that privilege some selves over others (Morley *et al.*, 2019). They may also reinforce who a self could be, with insights based on previous behaviour patterns. This means people are seeing familiar rather than unexpected content and so might not be able to imagine what the self could be (Loukissas, 2019).

The self is socially constructed through various times and places creating normative notions of the self. Spiel et al., (2018) highlight these normative notions are present in the design of self-tracking devices, acknowledging how these devices reflect biases within ourselves and can encourage appropriation. While their work discusses these biases in relation to individuals excluded from system design, they also reflect societal norms. For example, the self is viewed as someone who interacts with their self-tracking device the same way all the time. The device expects continuous use, even after an injury or when people might want downtime i.e., on weekends or holidays. However, for those following religious practices such Orthodox Jews observing the Sabbath, certain days means they don't interact with technology i.e., a Saturday. This means that religious practice is seen as "something that happens in people's heads or hearts rather than their bodies" (p. 7) and therefore not accounted for in system design, reinforcing notions of who these devices are designed for. Equally, Spiel et al., explain how the self is one that reflects those best served in society “white, thin, abled, neurotypical, not actively practising religion etc.” (p. 5). For example, for athletes with health conditions or impairments, these devices are harder to use (ibid). These tracking technologies can also create new health standards or norms, such as MyFitnessPal tracking neck fatness (Gross *et al.*, 2017) showing the power they have to define who a self is within system design.

5.3.3 How are notions of the self currently represented in self-tracking?

Given this understanding of who the self is in self-tracking systems and drawing on critiques of the personal informatics literature, this section outlines three assumptions from the literature. These assumptions are about the nature of the self represented in self-tracking systems. These being that the self is unitary or fragmented, in need of unifying, the self is in need of improvement, referred to here as ‘lacking’ and the self is knowable.

5.3.3.1 The unitary self

The unitary self shown in PI literature assumes that the ideal self is a united one. In other words, there are fragmented parts of the self, such as someone who wants to drink more water but also wants to exercise more. These tools help to bring these fragmented states into one complete self. This might be by bringing together multiple metrics to create coherent narratives about an individual’s life (Thomas *et al.*, 2018b), or for ease of use (Kim *et al.*, 2017). These tools might also need to adapt to the fluid self. This is a self that is constantly changing and so therefore needs constant monitoring through data types that can be easily measured and analysed rather than “what might be most meaningful” (Bietz *et al.*, 2016, p. 82) to someone using these self-tracking systems.

5.3.3.2 The ‘lacking self’

The ‘lacking self’ is simply that the self is viewed as something that requires improvement. There is an idea that through using PI tools, the self is something that needs to be worked on. This might be by improving the self, gaining more knowledge about the self, or reflecting on the self, but the self is never portrayed as adequate or enough. This can be seen through behaviour change technologies and theories being among the most frequently referenced (Epstein *et al.*, 2020a). While the self has limited memory that can be seen as “flawed” (Li *et al.*, 2010), machines have memory advantages that can be used to create tools that could ‘improve the self’. However, this implies that the self needs technological augmentation. Equally, machines can change how our lives are remembered as “forgetting and misremembering can be an integral part of how people construct their identities, create life narratives, and contextualise their life experience” (Gulotta et al., 2015, p. 2).

5.3.3.3 The knowable self

The knowable self, highlights how the literature indicates a need to understand more about ourselves and that the self can be knowable. This is often through measurable information and requires reflection to discover more about the self (Li et al., 2010). There seems to be trust in these systems to helps us discover things about ourselves either through automation (Thomas *et al.*, 2018a) or a what a system considers necessary to include (Gulotta *et al.*, 2015). This concept has also provided future directions for system design, supporting the notion that these systems should help us ‘know’ more about ourselves (Rapp and Tirassa, 2017). As explained by Hong there may be things that humans cannot know without technological assistance. That is if “knowing is achieved through mass-produced, autonomously operative devices” (2020, p. 7) it can generate information beyond human consciousness. Within PI literature it is implied that through these tools there is some truth about existence that can be revealed. Rather than acknowledging how complex, fluid and messy reality can be.

5.3.4 Considering the self in design

These many versions of the self show a disparity between how the self is represented through system design and what people or society expect the self to be. When there is excessive focus on the self, there may be adverse effects (Kersten - van Dijk *et al.*, 2015) such as health obsession. Health obsession occurs when systems present unnecessary data about the self, leading to systems being more about “entertainment medicine” (Gabriels and Moerenhout, 2018, p. 6). This causes a misunderstanding about what the purpose of self-tracking is; tracking for preventative care, managing a condition or other purposes? There is a problem with not knowing this purpose in self-tracking, as the purpose or multiple purposes changes how the self and multiple beings are represented in a system. This will only get worse with the introduction of AI into self-tracking systems as people tend to over trust data, even if it is not accurate (Morley *et al.*, 2019). People might blame their interpretation of data or not reaching a goal as a personal fault and rather than the system's fault for misrepresenting the self.

As designers we need to make these purposes clearer within the systems we design, especially when we may no longer be in control of how the technology learns and adapts. This could be as simple as asking people why they want to use the app during the onboarding stage. These systems are not only generating data about the self, but those around us. If these systems were in control of our relationships, they could reinforce societal expectations, norms and goals dictating what our relationships should be rather than relying on our own perceptions. This may result in prioritising certain selves over others, perpetuating unbalance and inequality within these systems. We as designers have a responsibility to address these biases around the self to make sure these systems prevent harm for everyone. We need to discuss how the self is currently represented in relation to multiple beings and how our future representations of relationships and connections might be designed differently.

5.4 Multiple beings

This chapter argues for a move beyond this bodily focus, meaning a discussion is needed around how this perception of the self and the body is currently represented in comparison to other bodies and beings. That is, how is the self currently measured against multiple beings? Multiple beings here are any agent in a self-tracking system, human and non-human compared to other beings through data. A being according to a dictionary definition is "a person or thing that exists" (Cambridge University Press, n.d.). Given this research's understanding of a 'thing', this can include anything that exists such as a companion animal like a cat or a plant. This terminology allows for the inclusion of many different entities that can be involved in our tracking systems.

While multiple beings are discussed here, there is an emphasis on humans compared with other humans, reflecting the majority of literature around current tracking practices.

With this outlined, how is the self compared with multiple beings in current system design? What are the issues with this current way of determining general wellness through purely metrics? As Rooksby indicates lived informatics are “often social and collaborative rather than personal” (2014, p. 1) and future self-tracking systems should “look beyond support for publishing data to social networks”. Research has been done around data sharing beyond social networks, with a large focus on data legibility. Tolmie et al., (2016) indicates how having data about the self (i.e., showering) and comparing the data with multiple beings (i.e., who showered quicker) creates tensions in relationships. This study discusses social data about close relations like a family, but this applies when analysing a larger collective. Strava (BBC, 2018) allowed users to see heatmaps of people’s routes while running but these revealed outlines of military bases causing privacy and security concerns. These data sharing concerns apply to interspecies tracking systems (van der Linden, 2021) such as revealing pet owners' behaviours, i.e., when they leave the house. Focusing only on the body and leaving no space for contextual meanings could lead to misrepresentation of the data. This could have adverse effects on a companion animal’s health and wellbeing.

To align with the system’s capabilities, design decisions have to be reductive allowing operations like comparison between an owner and their dog (Jayawardene *et al.*, 2021). Apart from reinforcing power hierarchies between these bodies, it has been found that sharing quantitative data creates new meanings within social relationships. Focus on social metrics can affect the real proximity to multiple beings (Wang *et al.*, 2017), compromise trust between family relations (Jørgensen *et al.*, 2016) and increase tension by comparing the bodies of family members (Pina *et al.*, 2017). These potential harms were only revealed after the systems were implemented fully and social dynamics came into play. Without design processes including lived informatics (Rooksby *et al.*, 2014) and contexts where this data might be used, it may never become clear what harms could develop. All these examples note problems with a purely quantitative approach to measuring multiple beings and their bodies. Kersten-van Dijk et al., (2016) discuss how we might design for social tracking needs beyond quantified data through storytelling i.e., stories of times dogs made us laugh.

However, these features are yet to exist in self-tracking systems and therefore it makes it difficult to know what impact qualitative data might have on the self. This is where design could come in, creating potential futures of qualitative data in self-tracking systems. Creating fictional worlds (Coulton *et al.*, 2017) could consider what potential harms might exist and whether this changes when data is visible about multiple beings rather than one being. For example, if our earphones were able to track conversations we had and when we were engaged in these conversations, what is the purpose of capturing this kind of data? Maybe to document past conversations and preserve memories? Designers could use design fiction to explore potential harms around the privacy implications of keeping data about every engaging conversation with multiple beings.

5.5 We are more than our bodies – why should we and how can we move beyond the body?

There are limitations with only using quantitative data in self-tracking systems to record the way our bodies act and react. We need to move past this current focus to consider general wellness experiences past reductive, comparable metrics. This thesis proposes that there is more to our health and wellbeing than our bodies and therefore we need to move beyond the body. This will begin to address the reductionist approach to tracking the self as well as multiple beings. Here it is argued that introducing different perspectives of contextualised health and wellbeing could provide different considerations for future self-tracking system design. But what might these perspectives be and what might they be able to capture about health and wellbeing experiences aside from metricised bodily goals?

5.5.1 More-than-human Perspectives - the way we relate to each other

Self-tracking systems exist for non-human animals (FitBark, 2021; Tractive, 2021; Whistle, 2021), but these systems also focus on multispecies bodily metrics and dictate to the owner what constitutes a healthy pet. These metrics are compared with us, intending to increase motivation in owners i.e., mutualistic benefits improving the health of both pet and owner by walking more steps (van der Linden, 2021). However, they can also reveal details about the owner's caregiving ability (van der Linden *et al.*, 2019). The relation between human and non-human's bodies currently represents the self's relationship with multiple beings in these tracking systems.

More-than-human ignores this emphasis on the body; perspectives are produced about how we construct and experience the world and what it means being-with multiple beings (Coulton and Lindley, 2019). If we understand how multiple beings experience the world, introducing these perspectives of the world might provide new considerations for future self-tracking system design. Haraway discusses how companion species "make life for humans what it is", noting how non-humans shape experiences like "organic beings as rice, bees, tulips" (2003, p. 15).

Equally as these systems currently focus on only the relation between human and non-human, as described by Haraway this is the "smallest possible unit of analysis" and instead we should focus on "living with animals, inhabiting their/our stories, trying to tell the truth about relationship, co-habiting an active history" (2003, p. 20), acknowledging their experiences as much as our own. Given these similarities across human and non-human tracking, there are limitations in how we currently define health and wellbeing through technology. This is explained in the literature review: focusing purely on metrics means some selves' experiences are supported, but these metrics are usually fixated on our bodies rather than our overall general wellness experiences. As we consider multiple beings, there is something missing about our experiences with them that needs a new perspective. Bogost refers to Nagel's essay "What is it like to be a bat?" (1974) in which Nagel argues that physical reductionism erases the subjectivity of experience by explaining "it away via underlying physical evidences" (Bogost, 2012, p. 62). Just focusing on the physical components of an event does not necessarily describe the subjective experience. So, what could describe an experience beyond the physical? Could this be our social circles, our environment, or our past experiences? And does this change the way we relate to each other and how we represent their experiences we can't directly access?

Leong et al., suggests we might integrate our data tracking practices with the needs and wellbeing of multiple beings or use "new knowledges" (Leong *et al.*, 2020, p. 267) to consider non-human ontologies in data tracking. This could be useful for designers to see whether this perspective influences the way we view our health and wellbeing. For example, how might a cat's perspective on health and wellbeing differ to our own? And how might this be implemented through self-tracking systems? As part of this, we need to acknowledge that these non-humans can have experiences separate from humans, that is, humans are not always the centre of an experience. This is explained by Bogost who suggests we can consider these configurations through object-oriented ontology, "drawing attention to things at all scales […] and pondering their nature [as well as their] relations with one another as much as ourselves" (2012, p. 6).

When considering more-than-human considerations relationship to technology, Suchman (1987) highlights, the difference between where something was designed and where it was placed changes how we interact with it. Giaccardi & Redström (2020) suggest that as our devices become increasingly sensitive to context they will ""learn" through their encounters with the world (us and each other)" and "they will begin to express agency and become active in a way we have never seen before" (2020, p. 3). How self-tracking systems "learn" and change over time and how they are used by different actors for multiple reasons is important to consider for design. They highlight through this perspective we design "in ways that are sensitive and responsive to the human condition" (2020, p. 9). We can see that this is dependent on space and the differing uses of things, but all these elements show some opportunities and challenges for how we use the more-than-human approach.

What if we did inhabit their/our stories as part of self-tracking systems to provide different more-than-human perspectives of general wellness experiences? Would this help move beyond the body and provide different considerations or implications for future self-tracking system design? For example, more-than-human perspectives applied to a mindfulness food app might track what we eat and help us to consider this more critically. It could be that considering a rice grain's view of the world creates new narratives i.e., the rice's journey to a person's plate creating self-awareness of where our food comes from.

5.5.2 Introducing different perspectives of contextualised health and wellbeing information

We know multiple beings' experiences of the world differ from our own and as discussed by Haraway inhabiting their stories might better represent our relationship with multiple beings. Therefore, this section argues that narratives through more interpretative or qualitative data might provide considerations for future self-tracking design. However, it could also provide challenges, given the complexities of capturing relationships with those around us.

Introducing different perspectives of contextualised health and wellbeing information meant introducing narratives that explores different considerations of general wellness experiences. How are narratives already discussed in self-tracking literature? Literature around narratives are largely discussed in relation to reflection, memory and legacy e.g. (Elsden and Kirk, 2014; Epstein *et al.*, 2020b; Gulotta *et al.*, 2017; Tan *et al.*, 2018). This literature raises many questions for design: if we did start to include more-than-human perspectives of contextualised information about our health and wellbeing, what would this look like? With this possibly representing information not just about ourselves, what might this mean for representing and reflecting our relationships with multiple beings? Additionally, given that we know there are already problems with self-tracking design, would there be implications i.e., opportunities, challenges, consequences with including these relationships in self-tracking systems, and what might result from considering these types of tracking in self-tracking design? Given the more-than-human understanding of what contributes to life experiences, we can start to imagine ways to introduce different perspectives in self-tracking systems. Stories and narratives are important in conversation and relating to each other, however we don't normally use or need precise metrics when talking to people. How do we currently use qualitative data to document experiences? What might be considered for introducing more-than-human perspectives in future self-tracking system design and what might this mean?

We might consider different aspects of qualitative data such as interpreting objects in photos i.e., balloons (Harris, 2011) or a series of photos as part of an interactive timeline (Harris, 2007), qualitative data types have been used to tell stories about people's lives and experiences. Others have shown how data can be used to add value to fictional stories such as creating awareness with the problems of IoT devices and the power they hold over our relationships (Desjardins and Biggs, 2021). Some have even used crafts such as postcards (Posavec and Lupi, 2016) and wall art (Ananthanarayan *et al.*, 2014) to create different interactions and reflections with more abstract data representations. However, with self-tracking design currently focusing on system capabilities through quantified metrics, it is unclear how qualitative data could be used in self-tracking systems to move beyond the body. This involves considering the implications of introducing new contextualised information like qualitative or more interpretative data through different perspectives of health and wellbeing experiences.

Kersten-van Dijk & IJsselsteign (2016) argue that self-tracking is more social, calling for the quantified self to become a more quantified us. This includes stories and experiences, or multimodal data such as pictures and videos, to reflect how people share, interact and collaborate with data. Others also discuss this need to include more elements of our experiences whether this is about adding social features to help tell a story (Elsden *et al.*, 2015) or highlighting qualities which help us make sense of things like a cat's purr (Lockton *et al.*, 2022). Equally, it might be that more interpretative systems could create contextualised information by changing the way our data is visualised (Drucker, 2014). Or changing what is valued in our system design (Winter *et al.*, 2022) considering social contexts as well as features (Cosley *et* *al.*, 2017). However, despite these examples highlighting experiences as something needed in our self-tracking systems, these features or representations of context are yet to exist. This makes it difficult to know how we might understand different data types and what challenges might arise from the inclusion of this new information.

Gulotta et al., (2015) explored a more qualitative approach, highlighting how we might be remembered or represented through digital systems and whether this aligns with a person's life experience. They highlight how capturing sensitive information about individuals may reveal things about a self that a family or other collective may wish to keep hidden. Desjardins et al., also indicate a mismatch between our perception of an experience (subjective) versus what actually occurred (objective) influencing how "data are perceived and gain meaning in the home" (2020, p. 9). Additionally, technological problems such as loss of connection may lead to unfinished narratives meaning the whole narrative was not documented, changing how we perceive or reflect on events. Dourish & Gómez Cruz (2018) describes issues with perception through data temporality. They explain how narratives are embedded in their own histories, geographies, and cultures which changes the stories data tells us. This is because narratives are based on different "understandings and experiences" (2018, p. 7). Our systems need to represent these experiences accurately, minimising where possible the existing biases. For example, Figure 43 shows a flowchart from Kyoto aquarium in Japan that was created to show the relationships between penguins. This resulted in networked data narratives about romance, heartbreak and affairs (Ebert, 2020). If these narratives were included in self-tracking systems, what consequences might arise from having relationship details exposed?

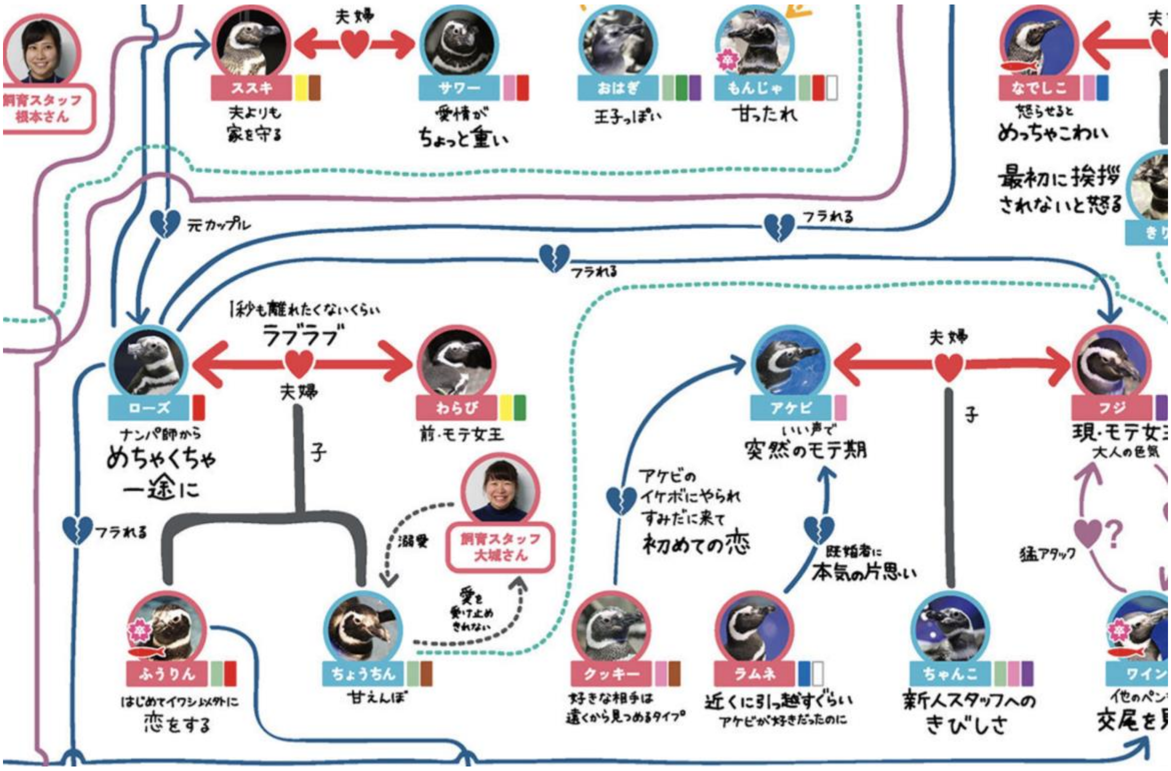

Figure 43 - Penguin relationship diagram. Image source: https://www.thisiscolossal.com/2020/07/penguin-flowcharts-Kyoto-Sumida-aquariums/

5.5.3 Opportunities and challenges of introducing more-than-human perspectives about multiple beings' general wellness

Introducing these different more-than-human perspectives could provide considerations for contextualised information in self-tracking design about multiple beings' wellbeing. It is important to consider the possible opportunities but also challenges with having this type of information in self-tracking systems. More-than-human perspectives could include different parts of general wellness experiences. Given that how we relate to each other is one aspect that can be seen to impact health and wellbeing experiences, what would it be like having these relationships represented in self-tracking systems? What might be the implications with including this?

5.5.3.1 Social Dynamics

Dependent on who the self is compared with, whether they are a family member or close friend, may change how the experience is documented in a self-tracking system. There are complex entanglements of relationships dependent on situations i.e., work versus social friends (Hancı *et al.*, 2019). Both professional and social contexts require different interactions but can alter the levels of relatedness and closeness of that being and what kind of narratives might be appropriate to see about them (see CoCo). There is also a darker side to relationships, social connections between friends and family can often break down, people get into fights and fall out or are no longer close. It might be that the person has died and being reminded of the fact can be unpleasant (Jenka, 2018). An example of this can be seen through the fictional paper CoCo which highlights complexities with social dynamics like social appropriateness. One fictional participant followed the app's advice skipping staff meetings, but this ultimately led to an increase in stress levels when his boss questioned his non-attendance. Our systems need to be able to take these contexts into account when interfering with our lives and relationships.

5.5.3.2 Digitising relationships - the messiness of relationships and wellbeing

Focusing on quantitative measurements in self-tracking presents a single perspective of health and wellbeing information. These systems can imply if you do X i.e., drink less caffeine then Y i.e., sleep quality will improve, without considering Z i.e., where you slept or your partner waking you up (Lockton *et al.*, 2020). This should be considered when designing relationships in self-tracking systems, especially with the way narratives focus on positive portrayals of memory and reflection for documentary purposes (Rooksby *et al.*, 2014). As Haraway critiques, the Western world's perception of our companion species such as dogs is not realistic, as it does not acknowledge that our relationship "is not especially nice; it is full of waste, cruelty, indifference, ignorance, and loss, as well as of joy, invention, labor, intelligence, and play" (2003, p. 12). Focusing on the positive aspects of this relationship distorts the actual connection between pet and owner. This is something designers need to consider if our future self-tracking systems include more data about how we relate to those around us. For example, if we had a pet tracking app that viewed general wellness experiences from a cat's perspective, location-based interfaces might include hunting stories i.e., prey killed/encountered and sensory experiences i.e., the feeling of the prey in the cat's mouth. This might be negative from a human perspective but is vital to a cat's wellbeing. This could provide new considerations for future self-tracking system design.

5.5.3.3 Automating relationships in self-tracking systems

Machines are gathering a vast number of metrics which can be used to determine or dictate the 'correct' way to behave and act. With algorithms and tools like ML being used to create personalised insights and recommendations in self-tracking systems, what happens if machines start generating insights around our connections with multiple beings? If we did have systems that mediated or provided insights about our relationships, would this change who we are (the self)? Hong highlights how machines can "communicate ceaselessly with the body" (2020, p. 7) meaning that the self could be changed without conscious awareness. For example, if a machine measures something about the self that a human themselves cannot sense (such as a galvanic skin response) a machine might be able to determine why a behaviour is occurring and automatically start to 'improve' a self without someone being conscious of these behaviour changes occurring. This in turn makes it hard for designers to intervene as it is unclear what might have caused behaviour changes. Turkle also raises a similar point around children's relationships with technology stating that "it may evoke unconscious memories of objects that lie for the child in the uncertain zone between self and not-self" (2005, p. 114). This also makes it hard to design for human sensitivities, when machines and algorithms can target sensitivities we don't know about (e.g. beyond human senses) and alter the self without any human intervention. Without having the resources or language to design AI systems and consider the associated consequences in the context of general wellness, this could have an impact on human wellbeing. As machines are capable of encouraging bodies to behave in certain ways based on information not known to humans, they are able to intervene with the self and make design decisions to 'improve' the body without designers intervening or questioning whether that decision is the right one to make.

Apart from recommendations like music and entertainment choices, people are less comfortable with personalisation, especially if people know how the recommendations work (Gulotta *et al.*, 2015). This means, people wish to have control over the systems they use. For example, levels of control over the data people receive might include the ability to remove incorrect insights. A sleep tracking app that suggests a person isn't sleeping well might increase autonomy by allowing people to select from options. For example, 'slept on the sofa' or 'partner was snoring' to note things the system does not account for.

5.6 More-than-Human perspectives of contextualised general wellness information

5.6.1 Speculative enquiry

This chapter has outlined how introducing more-than human perspectives of contextualised general wellness information could help move beyond the body. So far, the chapter has theorised about what this might mean but this section describes some speculative screens created to concretise what more-than-human perspectives might look like in self-tracking applications. This is to help make the ideas presented less abstract.

These are based on existing human and pet health and wellbeing tracking design. This will help with some initial grounding for the following chapter. Figure 44 shows speculative app screens based on the pet location tracking app *Whistle*. If we considered a more-than-human approach, taking into account the cat's routine, this might include when the cat is hunting. As explained by Haraway (2003) for a human this might be a negative action but is vital to a cat's wellbeing (Figure 44A). As cats focus on smell and taste more than visual elements, it might be useful to record multi-sensory experiences. For example, the positive experience the cat feels when catching the prey (Figure 44B), drawing on animism concepts which highlight the benefit of multisensory experiences (Lupton, 2020).

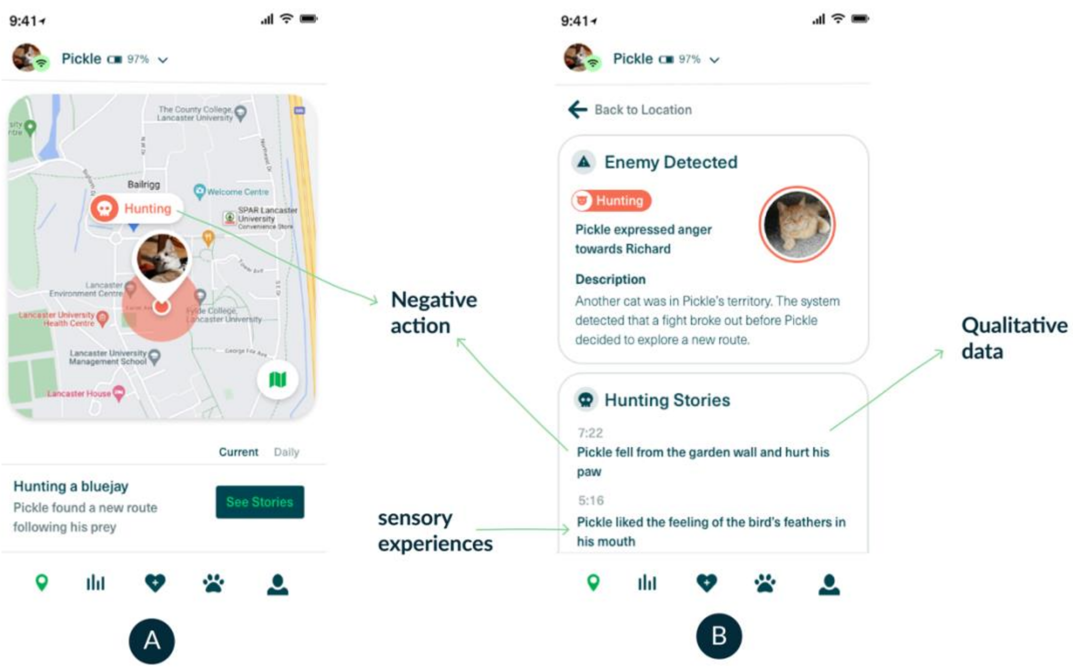

Figure 44 - Speculative app screens showing a more-than-human cat's perspective of the cat's wellbeing. A shows Pickle's location hunting a bird and B shows potential predators encountered and stories from his hunting experiences.

Figure 45 shows a few more ideas around more-than-human perspectives in tracking applications. Based off the mindfulness app Headspace's reliance on audio, a different aspect of health and wellbeing could be captured through audio recordings. This might be a mindfulness eating app from the perspective of the food a person is eating (Figure 45A). This reflects animistic design (Marenko and van Allen, 2016) having conversations with things rather than about things and creates a sense of response-ability allowing us to invite the response of the "other" (Lupton, 2020, p. 28; Barad and Kleinman, 2012). Following the style of the pet GPS tracking app Tractive, combining quantitative metrics like biometrics with more qualitative data like narrating stories could be done through photos about fun times you had with your pet (Figure 45B). This also helps us becoming-with (Haraway, 2016) our companion animals, including our entangled stories as part of these self-tracking systems.

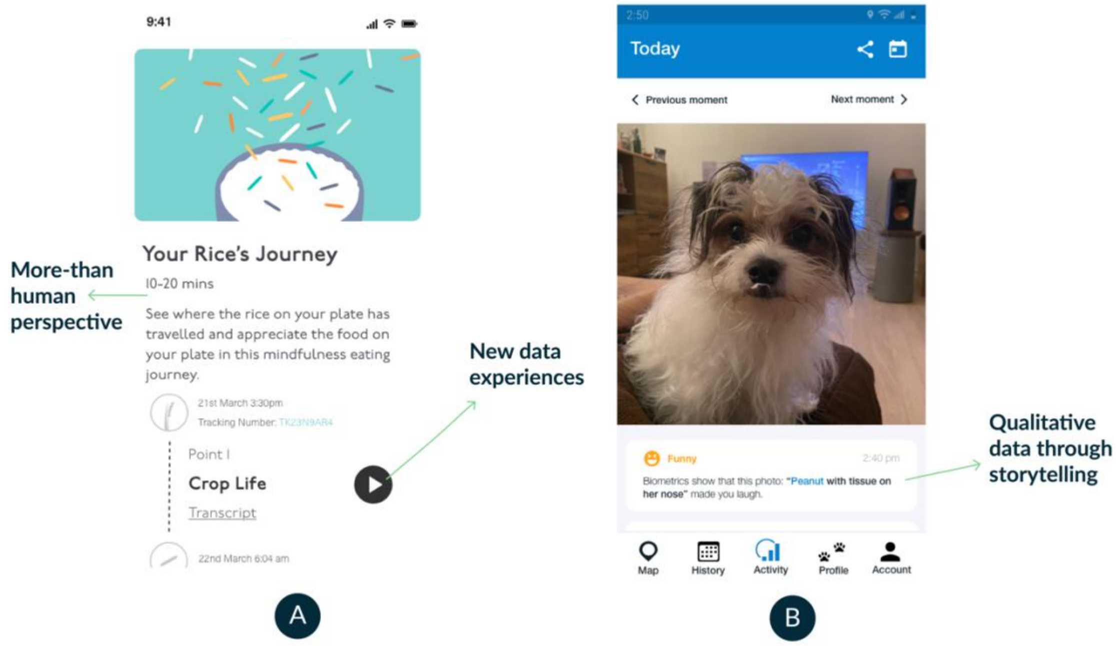

Figure 45 - Speculative app screens showing more-than-human perspectives on self-tracking. A shows the life cycle of food (rice) with audio clips narrating the journey. B shows a dog called Peanut with narratives based off biometric data (picture courtesy of Violet Owen)

As these examples show some considerations for what more-than-human perspectives could look like in practice, how does the argument outlined help advance research in the self-tracking field? This chapter shows that there are different ways that the self has been portrayed in personal informatics research, focusing on how the self is socially constructed and that this should be considered when designing systems about the self and multiple beings. From outlining problematic elements with the way self-tracking systems are designed, this chapter advocates for different perspectives of contextualised general wellness information to explore the implications of introducing these in self-tracking systems. This includes our relationships or connection to multiple beings. Following on from the themes that emerged from CoCo, when considering elements beyond metricised bodily goals, there are also considerations over the invasive nature of data on our relationships. Additionally, social factors that make up these experiences create their own challenges. With this said, what do the insights from this chapter provide in relation the broader questions of this thesis?

5.6.2 Explaining more-than-human perspectives of contextualised general wellness information

5.6.2.1 What does a single perspective of health and wellbeing miss about general wellness information?

Creating different considerations for contextualised general wellness information advocates for the introduction of more-than-human perspectives in self-tracking system design. CoCo argues that self-tracking systems need to consider multiple factors beyond the individual.-Therefore, this chapter looks at those social factors and how they form their own challenges for introducing different more-than-human perspectives. A single perspective of health and wellbeing shown in self-tracking systems only represents one part of health and wellbeing. This chapter determines that this part represented is metricised bodily insights. As self-tracking systems have progressed, bodies of multiple beings are compared, viewing us as a collective and encouraging us to compete with each other. Through this focus on bodies, this perspective only represents one part of who a self is and therefore only represents certain selves experiences. It is implied through assumptions about who this self is that there are expectations for how someone should look or behave (promoting hegemonic norms). This reinforces the idea about who a self should be or should aspire to. Self-tracking systems also expect continuous use or interaction from end users, reinforcing normative notions as this dismisses cultural and religious practices as well as how people actually live.

Additionally, the system perspective can be in charge of creating new health standards which alters how someone behaves or views themselves and has power to define who a self is. This assumes that the self is someone who needs improvement and worked on in order to create a ‘complete’ or ‘united’ self. Through these self-tracking systems, it is implied a self can know themselves better than they would have done without these tools. This system perspective of who a self is differs from people’s perceptions of the self i.e., reflecting who they are and this conflict changes how a self is represented.

5.6.2.2 What does it mean to introduce different more-than-human perspectives of contextualised general wellness information?

This can become problematic when in control of representing our relationships with other selves (multiple beings). More-than-human ways of experiencing the world could provide different considerations for new contextualised information in future system design and what constitutes a general wellness experience beyond metrics. This is by ignoring this emphasis on the body to understand how we experience the world, how this differs for multiple beings and what it is like being-with them. This means including more than physical components to health and wellbeing experiences taking to account our social circles, environment, past experiences, and the way we relate to each other. This also means acknowledging humans are one node in a complex network of connections that change over time, space and for different purposes meaning humans aren't always the centre of an experience. It is suggested in this chapter that more 'interpretative' data or qualitative data like different narratives could help weave in different being's stories and acknowledges multiple experiences often neglected in this singular system perspective of what health and wellbeing is. However, introducing these more-than-human perspectives of contextualised general wellness information could have implications for self-tracking system design. These are outlined here to explain considerations taken when implementing these perspectives into a project as discussed in the following chapter:

Revealing or exposing general wellness information: There are potential harms associated with new information types. There could be privacy concerns from keeping data about engaging conversations between people or from information gathered about multiple beings' unique experience of the world as non-human beings can access places humans cannot. For example, this new contextualised information could reveal information through exploring multisensory experiences not currently available in current self-tracking system design. This new information might also reveal details about a relationship that someone wishes to keep hidden.

Subjectivity of different human perspectives: The way events are interpreted and shared might not be the same for everyone involved in the experience given their geographies, cultures, and histories etc. This can change what some people feel is important to include about a general wellness experience and this can change how we reflect on events.

Complexities of self-tracking our connections to those around us: Drawing on Haraway, these different more-than-human perspectives might capture negative aspects of relationships which someone might not want to reflect upon. The way this information is presented could also distort or alter the relationship by revealing power dynamics present in a relationship and what parts of general wellness experiences are considered important to capture i.e., this would differ between a dog's perspective and a human's perspective of what is useful to receive. The social context could also be misinterpreted either by a system or someone viewing the information i.e., the closeness and temporality of a connection can change whether information is appropriate to receive.

5.6.3 Next steps

As this chapter advocates for introducing more-than-human perspectives of contextualised general wellness information to move beyond the body, there needs to be more concrete examples of how these ideas might work in practice. That is, including the needs and wellbeing of multiple beings and how we relate to those around us in self-tracking systems. What would it be like to interact with these different perspectives of contextualised general wellness information? Also, what implications might there be for introducing these new perspectives into self-tracking system design? Using speculative methods creating design fiction as world building can explore potential challenges such as harm in self-tracking systems before they are fully implemented and so might provide a starting point for testing these ideas in practice. This could also involve testing potential challenges with including more-than-human aspects in self-tracking systems, such as including negative aspects of a relationship.

Given this overview, it highlights some questions that still needed to be answered in the following chapter:

- How might people interact with information from different more-than-human perspectives and what implications might arise from introducing these perspectives in self-tracking systems?
    - Will these different more-than-human perspectives support understanding of contextualised health and wellbeing information or maybe introducing perspectives makes the information provided more confusing?
    - What parts of health and wellbeing experiences will these new perspectives be able to capture that purely metrics cannot?

5.7 Summary

Focusing on one perspective of what it means to be healthy and well has led to relying on system capabilities through metrics about the body. By explaining the differences between the body, the self and multiple beings, it becomes clear that there is a problem with comparing multiple beings to the self. Judging and comparing bodies to determine wellbeing helps reinforce biases and reveals information about our behaviours and social practices that supports some selves while ignoring or excluding different selves.

To move beyond the body, it is suggested this is done through more-than-human perspectives of contextualised general wellness information. Designers can use this theory to consider how we might use narratives about multiple beings through different perspectives of contextualised general wellness information that moves past bodily metrics. This research suggests that exploring narratives around our current relationships with multiple beings, as well as our relationships to non-human entities like non-human animals, may be a fruitful resource for design. Current research around narratives has started exploring data about multiple beings and how it might reflect on how a self is viewed. Faults with the system as well as our history, geography and culture can contribute to how these narratives are remembered and shaped.

In this chapter, three problems are highlighted with representing relationships in self-tracking systems: social dynamics, digitising relationships, and automating relationships. Social dynamics can change the way a relationship is represented in a system, for example creating new meanings in social relationships. Digitising relationships highlights a fine line between representing the whole relationship while still considering temporal dynamics and human sensitivities. Automating relationships causes concern over how designers shape and intervene when these systems learn and adapt by themselves. Some more concrete examples of how this argument might be applied to self-tracking technologies are discussed. This chapter concludes with the complexities of introducing more-than-human perspectives that might include parts of relationships with multiple beings. To put these ideas into practice, the following chapter will outline a project where participants interact with these perspectives and provide insights into new considerations of contextualised information in self-tracking systems.

Chapter 6 The Cat Study

6.1 Introduction

Chapter 5's Selves and Beings advocates for moving past a singular (system) perspective of contextualised general wellness information. This is because self-tracking systems follow a one-size fits all approach, viewing multiple beings as the same that can be analysed and understood through the same information. This can be seen in Figure 46 with self-tracking apps showing similar interface styles regardless of the body i.e., Figure 46 A&B's human and pet tracking leaderboards and Figure 46 C&D's metricised bodily insights about multiple beings, in this case a dog (C) and someone's mum (D). These apps show how we are now expected to interact with and understand information not just about ourselves but those around us. However, they provide a limited view or singular perspective of what it means to be 'healthy' and 'well'. This perspective provides limited context about multiple being's lives and only represent one small part of our general wellness experiences. It also shows a certain perception of the world, filled with cultural views, social constructs, knowledge, and actions. This can result in systems that support some beings more than others and could mean incorrect insights are made such as unachievable goals.

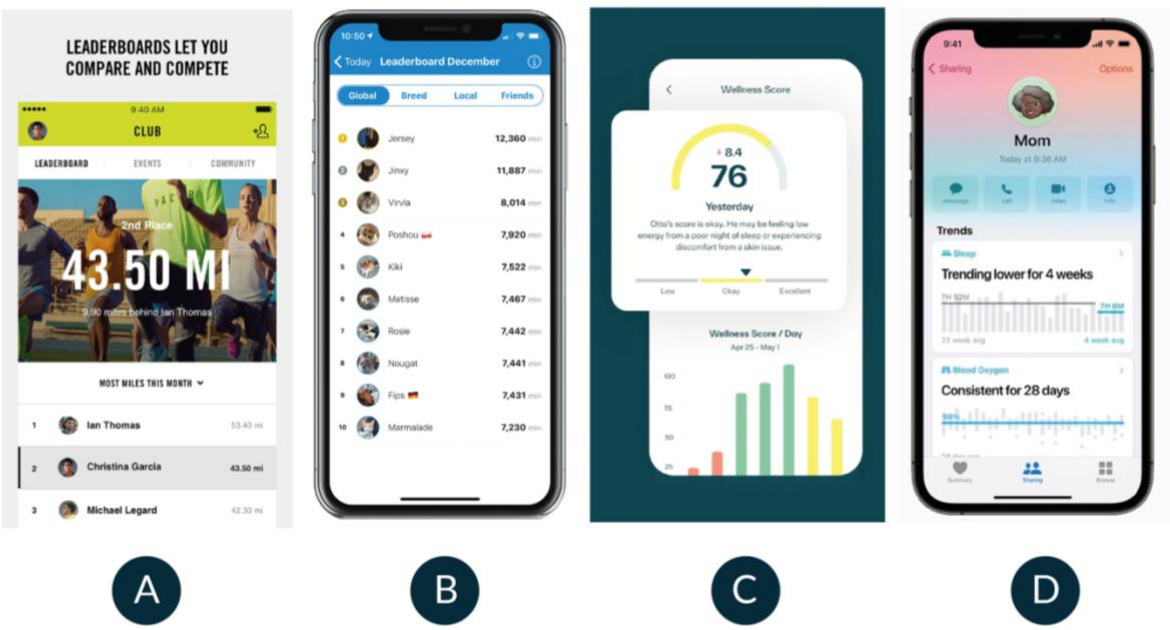

Figure 46 - Examples of self-tracking apps focus on multiple being's bodies. From left to right; A) Nike+ run club app showing a leaderboard against other members source: https://www.pamper.my/news/lifestyle/tech/new-

nike-run-club-app-improves-running-experience/. B) Tractive showing activity minutes of recorded cats across the world source: https://help.tractive.com/hc/en-us/articles/360011008859-What-are-the-different-leaderboards. C) Whistle showing wellness score of a pet source: https://play.google.com/store/apps/details?id=com.whistle.bolt. D) Apple Health sharing features showing health metrics about 'mom' source: https://www.apple.com/uk/newsroom/2021/06/apple-advances-personal-health-by-introducing-secure-sharing-and-new-insights/.

This chapter presents a study that turns the theoretical ideas presented in Selves and Beings into practice. It does this by introducing different perspectives of health and wellbeing information about multiple beings to people who use self-tracking systems. The multiple beings in this case are my cat Dumpling and indirectly my cat Pickle. These different perspectives are based on more-than-human theory and therefore presented here as *more-than-human perspectives*. The goal with this study was to understand the implications of introducing these more-than-human perspectives into self-tracking system design. This was through looking at how people interact with these different perspectives and understand (or interpret) the contextualised general wellness information provided through them. Design methods work well for exploring new considerations of contextualised information because they can test these concepts before they exist in self-tracking systems with the potential to cause harm.

Figure 47 breaks down the core parts of this study. This study began by interviewing cat owners who track things about themselves or their companion animal, looking at their understanding of contextualised information and self-tracking. The study engaged participants in 'A week in the life of Dumpling' (section 6.4.3) where participants were sent updates about the activities of my cat Dumpling via WhatsApp and interacted with the information provided. Each update was intended to highlight one of three key perspectives: a system's perspective (centred on data-led metrics regarding health and wellbeing), a cat's perspective (centred on a cat's view of the world), and human perspectives (centred on text-based interpretations of what was happening). We then facilitated discussions around participant's understanding of this information through a workshop.

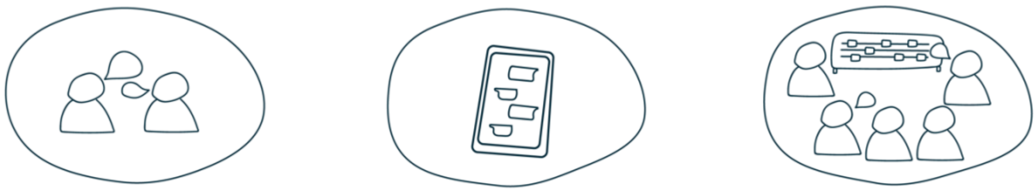

Figure 47 - Structure of the study presented in this chapter.

In this chapter, the reasons for including these perspectives are explained (section 6.2). Following this, the process for developing this study is explained before outlining how this project was conducted (section 6.4). The analysis from this project is then addressed (section 6.5) including the insights gained from this study (section 6.6). This chapter concludes with a discussion (section 6.7) about introducing different more-than-human perspectives of contextualised general wellness information. Through this chapter, potential challenges with including these new perspectives are highlighted. It is discussed whether it is possible to include different more-than-human perspectives without exposing those involved in the information to biases and other harms that could be detrimental to their wellbeing.

6.2 Developing more-than-human perspectives of contextualised general wellness information

As briefly explained in the introduction of this chapter, 3 perspectives were chosen to explore varying viewpoints of contextualised general wellness information about my cat Dumpling (and indirectly my cat Pickle). These perspectives are a system's perspective, a cat's perspective, and humans' perspectives. This section will summarise why each of these perspectives were chosen. These are also summarised below in Figure 48.

Figure 48 - Perspectives of contextualised general wellness information about my cat Dumpling chosen for this study.

6.2.1 Reasons for system perspectives

Chapter 5 shows examples of apps from more-than-human perspectives e.g., Pickle's general wellness experiences when hunting a bird which wouldn't be shown in current human-centric apps. Given the argument that general wellness tracking systems should reflect different perspectives, such as the cat's own perspective, it could be expected that the system perspective presented in this chapter would follow this style. However, the system perspective represents the way self-tracking is currently defined and shown in health and wellbeing (or general wellness) tracking applications centring on these human/technocentric models. This was intentional as humans will be the ones using these applications meaning it was important that this perspective reflected applications participants were used to seeing and could accept the app as something which could or did exist. While ideally self-tracking apps in the future would reflect a cat's perspective regardless of its use to human owners, the app presented to participants allowed the inclusion of some more unusual 'more-than-human' aspects while also acknowledging the steps needed to make an entirely cat-centric app a reality. Therefore, the graphical style of the app followed current self-tracking system design such as goals, metricised bodily insights, AI generated insights to visualise the activities of Dumpling through fictional app screens.

Providing participants with fictional metrics based on current system design we could see how this perspective helps people understand information about multiple beings but also what contextualised information it lacks. This perspective also allowed for the inclusion of more-than-human aspects i.e., negative aspects of cat's behaviour. Viewing these aspects from a system's perspective shows how these different types of information could be included in future self-tracking system design as well as any implications there might be by including this type of information.

6.2.2 Reasons for cat perspectives

Cats in this research represent multiple beings, that is something compared with a human in a self-tracking system. They also represent a close relationship like the ones we have with other humans and things as well. Research in the companion animals tracking space shows many examples of tracking applications for companion animals, but a majority of the research focuses on dogs (Ramokapane *et al.*, 2019; Jayawardene *et al.*, 2021; van der Linden *et al.*, 2019; Zamansky *et al.*, 2019). Canines in these systems are convenient to study because their activities such as walking involves both the human and dog, meaning they spend a lot of time around each other. However, cats are also part of these companion animal applications and lead much more separated lives from their humans, often being able to leave households through cat flaps (except for indoor cats). This means their activities are less known to their owners and can provide unique viewpoints of the world. For example, cats sit on high up surfaces or get into small spaces like boxes and can jump or use their unique bone structure to access areas closed off to humans i.e., going over, through or under fences. Even though they have a unique experience of the world, their general wellness is measured in the same way as different companion animals in self-tracking systems making them interesting to study. Therefore, cat's perspectives are used in this research through cameras that simulate current pet technologies and research i.e., using a fisheye lens to recreate some shots that would look like footage from a cat's collar, similar to the cameras used in New Horizon's cat study (BBC, 2014).

As described by Nagel (1974) we cannot directly access a cat's experience of the world, therefore a speculative approach works well in this instance. Additionally, from a methodological point of view, people can talk about their relationships with their cats as it is familiar to them. This means complex topics such as more-than-human theory and contextualised information can be discussed to gain richer information about self-tracking and our relationships and experiences with multiple beings.

6.2.3 Reasons for human perspectives

For the human perspective updates, it was important to include people's varied interpretations of Dumpling's activities which might change how we relate to our companion animals. This reflects more-than-human considerations about how we create narratives based on our interpretations (Hallam, 2010). This means it is important to consider multiple positionalities by embracing plurality (D'Ignazio and Klein, 2020) acknowledging that people make knowledge from particular standpoints and combining these will help improve understanding of the world. These considerations help to create self-tracking systems that are beneficial for all multiple beings involved. Due to the limited number of participants this research doesn't have a wide range of viewpoints. However, forming the human perspectives from multiple voices offers a starting point for how these voices could exist in future self-tracking systems.

6.3 Developing the structure for this study (how a week in the life of Dumpling was created)

At the second stage of this study, participants were sent updates from different perspectives about Dumpling's activities linked to his general wellness, called A week in the life of Dumpling. While the stages of this project will be discussed in more detail in section 6.4, it is important to understand the process of developing this study, before explaining how this was conducted. The preliminary work needed to create 'A week in the life of Dumpling' is explained here.

6.3.1 Observing Dumpling

For the second stage of this study, participants would be presented with contextualised information about Dumpling's activities from different perspectives through updates via WhatsApp. These updates represented a plausible series of activities a cat might do in their day to day lives meaning Dumpling's behaviours and routine was observed for 2 days. As can be seen in Figure 49, this involved writing down everything Dumpling did over two days in a diary. This followed similar observation techniques for documenting non-human's general wellness behaviours, as discussed in the methodology (Chapter 3, section 3.4.3.4).

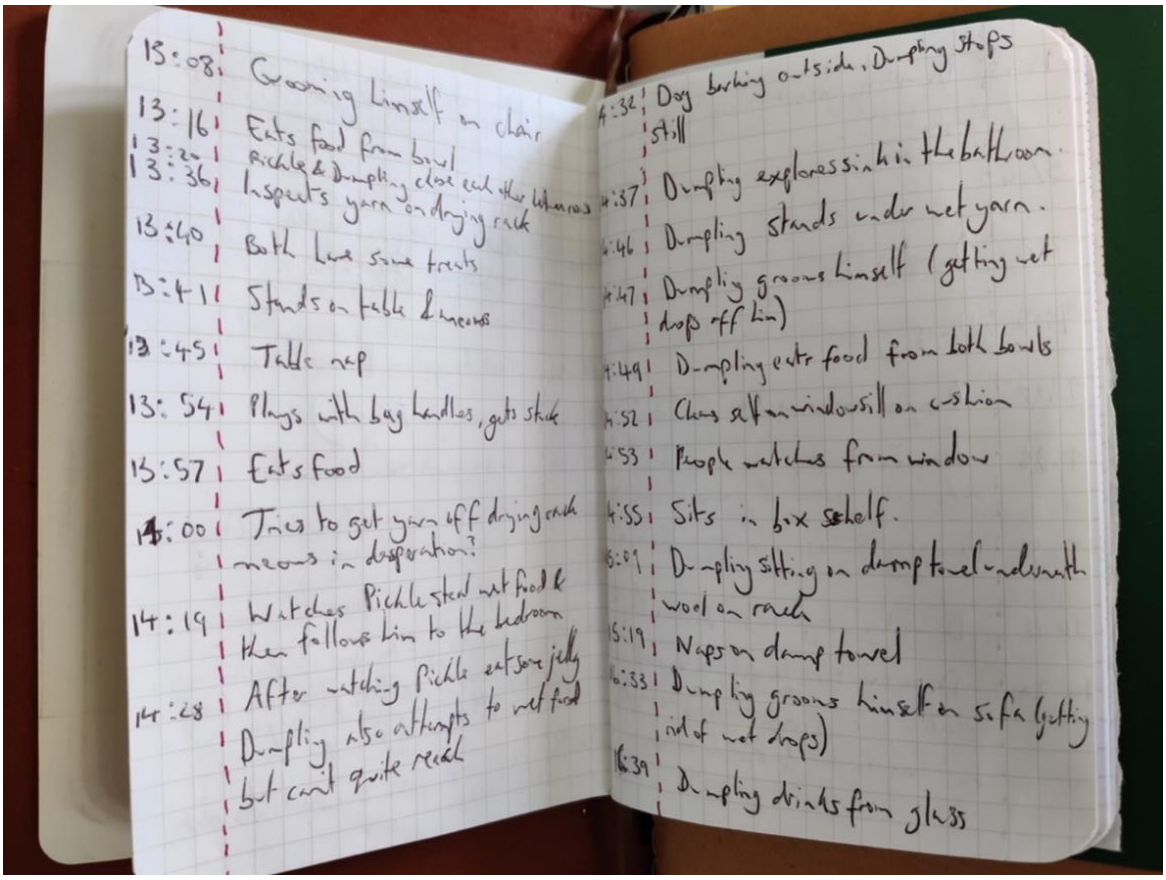

Figure 49 - Diary noting Dumpling's activities.

After the observation period was complete, some interesting moments were chosen as *key events*, seen in Figure 50. The key events formed the general wellness experiences described in the cat & system perspective updates sent to participants during 'A week in the life of Dumpling'.

Day messages were sent	Event occurring
Day 1	Pickle grooming (cleaning) Dumpling
Day 1	Nap on the windowsill
Day 2	Playing with yarn
Day 2	Padding (kneading on the side of the bed)
Day 3	Meowing for food (hungry)
Day 3	Watching out of the window
Day 4	Play fighting across a chair
Day 4	Sneaking into a storage box
Day 5	Chilling in the hallway
Day 5	Playing with a cardboard box

Figure 50 - Key events chosen as Dumpling's activities that would be sent to participants during 'A week in the life of Dumpling'

During observation, pictures and videos were also taken from various angles to test the best approach for creating the cat perspective updates. (i.e., up high Figure 51A, far away Figure 51B, up close Figure 51C&D, from the floor Figure 51E&F, through different camera lenses like landscape mode Figure 51G).

Figure 51 - Pictures of cats taken while observing Dumpling's actions, different angles were taken to understand what was best for simulating cats' perspectives.

6.3.2 Creating the perspectives updates

Now it was clear what activities were chosen to represent Dumpling's general wellness experiences, the various perspectives could be created. The process for creating these perspectives is outlined here.

6.3.2.1 System Perspective updates

The system perspective updates were created in Adobe XD, extending from the same visual style used for the 'cat interference' screens in the creation of CoCo. Updates created included charts/graphs breaking down sleep quality (Figure 52C) and more unusual information based on current self-tracking goals (Figure 52A). Additionally, machine learning capabilities were included to provide more contextualised information i.e., identifying emotions and behaviour from audio clips (Figure 52B). Participants were also sent goals and gamification style updates such as badges (Figure 52D). As will be discussed later, some more-than-human aspects were also included in the system perspective updates as seen through negative aspects of the cat's behaviour (fighting metrics) (Haraway, 2003).

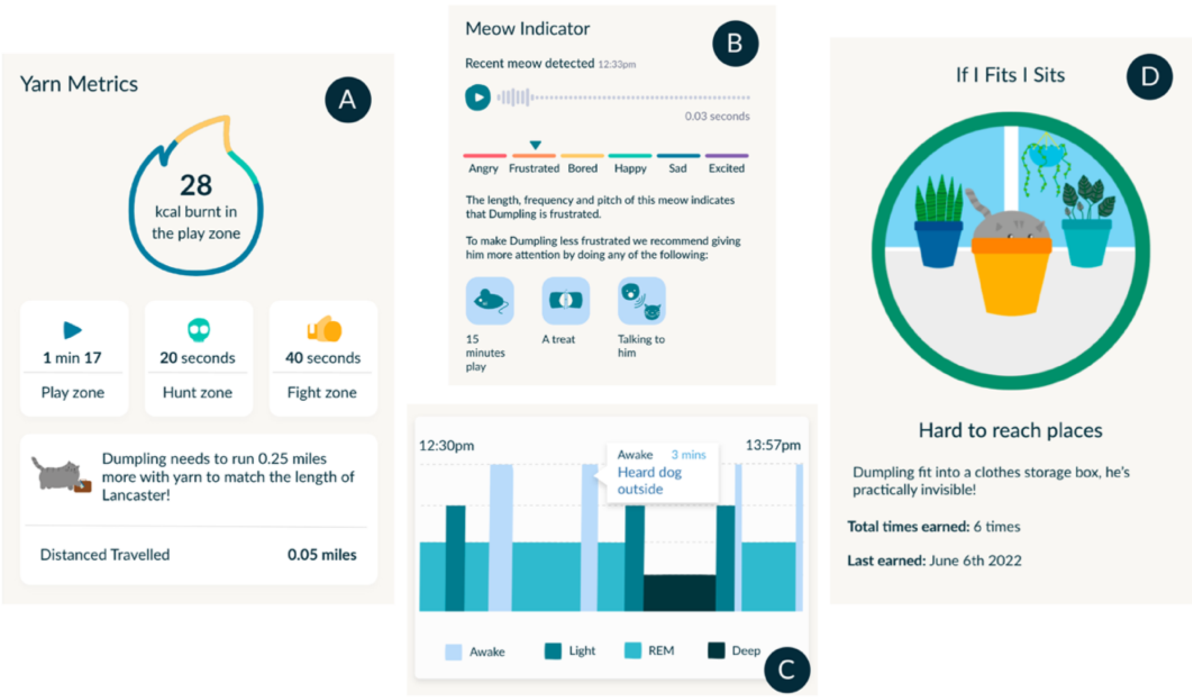

Figure 52 - Examples of system perspective messages sent to participants

6.3.2.2 Cat Perspective updates

The cat perspective updates represented the viewpoint of my cat Dumpling. For this perspective, participants were sent information through short video footage clips and photos from Dumpling's point of view (Figure 53B-D). Therefore, this also included footage about my other cat Pickle (Figure 53B-D). This footage was obtained through a cardboard 'cat-bot' (Figure 53A), using a Raspberry Pi 4, CamJam robotics kit and a Pi camera module v2.1. This follows similar Critter Cams and other video footage used in wildlife research as outlined in the research process chapter, section 3.4.3.4. Audio only content was also included in one update to see if non-visual information produced different understanding of the events occurring.

Figure 53 - Examples of messages from cat perspective sent to participants

6.3.2.3 Human Perspective updates

To create this perspective, we took participants responses to questions asked they were asked in 'A week in the life of Dumpling' such as: Based on the information you've just received, what do you think Dumpling was doing? These responses were sent to other participants to form the human perspective updates (see Figure 54). This perspective was created from other participants responses so we could explore if different interpretations provided additional knowledge and contextualised insights about what Dumpling was doing.

6.3.2.4 Structuring the perspective updates

As explained in section 6.3.2.3, the human perspective was gathered from different participant's responses. This meant developing an approach for gathering these responses and sending them to other participants. To make this easier to conduct, a randomised number was given to each participant, participants 1-3 would receive some updates with certain contextualised information from certain perspectives while participants 4-6 would receive others. This is explained in Figure 54 & Figure 55, with the icons representing the different perspectives i.e., cat = cat perspective, smiley face = human perspective, bot = system perspective.

As seen in Figure 54, if participants 4-6 were sent the cat and system perspective updates, participants 1-3 would receive a human perspective update (in this case they also received a cat update). Each set of participants received all perspectives individually (i.e., only receiving a cat update or only receiving a system update), as well as with different perspectives (receiving both a cat and system update together). This was to make sure responses were based on their actual understanding of the information rather than ordering effects. The following section will explain how this project was conducted, including examples of how this structure worked for the updates sent in WhatsApp during a week in the life of Dumpling.

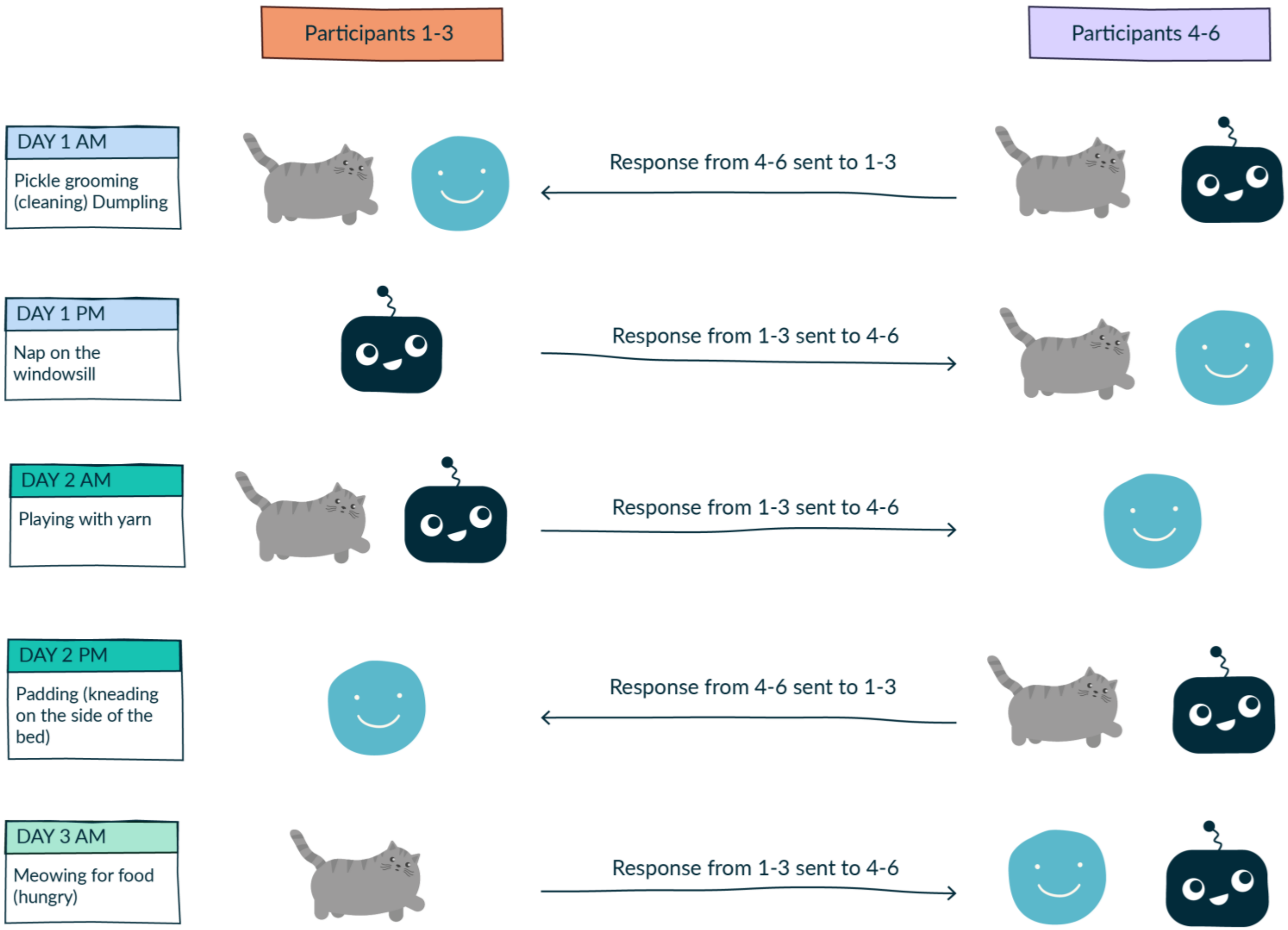

Figure 54 - Structure of varying levels of contextualised information (which participants received which updates from different perspectives) Day 1 am – Day 3 am

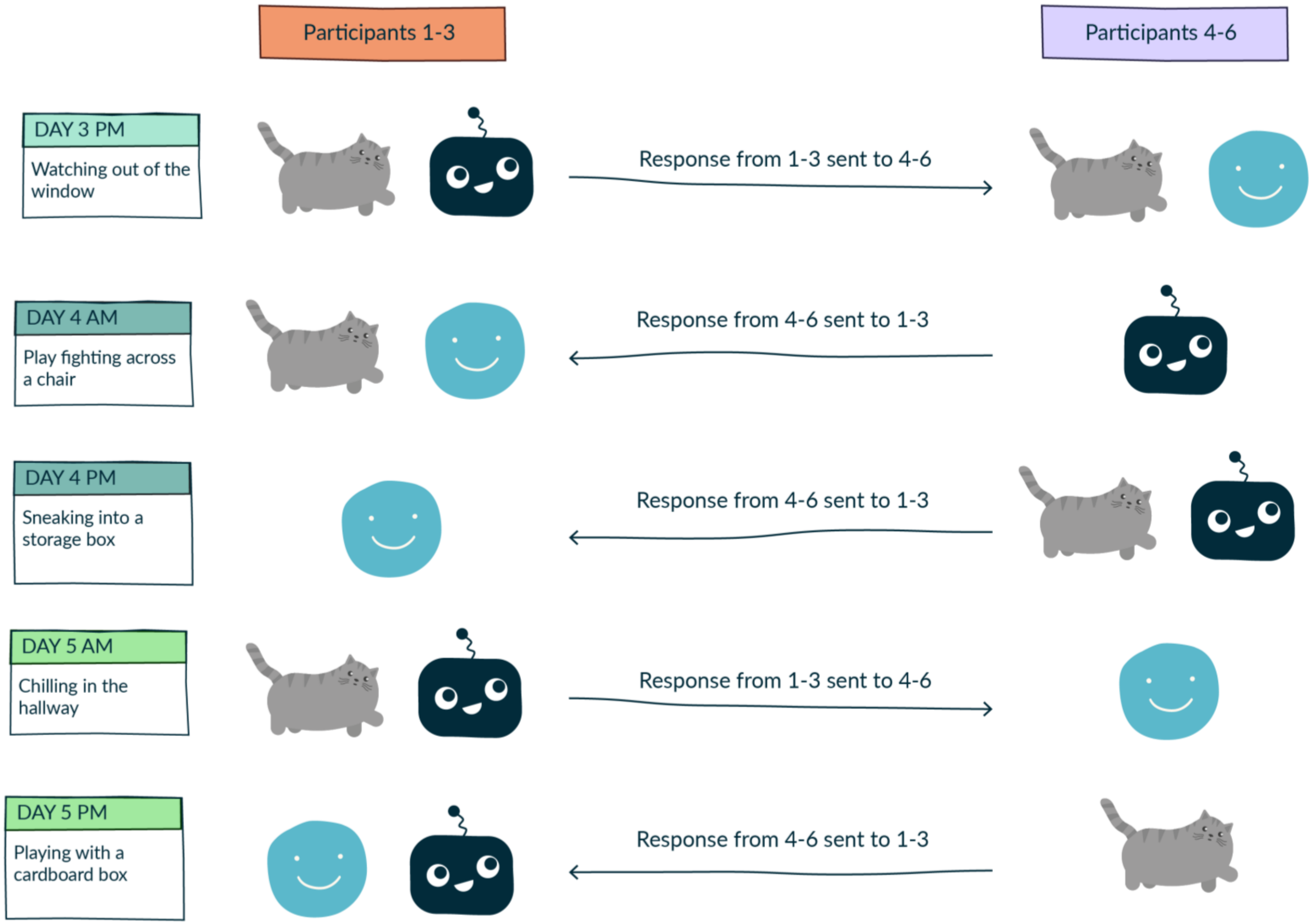

Figure 55 Structure of varying levels of contextualised information (which participants received which updates from different perspectives) Day 3am – Day 5pm

6.4 Conducting the study

6.4.1 Participants

6 people were recruited for this study. To reach both University and non-University staff, a poster was created and shared on social media channels (as described in 3.5.1). These posters were also placed around the University campus and sent via emails to colleagues within the University. This poster, along with other documents submitted for ethical approval, can be seen under Appendix B, B.1-5. Participants needed to fit the following simple criteria; they are over 18 years of age, currently track something about themselves and own a cat. The poster provided an email address to contact if people were interested and 10 people responded. They were sent a short questionnaire to fill out to check if they fit these criteria. These questions included general demographics information, a few questions about owning a cat and participant's current tracking practices. This allowed us to see how much experience participants had with both tracking and cat ownership prior to the study and design interview questions to fit this experience level. Four participants did not fit the criteria for different reasons i.e., some misunderstood the study and didn't track anything about themselves.

Possibly because of the criteria, only a small number of people were chosen to take part in the study, 5 females and 1 male. However, some other studies involving people's reactions to prototypes or self-tracking information have also used a small number of people (Wang *et al.*, 2017; Brombacher *et al.*, 2022; Ng *et al.*, 2022). As Desjardins et al., note, in this study rather than trying to represent a large population of people we were "aiming to find interesting and unique positions" (2020, p. 3). This project gathered participants to explore individuals' experience understanding contextualised general wellness information about multiple beings. Therefore, a small number of participants with their "unique positions" allowed for more in-depth discussion during the later stages of this project. It would have been impossible within the scope of the project to try to represent every human's experience.

However, this project provides a starting point for how these perspectives might be included in future system design. It also provides a potential method that future researchers could use to explore alternative perspectives. Figure 56 shows the demographics of the selected participants. Participants were given a £50 voucher to reimburse them for their time spent taking part in this study. This research was granted approval by the institutional ethical review board (see section 3.5).

Participant number	Age range	Gender	Ethnicity
1	45-54	Male	White
2	25-34	Female	White
3	35-44	Female	White
4	25-34	Female	White
5	45-54	Female	White
6	25-34	Female	White

Figure 56 - Table showing demographics of participants

6.4.2 Interviews

As described by Gray (2021), interviews are useful for exploring feelings and attitudes around a topic as well as providing participants with an opportunity to reflect on events. Therefore, interviews were useful in this research to gain an initial understanding of self-tracking prior to receiving any information about a cat and gather information related to participant's experience of living with their cat. This provided a reference point to look at when analysing their understanding of self-tracking information before and after a week in the life of Dumpling. All interviews were conducted via Microsoft Teams lasting between 35 and 40 minutes. The interview was split into four sections: questions about their cat, tracking habits, their thoughts around self-tracking and their initial understanding of contextualised information and self-tracking. The questions participants were asked can be seen under Appendix B, B.5. The data from the interviews will be discussed in 6.5 as part of the analysis, along with data gathered from 'A week in the life of Dumpling' and the workshop.

6.4.3 A week in the life of Dumpling

6.4.3.1 The week receiving messages about Dumpling

Participants were sent updates about what Dumpling was doing from different perspectives via WhatsApp twice a day for 5 days. We referred to this aspect of the study as 'A week in the life of Dumpling'. With each group of updates sent, participants were also asked what they thought was happening in the information provided and expected to reply with their opinions. They were sent an introductory video[12] to guide them through A week in the life of Dumpling.

While the updates were curated and some fictional, all updates represented contextualised general wellness information about Dumpling's health and wellbeing. These insights gave participants information or interpretations such as artificial intelligence (AI) generated insights, video clips[13] or photos about Dumpling's activities. The idea was that these insights were derived from health and wellbeing data such as sensors and unedited video or audio etc. As explained in 6.3.2.4 which updates participants received varied, splitting each participant into a group randomly (1-3 or 4-6) to help structure the different perspective updates they were sent during the week. An overview of the updates sent to participants from different perspectives are outlined below. The relevant icons symbolise the perspective they are from: cat = cat perspective, face = human perspective, bot = system perspective. Videos sent to participants are indicated by the play icon. It should be noted that like the diagram in 6.3.2.4, participants did not receive everything listed under each event i.e., day 1 am participant 1 received an update from one of the faces and the cat

[12] Introductory video the participants were sent: https://youtu.be/KQ7hULwtlOc

[13] While all updates participants received are outlined below, a playlist of the video clips they were sent has been created. Please visit the following link if you would like to view these videos: https://youtube.com/playlist?list=PL2WMjHrq_SAl-NpSrh-qjmnroKNG5MCRA

video but participant 4 received the cat video and the two app screens about cleanliness.

Figure 57 – Day 1AM – Day 2AM updates sent to participants

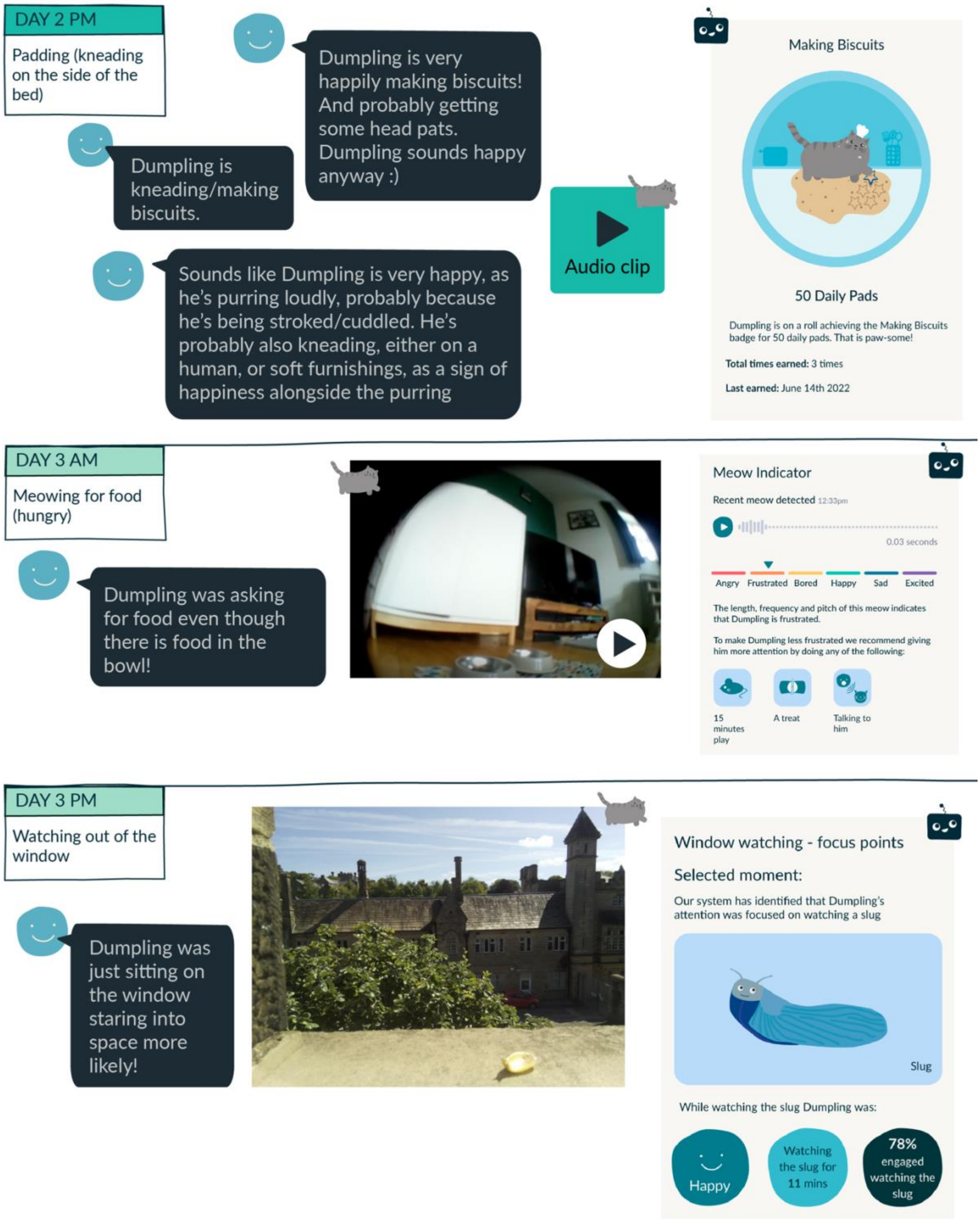

Figure 58 – Day 2PM to Day 3PM updates sent to participants

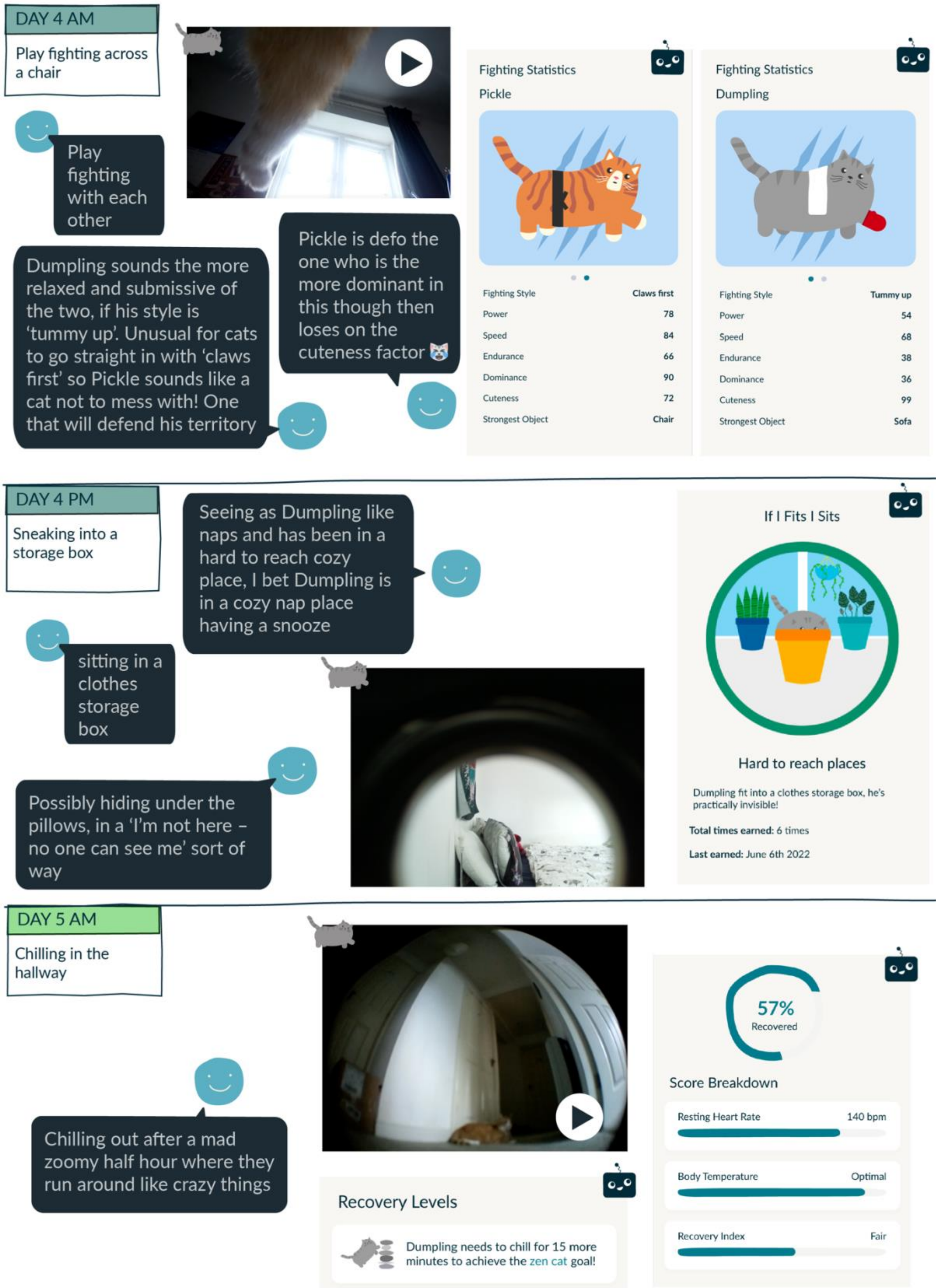

Figure 59 – Day 4AM to Day 5AM updates sent to participants

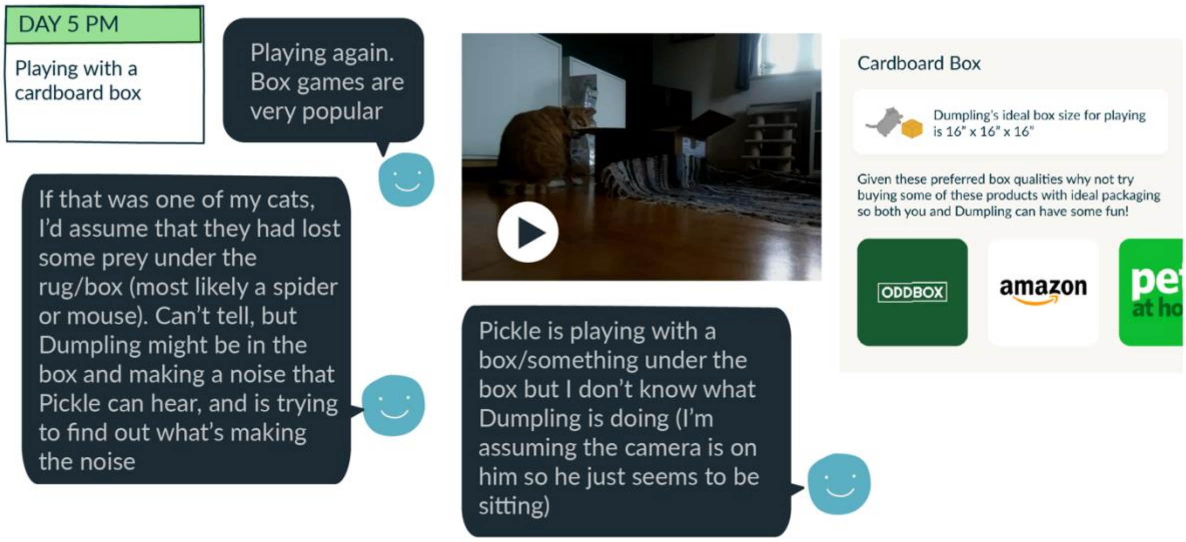

Figure 60 – Day 5 PM updates sent to participants

As the human perspective messages were generated from different participants, Figure 61 & Figure 62 show how this worked in WhatsApp. These figures show examples of updates and responses from participants throughout the week.

In Figure 61 we can see updates participants received on the morning of day 3 (Dumpling watching out of the window). Participants 1-3 were sent updates from the system and cat perspective. The system perspective update shows metrics about Dumpling watching a slug and the cat perspective update shows the view from the window with the shadow of the 'slug' on the window ledge. These participants are asked what they think is happening. Depending on response times of participants, sometimes one participant's response would form the human perspective. This was to ensure everyone still received one set of messages in the morning and another set in the afternoon giving everyone plenty of time to respond. Here participant 2's response was sent to participants in the group 4-6 along with an update from the cat perspective (the window picture). They would then also be asked what they thought was happening with Dumpling.

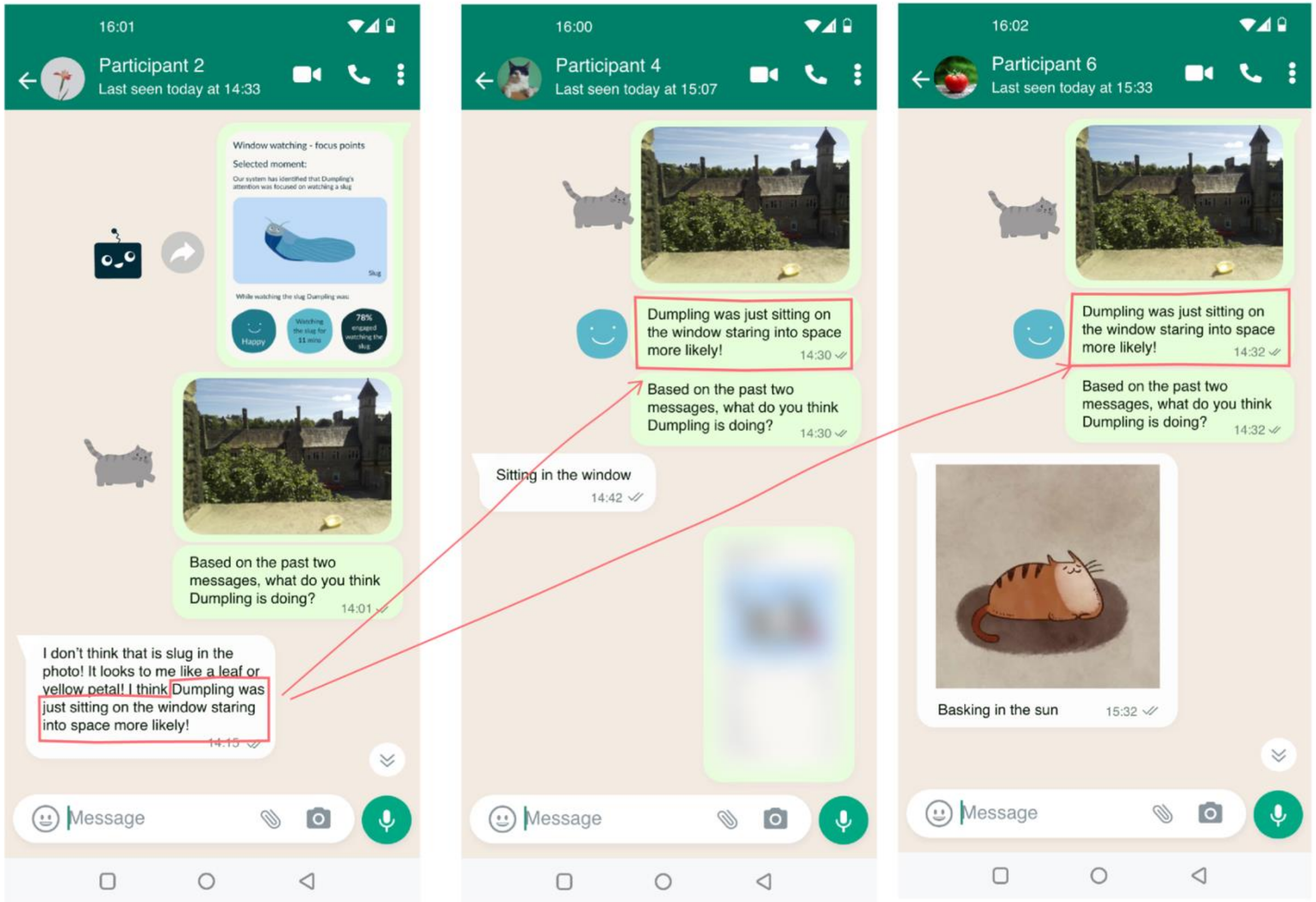

Figure 61 – Updates sent to participants 2, 4 & 6 the afternoon of day 3 and their responses. To form the human perspective, participant 2's response was sent to both participant 4 & 6. WhatsApp layout & profile pictures have been created in Adobe XD to protect anonymity. Picture blurred out in 4 because it relates to the following update..

For another example, Figure 62 shows updates participants received on day 4 (the cats fighting). Here participants 4-6 were only sent the system perspective (metrics comparing the cat's fighting styles) but some of the participants responded quickly, so participants 1-3 received varied human perspectives. As seen in this figure, participant 5's response was sent to participant 2 and participant 4's response was sent to participant 3. Participants 1-3 also received the cat's perspective video (Pickle jumping on a chair). Using participants to develop the human perspective also reduced confirmation bias, as these updates could not be curated to align with my beliefs about what might be considered confusing or understandable information.

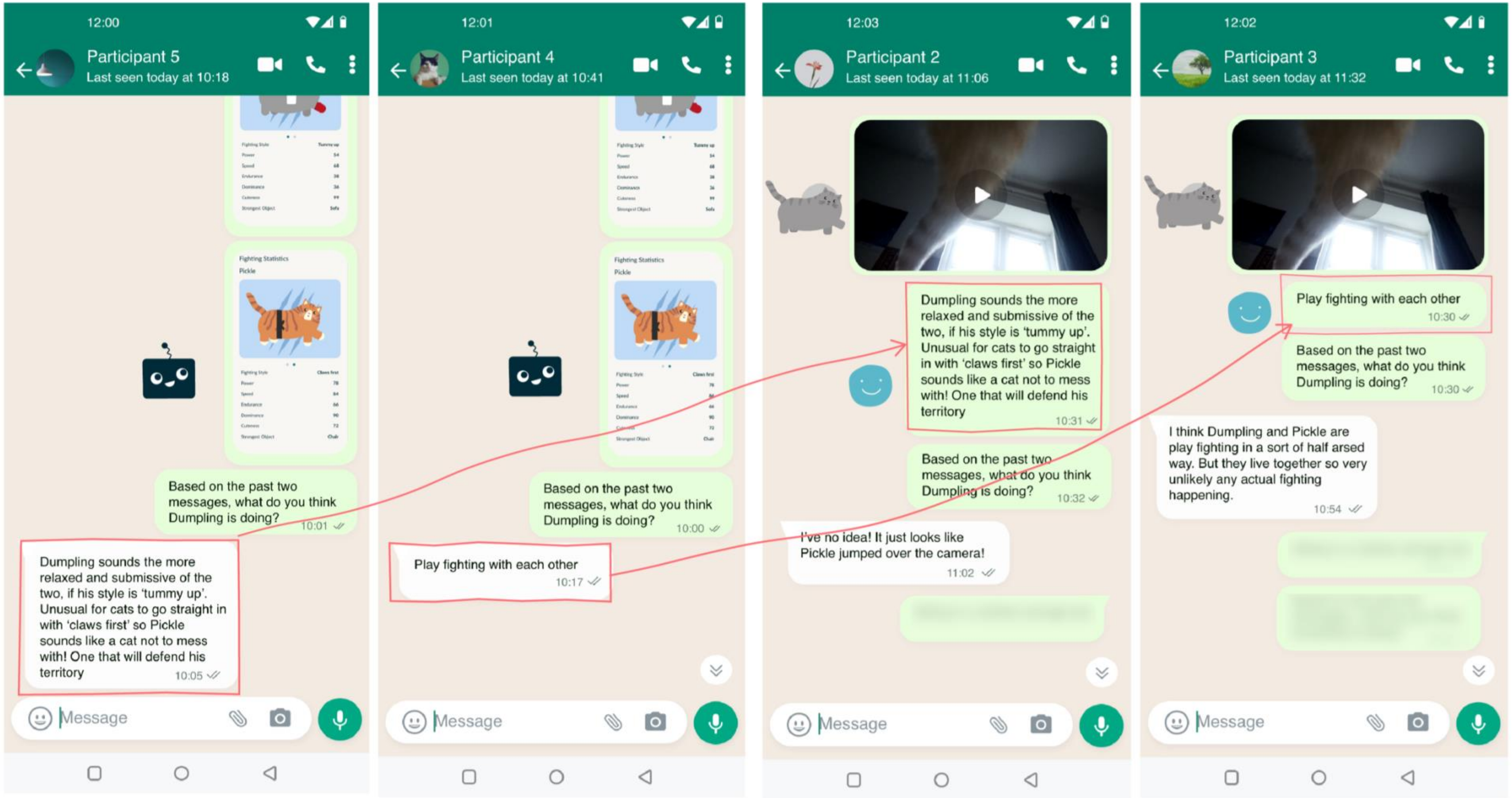

Figure 62 - Example of updates sent to participants 5, 4, 2, & 3 the morning of day 4. To form the human perspective the response from participant 5 was sent to participant 2 and the response from participant 4 was sent to participant 3. WhatsApp layout & profile pictures have been created in Adobe XD to protect anonymity. Messages blurred out as they relate to the follow prompt.

6.4.4 Workshop

The workshop had to be shortly after the week experience, so participants did not forget what they were shown. However, this was conducted over the summer and with annual leave creating challenges, the workshop was done with one participant first who couldn't make the chosen date for the workshop. Their responses were included in the activities used for the main workshop, so all 6 participants thoughts were discussed in the main workshop. For the first workshop, notes were made to capture the participant's thoughts that were not present on the post it notes. Ethical approval for audio recording participants was obtained after it was proven difficult to write responses from 1 participant, let alone 6. A second researcher wrote orange post it notes (as seen in Figure 63) to summarise the conversation.

The workshop began with a short presentation where the concept of context-awareness in self-tracking was explained so participants could later understand why they were sent varying levels of contextualised information. Following this a short icebreaker gave each person an opportunity to introduce themselves and their cat either through pictures sent beforehand or through the participant's own devices. This helped the group to become comfortable with each other and learn a bit more about everyone's experiences living with a cat. The workshop was split into two parts with the first half focused on contextualised information (Figure 63) and the second half focused on the perspective updates (Figure 64). For the first half of the workshop, participants were presented with the timeline of the updates they were sent during 'A week in the life of Dumpling'.

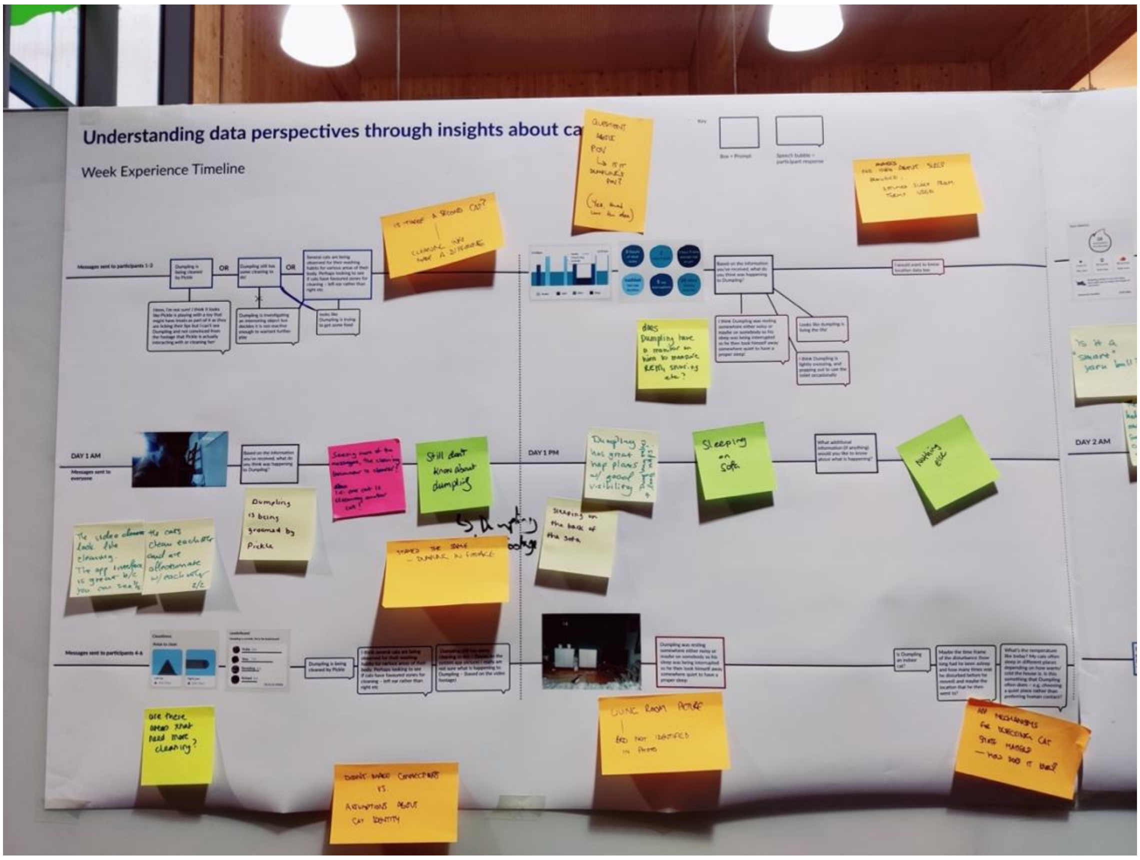

Figure 63 - Activity 1 – Timeline of events showing different levels of context people were sent

The timeline (seen in Figure 63) was split into 3 variations of information participants received - the top line what participants 1-3 saw, the bottom-line what participants 4-6 saw and the middle line representing updates sent to everyone. Participants were asked to read through the timeline and summarise in a few words on a post-it note what activity they thought Dumpling was doing. While they were asked to do this during the week in the life, they now had additional information from updates other participants were sent. Facilitating a discussion allowed participants to expand on initial thoughts given during the week in the life, as well as provoke a deeper discussion around how additional information changed this understanding, interpretation, and awareness of context.

Participants were initially confused about the different types of information provided, after explaining the concept of different perspectives i.e., cat, system etc. they engaged well with the task. As the workshop was held in person, the paper timeline could not display audio and video content to participants.

Responses were based on a screenshot from the video or knowledge from other videos they were sent throughout the week. It would have been helpful to have a digital version of the timeline so that both versions could have been used for the 'interactive' elements i.e., videos and one audio clip. However, participants provided in depth responses about the week in the life of Dumpling. Therefore, if these 'interactive' elements were included, a much longer workshop would have been needed.

For the second half of the workshop, participants were asked to write post it notes for different strengths and weaknesses of each perspective (Figure 64). This was articulated to participants as whether there was a type of information they preferred or whether there was something they could have only learnt from one of the perspectives that maybe made it easier to understand what was happening in the information provided. Figure 65 shows a close-up version of some of their responses about the weaknesses of the human perspective.

Following this, participants were asked to use yarn and paper tags to link these arguments across the different perspectives. This allowed us to see if different perspective updates provided unique contextualised information. This was especially true for information from more-than-human perspectives, representing types of information not currently present in self-tracking systems. This was explained to the participants through a couple of examples i.e., if you received system perspective updates and you thought the metrics were easy to understand, if you received the cat perspective update at the same time, was this a weakness? For example, did it cause confusion in addition to the metrics you received? Initially, this was a harder task for participants to grasp overall, struggling to understand how the human perspective would be implemented in self-tracking systems. After explaining that this wasn't about whether this was possible to implement, participants were able to successfully engage with the task, as can be seen through the number of post-it notes produced. To see additional photos taken from the workshop, please see Appendix C, C.2. and for text versions of these responses, see C.2.1.

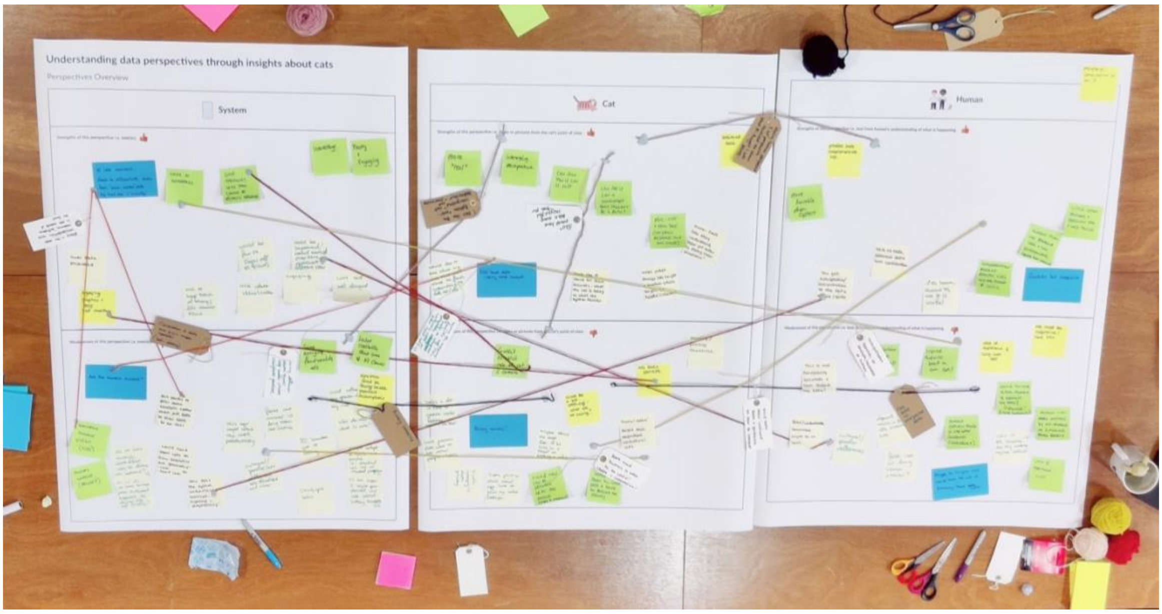

Figure 64 Activity 2 – Participants thoughts around each of the perspectives top picture shows the completed activity.

Figure 65 – Activity 2 zoomed in view of the weaknesses of human perspective, to make some of the responses legible.

6.5 Analysis

6.5.1 Conducting Reflective Thematic Analysis (RTA)

As explained under Chapter 3 section 3.6.1, all data was analysed using Braun and Clarke's reflexive thematic analysis (RTA) (Braun and Clarke, 2021). Within RTA there are phases for carrying out qualitative analysis, but as explained under the methodology, there is not a set 'recipe' to follow. As a reminder of these phases a diagram is provided in Figure 66. This diagram shows that RTA provides guidelines and does not mean following a linear process i.e., you don't have to complete one phase and then move onto the next. This form of analysis acknowledges that this process will differ depending on whoever is conducting the research. Therefore, it is more about researchers reflecting on their own views and biases (hence the term RTA) and using this to judge whether certain phases need to be iterated upon.

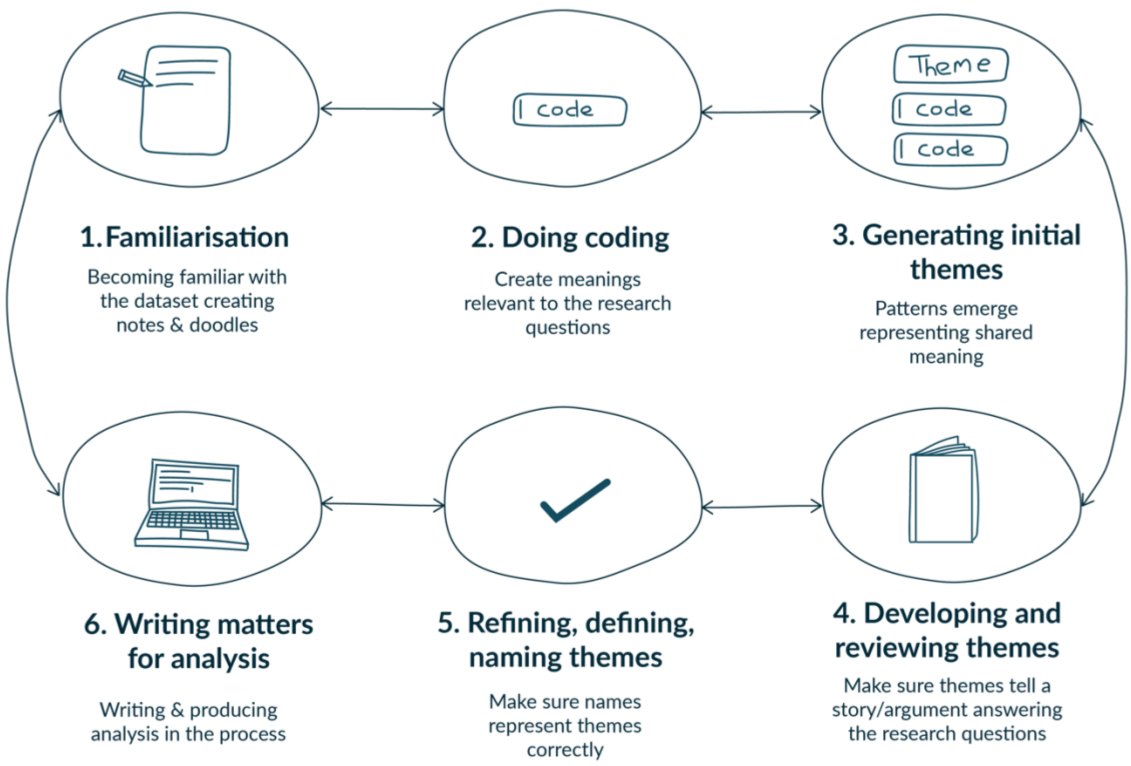

Figure 66 - RTA process. The arrows indicate that this is not a linear process and you can go back to any phase wherever necessary.

Following the phase of familiarisation, I went through all the documents for the interviews, the week in the life and workshop. Initially I highlighted anything that seemed like it was interesting to note. I began creating codes for everything I thought could be interesting before moving onto the next stage. However, it became clear that this is not RTA but grounded theory (see section 3.3.1.2) and I was producing codes that would have tried to address completely different aims. For example, capturing technical issues participants had with self-tracking sensor accuracy, which are problems for computer scientists and engineers to address rather than designers.

After revisiting Braun and Clarke's practical guide several times, I began to understand the approach a bit more. I still used this initial misunderstanding to familiarise myself with the data and see how certain elements from interview responses could be useful to capture at this stage. To summarise this familiarisation, a diagram was created showing factors from interview responses that might affect people's understanding i.e., participants who worked with data as part of their job. This data was not needed for creating codes and themes as it did not directly relate to what this study was trying to answer (how people interact with (and therefore understand) contextualised general wellness information from different more-than-human perspectives). However, the diagram helped reflect on the experience levels of the participants i.e., how long they've owned a cat for.

An example of this familiarisation diagram is shown below in Figure 67. This describes 3 participant's cats outlining factors that might change the participants' understanding of data (please note all cats' names have been anonymised). For example, Lasagne's owner manually tracked his weight and medication schedule. Therefore, this participant had a better understanding of health and wellbeing cat metrics, having already carried out similar practices themselves. Equally, Beans' owner used a WhatsApp group to share pictures of his whereabouts with neighbours, therefore this owner was used to sharing data about a cat with those around them.

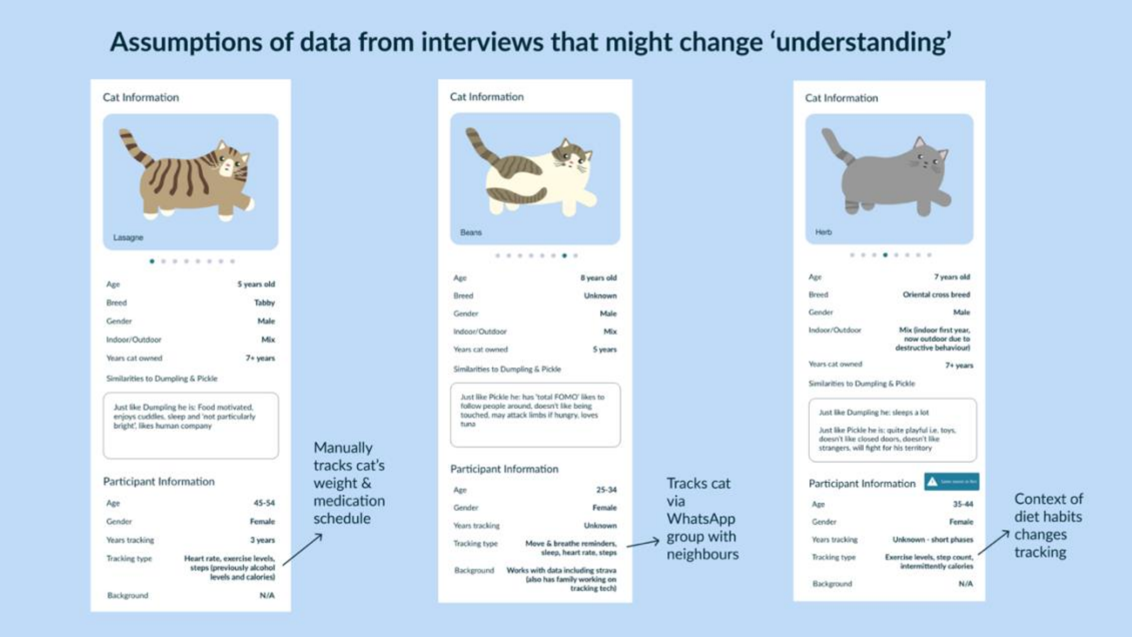

Figure 67 - Assumptions of data from interviews that might change understanding diagram

To conduct this analysis, the qualitative software tool NVivo was used. This software helped analyse interviews and other text-based documents to help streamline the process. This worked well for most stages of the research but, in design research, different creative methods i.e., workshop activities using post it notes, means the analysis stage relies on interpreting photos as well as text. This software did not work well for photos, selecting the wrong part of the photo, making the codes less useful for analysis. This required converting these photos to text for analysis while noting the relevant positioning of post it notes as this was useful to see what updates helped participants interpret the contextualised information provided.

Following familiarisation, codes were created linked to specific contextualised general wellness information different perspectives provided or missed i.e., more-than-human perspectives were found to help people explain the cat's emotions and feelings, so the code emotion was created. These codes were sorted and adapted under themes related to what this revealed about the different perspectives i.e., one theme being subjectiveness of more-than-human perspectives. Additionally, codes were created for logging purposes. For example, anything linked to an interview was recorded under an interview code, same for workshops etc. To help understand how certain participants views might have changed across the study, anonymised codes representing each participant were created as ‘voices’ to differentiate between the responses recorded. Additionally, where relevant responses linked to a particular perspective i.e., cat, system, human were coded under relevant codes to help make later stages of analysis easier to conduct.

To refine the initial created codes, rather than having broad themes that represented a range of responses to an issue, code labels were adapted to better explain shared meanings. For example, it was found that the system perspective uses comparisons to help people make sense of information but specifically this was because self-tracking systems compare our data against historical data (i.e., data from the past month) as well as comparing us against other users (i.e., is the cat in a typical range compared with other cats of the same age and breed). This allowed patterns to emerge across the dataset and meant I could reflect and iterate on the created codes and themes. Across all phases, notes were made to reflect my thoughts around the emerging themes and patterns which helped to decide on relevant themes in later stages of the analysis. The following section explains themes that emerged from this analysis.

6.6 Insights from the study

The themes presented here link across all stages of the study with relevant responses from participants in the interviews, a week in the life and workshop included under each of these themes. The themes provided outline what the system perspective could or could not provide to help interact with (and understand) contextualised information about multiple beings’ general wellness. Following this the more-than-human perspectives themes are discussed to highlight the implications with introducing these different types of contextualised general wellness information in self-tracking systems. Throughout the analysis where quotes are used, P = Participant response. However, due to the use of post it notes etc. it was not possible to attribute all quotes to specific participants in the workshop. These are written as either WA1/2 = Workshop Activity 1 or 2.

6.6.1 Understanding the system perspective of contextualised general wellness information

Throughout our analysis, the participant's responses revealed that metrics, whether the ones used in the system perspective updates or more generally self-tracking systems, do help understanding of health and wellbeing insights from data. Interface design can transform complex data into simple metrics and gamified methods such as comparing metrics to other users which helps ease our cognitive load (section 6.6.1.1). However, this design suggests there is a correct way to act on the information provided. This can be problematic because of the trust people have in this information to guide them. But this system perspective can only act on partial, limited information that can be measured. Additionally, the system perspective contain bias from those developing it and can lack contextual information about someone's life. This could result in harm and limited effectiveness, if people can't follow information catered towards a particular type of user rather than an individual (section 6.6.1.2). Subsequently, this analysis supports the inclusion of more-than-human perspectives in self-tracking systems which might provide different considerations of contextualised general wellness information (section 6.6.2).

6.6.1.1 The system perspective can aid understanding through simplified metrics and comparisons

Across all stages, participants responses suggested that the interface design in the system perspective helps transform complex data into simplified metrics and gamified mechanisms. This supports understanding through features such as activity zones, targets, and goals i.e., aerobic or anaerobic heart zones (P1) which helped participants perceive how close they were to achieving a goal. These inferred insights were viewed as different to traditional graph-based information. Seen by participants as providing meaning or 'value' as described by one "I like numbers. Good to differentiate data from 'value-added' data e.g., heart rate v 'activity'" (WA2 Figure 68A). Participants responses also highlighted how comparative metrics helped their understanding, mentioning in interviews how they compare their own metrics against a "typical range" (P4). This range might be data pooled from multiple people that represent a norm, using factors such as demographics to compare people. This creates cognitive ease, allowing our minds to effortlessly identify causal connections between things (Kahneman, 2011, p. 10). This also seemed to apply to comparisons between cats, as described in the workshop “is that a normal HR for a cat of Dumpling’s age? How does it compare?” (WA1 Figure 68B).

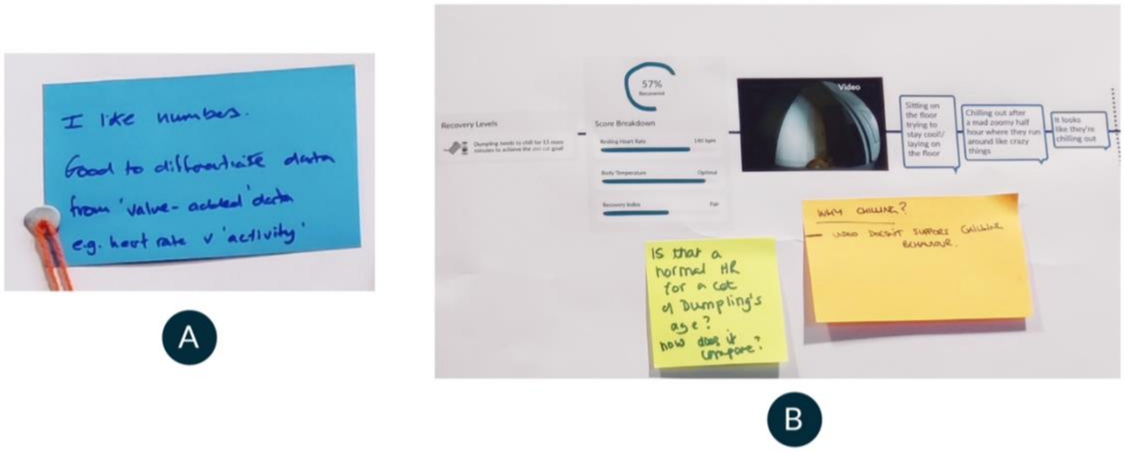

Figure 68 - Participants responses linked to simplified metrics and comparisons. A states “I like numbers. Good to differentiate data from ‘value-added’ data e.g., heart rate v ‘activity’”. B states “Is that a normal HR for a cat of Dumpling’s age? How does it compare?” with the researcher’s comments on the post it note stating “why chilling? Video doesn’t support chilling behaviour”.

6.6.1.2 The system perspective misses out the complexities of real life

However, participants revealed that they rely on the system perspective to explain the complexities of real life. This indicates issues with this current approach to self-tracking system design. During interviews, participants reasoned that there was a correct way to improve on health-oriented metrics “so it’s that sort of thing really. It’s being able to quantify. You doing enough? Are you doing the right sort of thing” (P1). This “enough” or “right sort of thing” implies that there is an expectation from the system about how someone should exercise. Equally, there’s an assumption from people that the system will inform you of the correct, or expected way, to improve on the information provided. Even if these insights do not really mean anything, numbers and goals were significant in how people interacted with and used self-tracking systems:

“this is the point with the technology is— we're none the wiser. So we just latch on to that and then you're like, well, I'm only doing 6-7. How? This is a disaster that I'm not getting my daily 10,000 steps when that's the number plucked out of the air for symbolic value” (P2).

These examples show the trust people place in these self-tracking systems. Even if the metrics are arbitrary, people might change their behaviour or try to achieve goals outlined by a system (Kersten - van Dijk *et al.*, 2015). As shown in previous literature, this can produce strong emotions such as feeling like a “disaster” when they can’t reach the expectations of the system (Ancker *et al.*, 2015, p. 16).

The system perspective was found to be too generic as it “doesn’t adapt to each cat maybe i.e., disabled cat, cat w/thyroid problems as an owner I might get stressed my cat wasn’t hitting targets” (WA2). Due to this lack of personalisation, it might mean people receive insights about themselves or multiple beings that are not appropriate for them to receive. Both cats described would not be able to reach activity levels of an able-bodied cat. This not only renders the insights as meaningless but could result in harm of both beings involved in the metrics. If people trust the metrics, they might overexert their cat by trying to act on the insights given. They could also stress themselves out if they believe that not achieving these targets indicates inadequate care of their companion animal.

Participants also questioned whether those developing health and wellbeing tracking systems give people contextualised information that is easy to measure, rather than what people might want to know. This raises questions about how these decisions are made. For example, a system perspective update with cat fighting insights, used cuteness as a metric. This prompted one user to ask, “who decides what is cute?” (WA2 Figure 69A) and questioned the reliability of the information provided “do we have enough peer reviewed research to deliver the app reliably” (WA2 Figure 69B). One participant argued that the design of these systems reflects societal values. Therefore, these systems reflect not what is important to an individual but what other people think we should be doing to be "good, healthy consumers and citizens" (P2). Participants noted that this can lead to bias, as those creating the systems can only create "mirrors of ourselves" (P6). Therefore, if there is a lack of diversity in those developing the system such as being "a certain class of male and educated male" (P6), they could promote certain life experiences over others. This could all culminate in providing systems that are understandable for some people but not for others. For example, the system perspective update's use of idioms reflects cultural and language barriers that could be present in a system, as well as my own worldviews and biases embedded into the self-tracking system metrics presented to participants. Insights about Dumpling padding on the side of the bed caused confusion for many participants with this response showing the full extent of this confusion:

> *"How can a cat make biscuits?! They can't hold the spoons... I would want to know what sort of biscuits metaphorical?" (P3)*

As this is a UK based project, the term "making biscuits" (see Figure 69C) was not familiar with everyone. This is often an American term, showing the importance of language used within system design to help with understanding of contextualised general wellness information. As well as cultural, it is also an accessibility issue if the language used is unclear. For example, people on the autism spectrum may struggle to understand what is happening from a text description if filled with figures of speech or idioms. If these types of language are used, it could limit who this information is for and benefit only certain users as a result. It was also found that words used in the app screens influenced particular elements for participants to pay attention to. For example, a speech bubble in Dumpling's sleep graph leading participants believe Dumpling went to sleep in a "noisy" location (P2 Figure 69D).

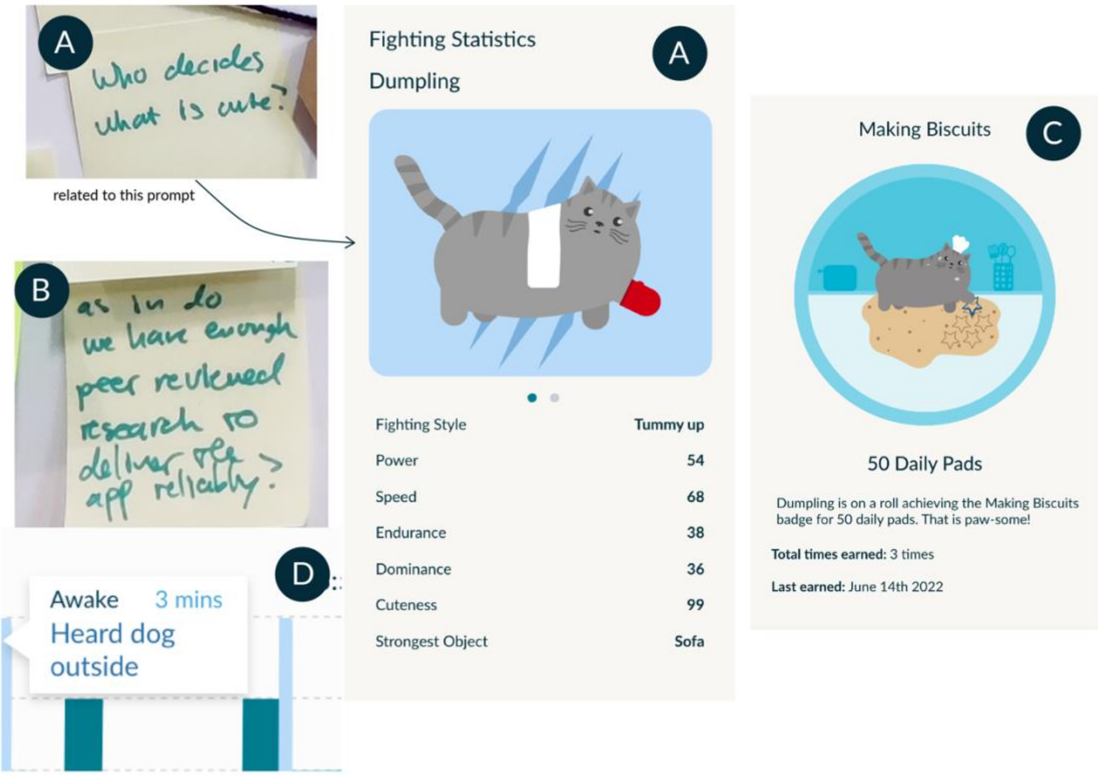

Figure 69 – Participants responses to system perspective missing out on complexities of life with some system app screens shown related to these responses.

6.6.2 Understanding more-than-human perspectives of contextualised general wellness information

The way self-tracking systems currently provide contextualised general wellness information about ourselves and multiple beings, as shown in section 6.6.1, highlights potential problematic aspects of system design. This analysis so far, based on participant's responses, shows that the system perspective does not capture enough information or the right kind of information. This means they cannot successfully represent someone's health and wellbeing experiences. As described by one participant in the interviews, self-tracking systems often have a limited data set. This means they can only report on either measurable things or on information the system has:

> *"The AI will just generate a recommendation based on metrics which aren't actually reflective, they're just the things that you*

can measure, but not necessarily the things you can feel and experience and take into consideration." (P6)

This shows availability heuristic issues with the system perspective, tracking what's easy rather than what's valuable to measure (Thomas, 2020, p. 3). More-than-human perspectives may help track this value through the different ways multiple beings interpret, feel, and experience the world. Below some of the themes found from the cat and human perspective updates are discussed, as well as some more-than-human aspects used in the system perspective updates. The themes outline some potential challenges or harms with including contextual insights, such as feelings rather than just measurable moments. This includes confirmation or narrative bias, using logic and other information to confirm beliefs or make sense of unexpected information. This improves clarity but reduces certainty such as accuracy and consistency of information. This is based on influence from the world around us and who is using or interpreting the information given (section 6.6.2.1). Visual elements from the cat's perspective such as photos may act as a vital factor for decision making. However, certain elements of a photo can alter peoples' focus and undermine confidence in other information given (section 6.6.2.2). More-than-human perspectives were also found to change the way information is perceived. Additionally, what people find useful to know and when it is useful to know it (section 6.6.2.3).

6.6.2.1 The power of logic can lead to false and misleading information

During the workshop, the human perspective updates were described by participants as being able to "more accurately interpret real world cues" (WA2). This was because humans have the "power of logic" (WA2) and "know cat behaviour well and can extrapolate (better than machine)" (WA2). As described by Nagel (1974), humans can believe cats have different experiences of the world, even if they can't directly access that experience. These real-world cues were seen to help consider what this experience would be and that this was something that a machine (or self-tracking system) could not do, highlighting that there was value in additional perspectives. While Barad (2012) argues that we should introduce response-ability to enable cat's responses, humans in this project assumed they could speak for a cat's experience, given that they regularly interact with them, and cats are entangled within our lives. This follows Jain (2023) and Haraway's (2016) argument about companion animal's becoming-with humans over thousands of years. Human's perspectives could be viewed as diminishing companion animal's experience of the world, by speaking for rather than enabling an animal's response about their experience. However, including multiple positionalities could start to consider alternative narratives about the cat's experience compared with current self-tracking design which only considers a singular system point of view.

This was supported by participants making sense of information provided, in some instances using a combination of perspectives to make sense of the information to "help make more complete picture" (WA2). This could help with clarity about what the updates were showing i.e., "seeing more of the messages, the cleaning behaviour is clearer! i.e., one cat is cleaning another cat!" (WA1 Figure 70A). However, this "power of logic" (WA2) used to piece information together from multiple perspectives could reinforce or confirm beliefs about the information given, indicating confirmation bias (Walter *et al.*, n.d.). For example, one participant stated that having the human and cat perspective updates "reassured me about what I thought I was seeing" (WA2). This "reassurance" could help ease anxieties, as discussed in section 6.6.2.3. However, it could also potentially lead to incorrect conclusions if their preconceptions of what they thought was happening was incorrect. This would reinforce an incorrect understanding of the information provided. Equally, the narrative could be based on what the human felt important to note rather than what was actually happening i.e., assuming the metrics about cats playing with yarn, combined with the assumption the owner was involved in the footage, meant the activity was about reducing the weight of the cat rather than just about the cats playing (Figure 70D). This reflects our intention when viewing information, as outlined by Hallam (2010) and how that can change the narratives that are seen and remembered about those around us. Therefore, multiple perspectives could help consider different narratives to better make sense of the world (as explained through plurality (D'Ignazio and Klein, 2020)).

Sometimes there was confusion or gaps in knowledge about what the perspective updates meant. In these instances, participants created narratives to help aid their understanding. For example, participants used knowledge of their own cat's behaviour to question surprising or unexpected information i.e., "unusual for cats to go straight in with 'claws first'" (P5 Figure 70B). They also relied on context from their own spaces to help with this reasoning i.e., assuming where the cat was located "oh right so I thought that was the sofa and because it was facing the TV" (P2 Figure 70C).

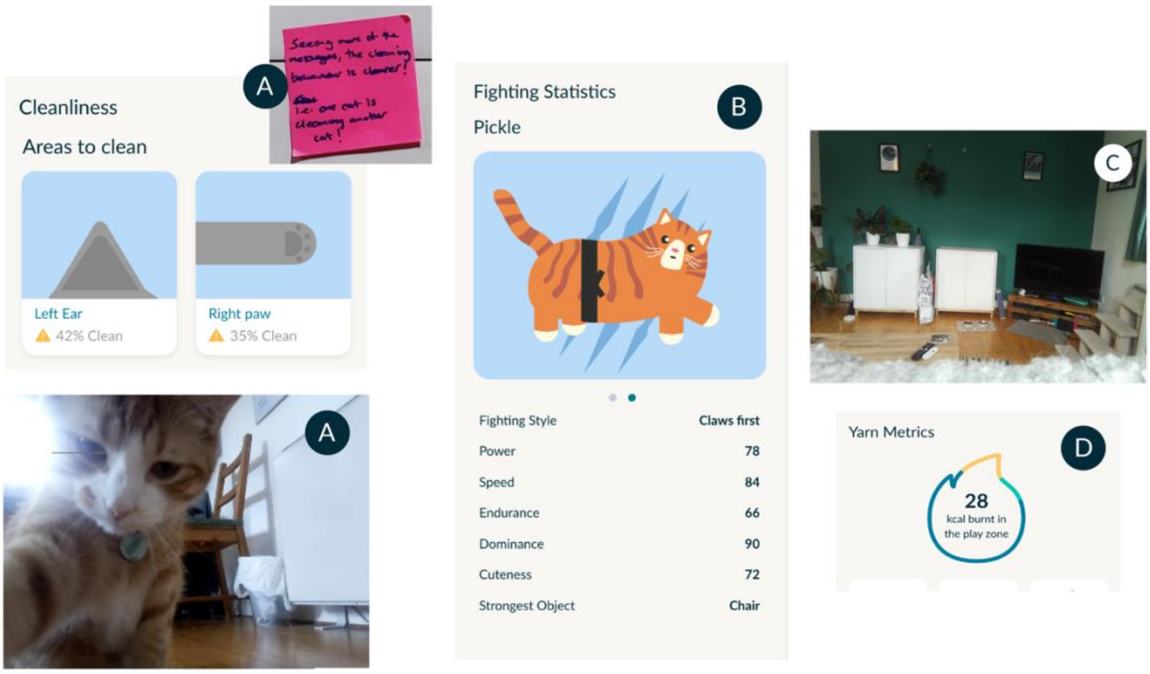

Figure 70 - Different types of perspectives sent that altered what people thought was happening

Additionally, when audio was provided, multisensory experiences were assumed such as the emotions of the cat. One participant stated that it "sounds like Dumpling is very happy, as he's purring loudly, probably because he's being stroked/cuddled" (P5). Equally adding textural properties of objects into the narrative like a "soft blanket or furnishing" (WA2) helped to infer these emotions. This supports animism concepts (Lupton, 2020), highlighting how sensory embodied experiences are considered important when capturing companion animal general wellness narratives.

However, these are all examples of narrative bias (Whitenton, 2017), seeing events as a story with a logical chain of events to make sense of what is happening. This could be an issue if these perspectives were used to give other people information. As this knowledge is partial and based on a person's own understanding of the world, it is not necessarily accurate or reliable. This could undermine trust in the information given. This is especially true when the narratives are based on limited or incorrect information. For example, if humans were in control of inputting data (self-reporting), it can make more-than-human perspectives less accurate as people reason in different ways:

> *"It also relies on self-reporting and people are— notoriously lie in self reporting even when they're really hurting themselves like I'm like should I add that butter? No butter doesn't count. There was only a little bit of butter, so I won't track that." (P3)*

If more-than-human perspectives were sent to other people to provide information about an event, it might be that they are based on "partial/flawed info" (WA2), such as the self-reporting example. This could mean that the information provided is "not necessarily accurate" (WA2) and can therefore "distort" (WA2) the information presented. Who is interpreting these insights also highlights issues with using multiple interpretations of information. Even if the information came from a considered expert i.e., a personal trainer for exercising insights "if you spoke to two or three, you wouldn't get exactly the same answer every time" (P1). While plurality can help include diverse perspectives, in self-tracking systems consistency was seen by participants as needed for more accurate or reliable information. This inconsistency according to Kahneman is because of "extreme context dependency" (Kahneman, 2011, p. 21). This means that stimuli in our environment unconsciously influence our thoughts and actions. As it is unclear what might cause these changes of opinion, it poses a challenge about whose decisions we trust, as well as how this trust is decided, given potential power dynamics surrounding whose voices are given a platform and considered truthful. This also raises a question, can design intervene to improve consistency?

> *"I saw these [pointing to the cat and human updates] and seeing this [the system update] completely changed the tone for me and I've got two children under 10 and I could easily see them being like ok we've got a game we could play (laughter) let's make the cats fight and it's like top trumps and that took quite a sinister tone for me" (P1 see Figure 71)*

While this is about how information displayed in a system can change how it is interpreted, it's important to note who is interpreting the information creates this narrative shift. This highlights a potential issue with relying on people's perceptions of events. It could lead to not only false narratives, but drastically different information sent to different users, meaning the information provided might not be dependable. As highlighted by one participant "humans explain things in odd ways sometimes (consistency)" (WA2). It is important that self-tracking system designers consider how diverse opinions are included and valued while still creating additional information people can rely on.

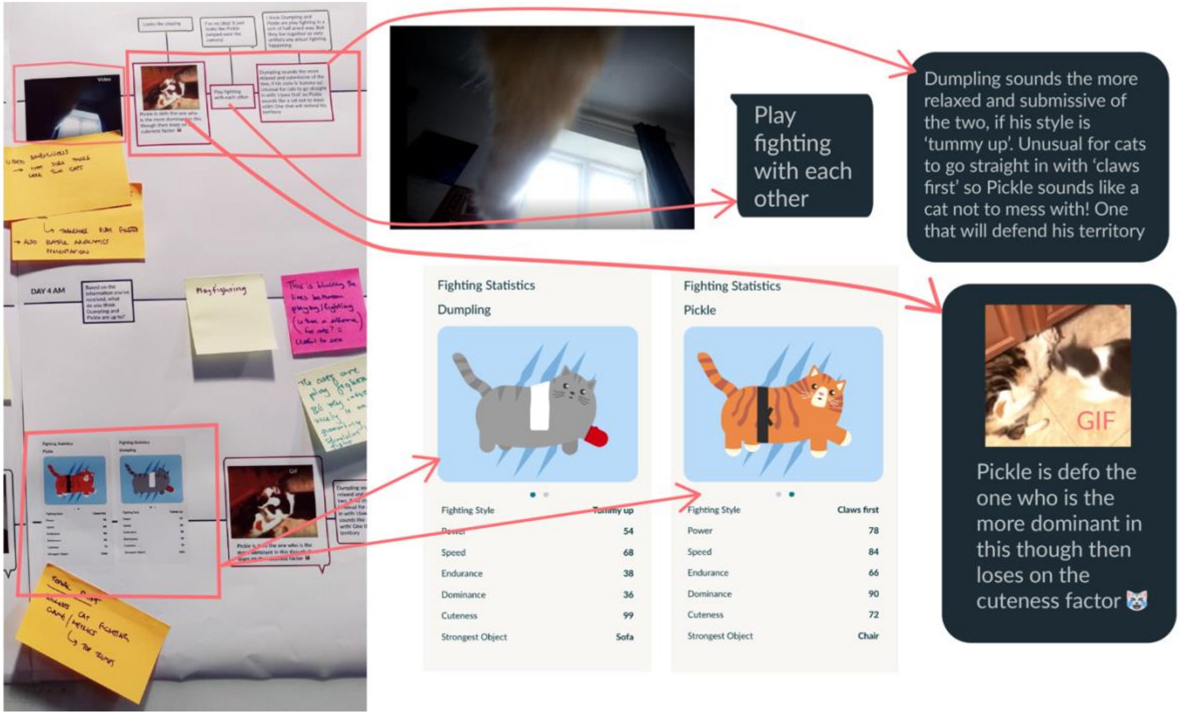

Figure 71 - Different perspective updates from Day 4 AM (cats fighting) participant 1 was referring to when talking about the tonal shift in the information presented.

6.6.2.2 More-than-human perspectives can lead to distrust of other information given

Multiple updates given to participants, sometimes caused them to question the other information they were given. This was most notable when a cat perspective update about Dumpling watching from the window showed a photo with a leaf and a shadow on the window (Figure 72B). The system perspective update suggested Dumpling was staring at a slug (Figure 72A). All participants who got both perspective updates identified that there was no slug in the picture and used this to assume what Dumpling was doing. One stated "I don't think that is a slug in the photo! It looks to me like a leaf or yellow petal! I think Dumpling was just sitting on the window staring into space more likely!" (P1). Participants noted that this message compromised other information they received stating that the "credibility of the app is called into question" (P2). Another highlighting that these interpretation errors in the app "could undermine confidence in other aspects of the feed" (WA2). In this case their assumptions were correct, and the system perspective update was showing incorrect information, wrongly identifying the leaf as a slug. Participants looked specifically at the 'slug' in the photo because the information in the system perspective update suggested that a slug had been identified. However, it could be that the system might be showing the correct insight and adding more-than-human perspectives such as a photo or video clip from a companion animal's point of view skews their understanding of what is happening. Footage from the cat perspective update where Dumpling was meowing for food highlights this possibility (Figure 72C). The footage made people believe that there was food in the cat's bowl even though it was empty (due to the angle and reflection on the bowl). This led them to believe Dumpling wanted food, "I was thinking that Dumpling was asking for food even though there is food in the bowl!" (P2). This changed their understanding of what was happening because of what they believed they could see in the footage. This provided a more powerful indicator to them than other information given.

Figure 72 - System and Cat perspectives sent to participants on Day 3PM (Dumpling watching from the window) and Day 3AM (Dumpling meowing for food)

Both these examples show how visual cues provided in more-than-human perspectives could lead to inattentional blindness (Simons and Chabris, 1999) especially if video footage rather than photos are used. These two examples differ slightly as the system perspective update did not mention the food bowl. However, for the slug picture, participants focused on the 'slug' because of the 'task' (Kahneman, 2011) set out by the speculative app through the 'detection' of the slug. Others in the workshop noted that they didn't notice the 'slug' until they looked at the metrics. This could mean they'd ignore some other obvious indicators in the photo about what was happening such as a bird flying past.

This would not make a difference to Dumpling's wellbeing. But if the system was supposed to alert a person that their cat or child is in danger, they could determine through the more-than-human perspectives that they were ok (as described by participants through visual cues such as heights, locations of things and being able to quickly recognise your own house (WA2)). If multiple beings were actually in danger, including metrics that contradict these more-than-human perspectives could compromise wellbeing by noting elements of footage to focus on.

6.6.2.3 Human sensitivities change what contextualised general wellness information can or should show

Participants discussed how human knowledge "can supplement ambiguous data due to existing knowledge & empathy" (WA2). It is implied here that a human interpretating information can provide a more contextually rich interpretation. This is because human values like 'empathy' are seen to provide meaning to help understanding. With empathy also comes an emotional toll from receiving negative data, described here as human sensitivities. Within current system design there is a focus on representing things in a light-hearted or positive way, as noted by participants. This changed the way they perceived information given and whether they wanted to see more of these insights. For example, people enjoyed more positive visualisations about a fight between the two cats. This highlights how Haraway's (2003) considerations to represent an authentic connection with our companion animals could be in included in self-tracking systems. Graphics and metrics helped increase confidence in the behaviour occurring (see Figure 73). One participant said, "see that was what made me confident that they were play fighting because of way the analytics were given because it puts kind of a light-hearted spin on it".

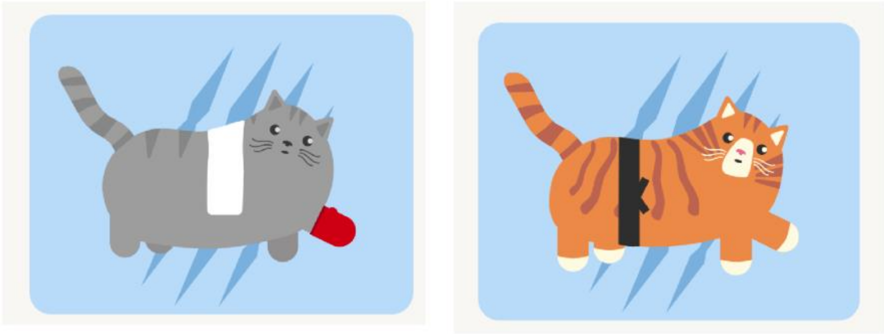

Figure 73 - 'light-hearted' graphics participant was referring to.

However, participants pointed out that if a more-than-human perspective presents us with taboo or socially unacceptable information, this changes what information people would like to see displayed. Haraway (2003) argues that we should acknowledge the waste and cruelty involved in our relationships with companion animals. This is hard to implement in self-tracking apps because of the social implications that could impact on the general wellness of multiple beings. Cats' perspectives can capture information in both public and private spaces which could hold people accountable or put the cat in danger. This is because as described by Bennett and Roser, this perspective allows us the opportunity of "being-with" non-humans and experience unfamiliar spaces accessible through their perspective. This was explained through participants noting that cats could capture information in bathrooms (P5) and bedrooms (P4) as well as potentially capturing crimes (P5). They can also capture information in neighbour's gardens and homes which was seen as potentially altering people's relationships with both cats and humans around them (P6, P1, P4). This is because if this information was shared it could also make neighbours accountable. For example, camera footage potentially answering which cat was "pooing in her [the neighbour's] flowers" (P6).

Equally, aspects of cat's behaviour might be vital to their routine and general wellness experiences i.e., catching prey. However, visually displaying things like prey continues to highlight what is socially acceptable for self-tracking systems to capture. For example, one participant said, "it's like my cat kills mice I don't want to actually open my app in the morning and see that" (P6). With humans it might not be socially acceptable to include negative aspects of relationships between humans in our tracking systems. However, what might be a negative action for a human might not be for a cat, as explained by one participant (P6) through the book Why Cat's Paint (Silver and Busch, 1994). The book shown in Figure 74 shows household items such as a fridge covered in paint or a tangle of wool across the floor. This could be described as negative behaviour as these items are destroyed. However, it could also be an example of cats owning a space and acting on natural instincts such as hunting, vital to a healthy routine.

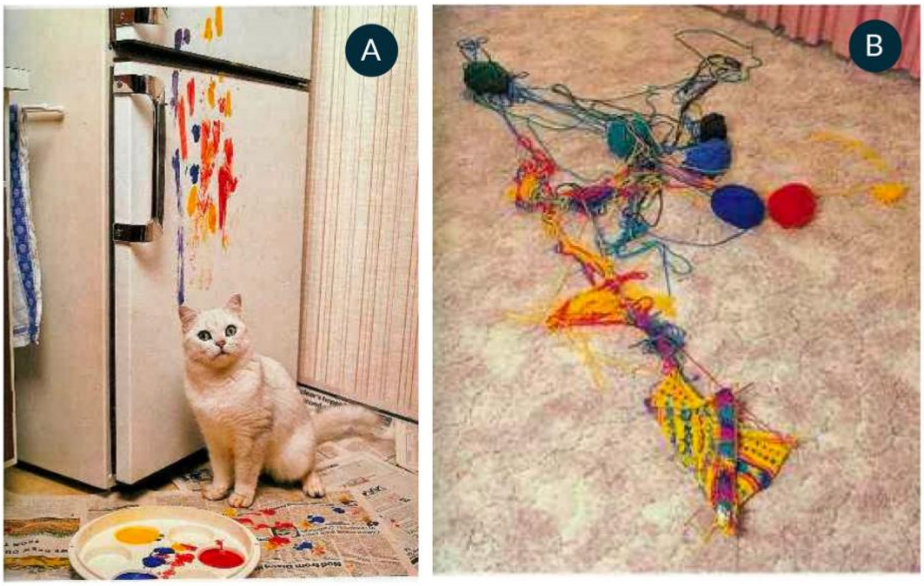

Figure 74 - Excerpt from Why Cat's Paint by Silver and Busch. Image source: https://awfullibrarybooks.net/why-cats-paint/.

This shows how there needs to be a certain balance between perceived negative information that might be necessary to receive to support multiple beings' health and wellbeing. As part of this balance, this includes being conscious of certain types of information that might cause harm i.e., interacting with negative insights which could cause distress to the intended user.

In terms of what this information could reveal about participants this was not seen to be a concern. Participants discussed how they'd like to know more about the routines of their cats, knowing their cats were social with some cats but not with others such as having "actively seem him [the cat] leave the house to join her [another cat] and go for a walk" (P2). This supports Haraway's (2016) depiction of companion animal's own worldings separate from our own. Through the consideration of different perspectives such as a cat, these narratives could become part of our representation of their wellbeing experiences in self-tracking systems, not considered through current system design. However, participants never mentioned what this information could reveal about their relationship with their cat and how it could highlight behaviour changes i.e., one participant discussing taping open the cat flap so the cat could leave (P4) or feeding the cat in a certain way because of the cat's fussy eating (P5). Revealing these types of behaviour in self-tracking systems could alter the way our relationships with multiple beings are portrayed.

Time seemed to play a key role in information people found useful to know about multiple beings. Firstly, their ability to act on the insights they received in a timely manner helped determine whether this was necessary information to have. For example, context on where a user was and their proximity to the cat. Whether this was close at home (P4) or further afield like work (P6) or travelling (P2) changed whether they could quickly check on their cat. Therefore, this changed the insights they wished to receive. If they couldn't check on their cat, there was a feeling that having this information could result in "raising my cortisol levels and shortening my lifespan" (P6). Participants mentioned that not receiving information for a while can be equally as concerning with apps now being used in nursery to provide people with regular updates of their children's activities i.e., didn't eat their peas (P1), so not receiving information can cause alarm:

> *"yeah and what happens if the data stops? You know people rushing home to see their cats like oh god is Pickle alive I haven't had an update about the resting heart rate since 11 o clock this morning" (WA2).*

If people normally get a regular update about their cat's wellbeing i.e., their heart rate and then no information has been shown to them for a while, this could indicate a problem. If nothing is wrong this causes unnecessary panic. There seems to be an expectation of how much information a person will receive and a level that is normal to them. As explained by Wakkary et al (2017) multiple beings shape us and we shape them. This means that while we experience the world differently, information about multiple beings can impact us, as well as how information about us can impact them. For designers looking to include these relationships in self-tracking systems, more work is needed to find out the correct level of information to receive that encourages multi-species flourishing (Haraway, 2016).

6.7 Discussion

Interface design used in the system perspective aids understanding of data by easing our cognitive load. It was viewed that within this perspective there were types of information that provided more "value" i.e., activity levels providing more contextualised information compared with heart rate. This is because this type of information infers context to explain behavioural insights that would be harder to interpret from more complex information such as a graph or chart. With this said, these simplified measurements can't capture everything about a being's health and wellbeing. It was suggested in the insights from this project (section 6.6) that more-than-human perspectives could shed light on different aspects of multiple beings general wellness experiences, highlighting what is useful to know rather than what is easy to measure. Following more-than-human theory supported by Nagel (1974) and Lupton (2020), people used real world cues to help understand these experiences, in a way that a system could not. For example, using logic and visual cues used in photos to make sense of information and create alternative narratives about the cat's wellbeing experiences and how multiple beings are reflected upon, not possible through current self-tracking system design. Advocated for through animism concepts (Lupton, 2020), multisensory experiences gathered from audio and subjective storytelling, highlights the importance of sensory embodied experiences for general wellness narratives. For example, the emotions of the cat and textural properties that reveal aspects about multiple beings' wellbeing i.e., a blanket making the cat calm. This was especially useful when context was unknown, such as unfamiliarity about the environment or the cat.

While the insights discussed are specific to people's interaction with different perspectives of contextualised general wellness information about a cat, some of these insights can apply to any multiple beings. For example, 6.6.1.2 discusses how it is perceived that there is a particular cat designed for, implying cats have to achieve targets not possible for all cats. This reflects the argument presented across this thesis (particularly chapter 2 and 5) about how self-tracking systems take a one size fits all approach to wellbeing. This shows that a singular system perspective fails to represent multiple beings as well as selves in self-tracking systems. However, this doesn't necessarily mean that introducing more-than-human perspectives didn't come without implications.

While plurality (D'Ignazio and Klein, 2020) allows for more diverse perspectives to be included, incorporating multiple (more-than-human) perspectives was seen to create inconsistent information and therefore intervened in people's trust in the information provided. However, these more contextually accurate viewpoints also increased clarity about what was happening. This highlighted a need for different perspectives of contextualised general wellness information, "both basic unbiased data & guidance on how to interpret" other perspectives (WA2). However, implementing these forms of information could introduce various cognitive biases and potential harm into system design. These biases might unintentionally harm some involved in self-tracking system design. This could be by including more authentic connections that provide us with an opportunity for being-with non-humans and making unfamiliar spaces accessible (Tsaknaki *et al.*, 2022). By doing this, these more-than-human perspectives revealed behaviours that were previously hidden i.e., cats perceived negative behaviour in public and private spaces as well as capturing potentially socially unacceptable things such as recording in the bathroom. Despite these boundaries about what not to include in these systems, this study found that presenting information in a light-hearted way i.e., graphics about cats fighting was acceptable for people to receive. To help include general wellness experiences that support human sensitivities as well as parts of multiple beings' wellbeing i.e., hunting, presenting information through these graphical forms can help support multi-species flourishing in future self-tracking system design.

Using an earlier established concept of plurality, combining information from different more-than-human perspectives might be one approach. Just as plurality combines multiple positionalities to gain a richer understanding of the world, participants discussed collective viewpoints. They suggested crowdsourcing as a way to decrease subjectivity present in the human perspective updates. Self-tracking system metrics might be combined with multiple opinions of different humans such as "80% of people thought this was your neighbours garden" (P1) to aid understanding. This combination of perspectives could give useful indicators to help people decide how to act on information given.

Even through this suggestion, subjectivity still might arise as even 'experts' will consider many complexities when making their decisions (Kahneman, 2011, p. 21) resulting in differing opinions. A collective view might also be prone to the bandwagon effect (Thomas, 2020, p. 3). Following an idea or belief because 'everyone' is, might reflect biases present in society. This could mean viewpoints aligning with the masses (e.g., Dumpling meowing for food) might be followed even if the minority view (e.g., Dumpling meowing for attention) is the correct one. Equally it is unclear whether humans are just making up general wellness experiences from different bits of information, finding logical patterns where there aren't any. This raises complexities with including more-than-human perspectives. For example, how we introduce different more-than-human perspectives to provide different contextualised information that is still useful but also accurate and trustworthy, so these new considerations are adapted by those using self-tracking systems.

6.7.1 Reflecting on the process of the Cat Study

Developing more-than-human perspectives through speculative methods allowed contextualised information to be tested in a preliminary design phase with participants before these systems were implemented where harm could occur. Recreating the viewpoint from a cat was challenging but was useful for representing plausible general wellness experiences from the way a cat views the world. Trying to get these shots without getting the other cat in the camera (Figure 75B), at non-distorted angles (Figure 75A), in bright enough spaces (Figure 75C) took a while to achieve the final artefacts presented to participants. However, through doing and making, the approach could be much more experimental to simulate a cat perspective for the required artefacts presented to participants. This also created engagement with the participants that was not possible through purely interviews and workshops.

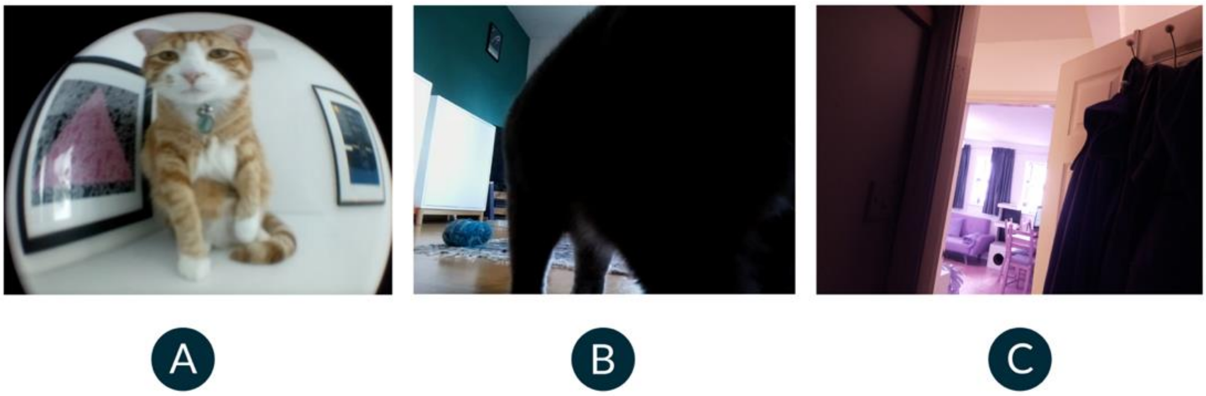

Figure 75 - Problems with filming cats from left to right. A) Pickle's body shape being too distorted by the fish eye lens B) Dumpling standing in front of the camera despite this viewpoint being from his perspective C) low level lighting in places like a storage cupboard required infrared camera footage

Fictional artefacts i.e., app screens also helped to create a plausible experience by simulating existing interactions with self-tracking systems. Replicating contextualised information related to my own cats was necessary for this research. This was because people might be given information about multiple beings in self-tracking systems they have little to no context about. Generating these perspectives myself also removed the need to gain lots of information about the participants and protect their wellbeing in the process i.e., understanding their relationship with their cat and exposing this relationship through the presented artefacts. They could still use their experience of living with a cat to provide insights about what they would find useful to have and what was confusing to make sense of.

This project helped to move design fiction from the digital to physical space in this research. Even though participants were sent digital prompts through various messages, the experience of being sent various updates was discussed in an in-person workshop. This helped engage people not familiar with design research around future thinking. This study took place over just a few weeks showing the value design research can have within the development process, highlighting a way to intervene where technical approaches could not. This was through exploring how context could be tested much earlier in the process and understand the implications of these different perspectives in self-tracking systems without implementing them in working systems where they could cause harm.

In terms of participants responses, one downside of the workshops was it was held in person, so people could not see videos sent to some participants throughout a week in the life of Dumpling. If this type of activity was carried out again, a digital format would allow different human perspectives to arise and help diversify the study conducted. This is because the online space could reach cat owners from different cultures, backgrounds and histories to share their experiences with living with cats.

6.8 Summary

This chapter outlines a study that introduces different perspectives of contextualised general wellness information about my cat Dumpling (and indirectly my cat Pickle) to people who self-track. This was done through interviews, a week in the life of Dumpling where participants received information about Dumpling's activities via WhatsApp and a workshop.
The aim with this study was to understand the implications of introducing more-than-human perspectives into self-tracking system design. Through this project

it was found that the system perspective can help our understanding of this information by providing simple metrics and comparisons to help ease our cognitive load. However, this perspective also implies there's a correct way to act on this information. This is despite the system only being able to provide generic information based on what those developing these systems feel is important to measure. This could reinforce normative standards and reflects systems that can support some selves understanding but not others, through certain language and aspects of bodily general wellness metrics included in self-tracking system design.

Through the introduction of more-than-human perspectives of contextualised general wellness information, different parts of multiple beings' health and wellbeing experiences (aside from bodily metrics) were revealed. This could be seen through multi-sensory experiences such as audio indicating emotions or feelings of the cat, or narrative assumptions including textural elements that help add to wellness experiences i.e., a soft blanket. These narratives could help make potentially confusing information clearer. People relied on unexpected information, visual cues from the cat perspective as well as context from their own spaces to help reason what was happening. However, this logic used to create these narratives could reinforce or confirm beliefs about incorrect information altering understanding of the information provided. These assumptions changed what the human felt was important to note, what they were willing or felt acceptable to receive, when and how often they received information and who was involved in the information provided. These more-than-human perspectives could also compromise trust in other information provided. Narratives also changed based on who was interpreting the information and that person's intentions as well as their experience with cats. This raised questions about potential bias included through these different perspectives and whose wellbeing would benefit from the way information was represented and perceived. This chapter concludes with a discussion about the implications for introducing these different perspectives that people find useful while also being trustworthy. This also includes the ability to provide an accurate depiction of general wellness experiences and relationships with multiple beings.

Given that all the projects developed as part of this thesis have been discussed, the following chapter will consider each of these projects in relation to each other. It will summarise how the introduction of more-than-human perspectives can have implications for context-aware self-tracking system design. Following this, it will use this understanding to reflect on emergent themes and questions that still remain beyond the scope of this thesis.

Chapter 7 Design insights for more-than-human context-aware self-tracking systems

Across this thesis, projects conducted, and insights made have been based on the research questions outlined in the introduction (Chapter 1). These questions being:

- What if self-tracking systems considered different (more-than-human) perspectives of contextualised general wellness information?
- What would this mean for future self-tracking system design?
    - As in, what would it be like to interact with these perspectives in self-tracking systems?
    - Would there be implications with including these new perspectives?

Throughout these projects, these questions have been addressed. The insights from across these projects have been collated and presented here as design insights for more-than-human context-aware self-tracking systems.

Figure 76 shows the relevant sections of this thesis where these insights were taken from. These insights show the implications (including the opportunities and challenges) when people interact with different perspectives of contextualised general wellness information (section 7.1-7.6). Throughout, these implications have focused on our social relations when introducing different contextualised information that captures more about general wellness experiences and our relationships with multiple beings. More-than-human theory has helped to create insights that consider new opportunities and challenges beyond human-centric concerns. This includes moving beyond bodily metrics to consider aspects of general wellness experiences such as authentic connections/relationships, multi-sensory experiences, and plurality. Highlighting these implications provides designers with considerations for future self-tracking system design (section 7.7).

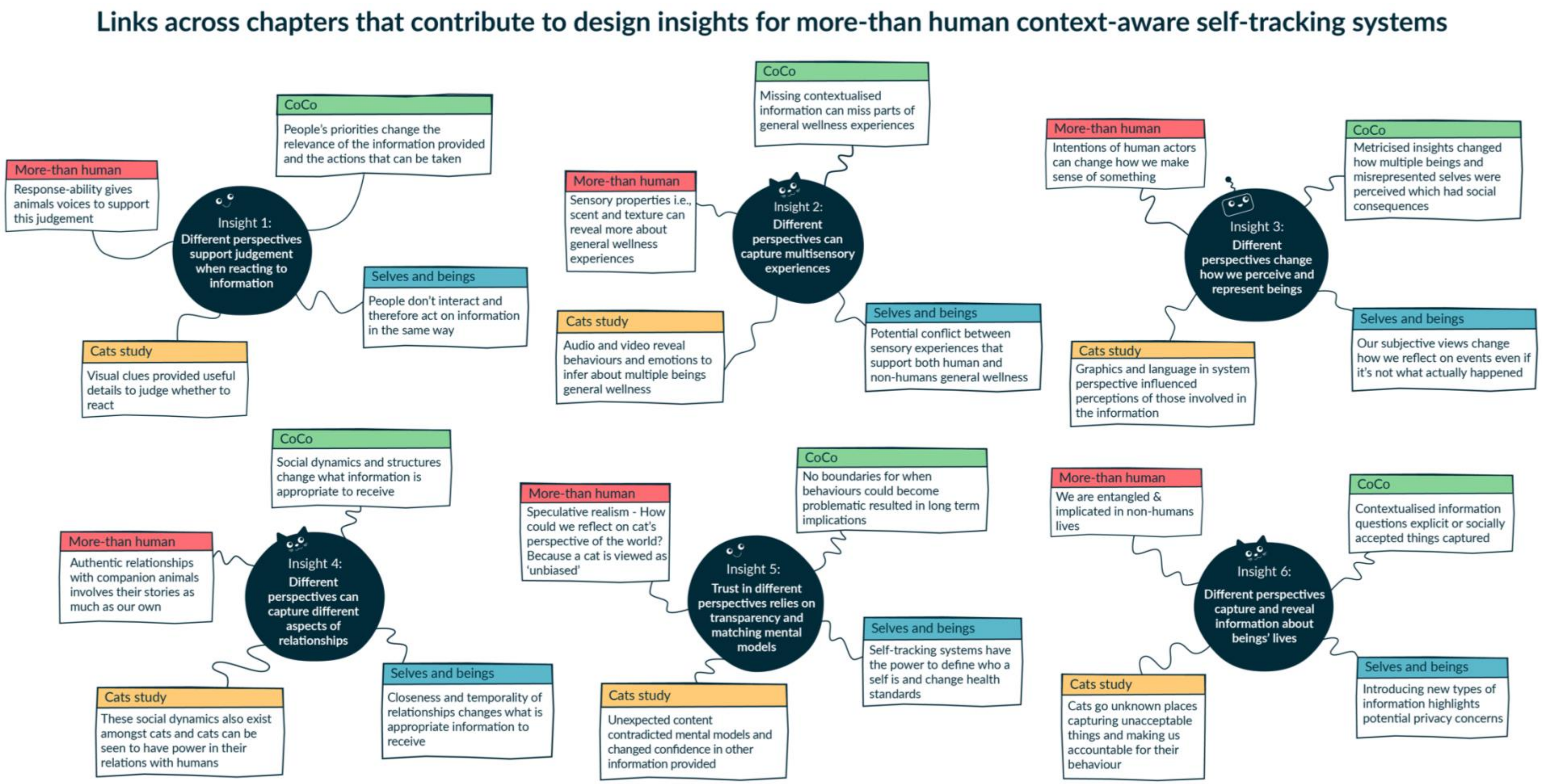

Figure 76 - Diagram with relevant sections from across the thesis where design insights for more-than-human context-aware self tracking systems were drawn from The faces show the various perspectives the insights mostly align with (human face = human perception of information, cat = more-than-human theory influencing information, bot = system perspective altering information presented)

7.1 Insight 1: Different perspectives support judgement when reacting to information

Visual cues provided through more-than-human perspectives' meant people could make sense of contextualised information. This supported judgement about whether to act or react to the information provided.

CoCo (Chapter 4) shows that people's preferences or priorities might alter whether someone can act on contextualised information provided by self-tracking systems. Priorities and preferences were wrapped up in relationships which changed whether an action was possible. For example, CoCo's recommendations to activate mood lighting could not be completed by the character Gina as looking after her crying baby was more important than a temporary increase in stress. Equally, the actions of one person can impact the relevance of information about someone else's general wellness. Despite being based on relevant data, the time-sensitivity of Gina's daughter's medication was impossible to act upon because she had just had wine.

Selves and Beings (Chapter 5) outlined that this was a problem with a singular system perspective, as a system expects continuous use and interaction in the same way even after an injury or on weekends and holidays. Therefore, a singular perspective does not consider different ways people could interact with the same information. Assuming everyone interacts with information identically, and therefore reacts identically.

More-than-human perspectives provided in the Cats Study (Chapter 6) helped support preferences or priorities for interacting with general wellness information. The information provided from the cat's perspective was seen as useful as it could allow people to react in real time and judge whether they needed to act on the information provided about multiple beings. This judgement could be made from different contextualised information such as reacting quicker by recognising your own house (i.e., Figure 77A) as well as visual cues such as height and location which could be assumed or determined from the content (i.e., Figure 77B). These cues meant people could tell if the cat wasn't where they should be and react to safety concerns i.e., the cat in a tree. This highlights that this perspective was particularly useful to have about multiple beings for caregiving responsibilities, especially when the cat might not be close to the human. People could then use their own logic to determine whether they needed to react to the information provided.

While this shows how this was useful for a human's perspective allowing them to react, this ability to react also links to more-than-human theory. Lupton quotes Barad's concept of response-ability, or the ability to respond which invites, welcomes and enables the response of the "Other", in this case the companion animal's perspective (Lupton, 2020, p. 28; Barad and Kleinman, 2012). Their perspective gives us access to unfamiliar spaces allowing us to be-with (Tsaknaki *et al.*, 2022) multiple beings, providing them with a voice in self-tracking systems. This allows those using the systems to be able to judge and learn from the visual cues to act on the information and maybe interact differently with multiple beings. It might also be that other sensory experiences could help with this concept.

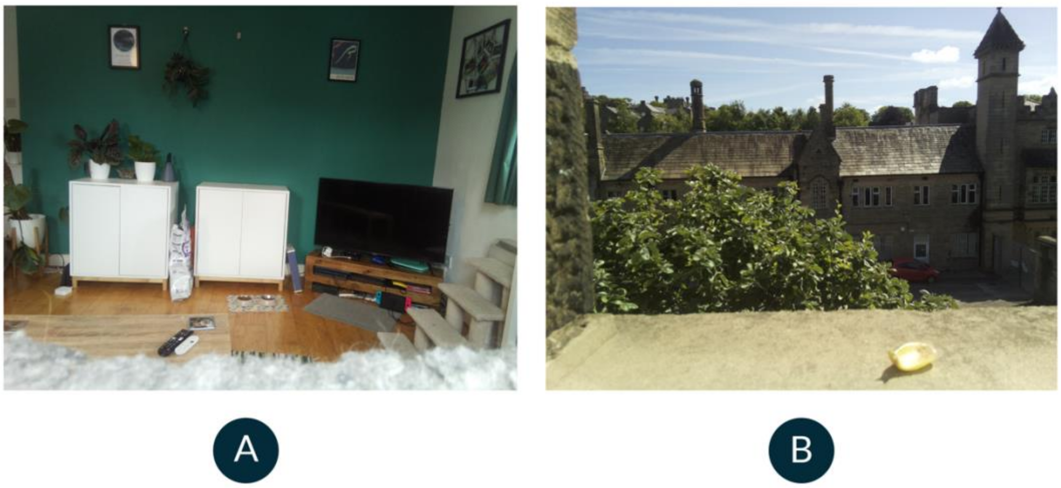

Figure 77 - Cat perspective pictures that have visual cues that allow people to judge whether to act on the information provided. A – shows one prompt sent to participants from a cat on their bed on the windowsill up high but if about a person's own home, they would easily be able to recognise their own living room. B –

shows a prompt sent to participants about a cat watching a 'slug' or jade plant leaf on the window, it's not clear from here if it is a window so could be something to alert someone to if it appears the cat is in danger.

7.2 Insight 2: Different perspectives can capture multisensory experiences

More-than-human perspectives can provide multisensory experiences (through audio and video) to capture emotions and behaviours that allow people to infer more about multiple beings' general wellness

CoCo highlights how there are problems with the way contextualised information is currently understood. Missing contextualised information can result in system's decision-making assuming cause and effect. Limited information is used to infer certain actions or behaviours someone should follow. However, this can have consequences such as the character Ron's bad sleep was linked to his cat Muffin waking him up, reinforcing his theory that the cat was to blame and rehoming Muffin. However, his wife Dorris pointed out that he was falling asleep in front of the television, and this could have been why he woke up.

More-than-human perspectives can explore the use of multisensory experiences to reveal more about general wellness experiences, either about our own or multiple beings. Drawing on animism concepts, *things* can be seen to connect to humans and non-humans at a "more-than representational level" (Lupton, 2020, p. 24). This connection can be seen through sensory properties such as scent and texture, revealing more about our relationship to the world around us. Selves and Beings discusses how the way a non-human being experiences the world could represent other parts of general wellness experiences. Here it was noted the potential conflict between supporting multiple wellbeing experiences i.e., sensory experiences of a cat catching prey, like the feeling of feather in a cat's mouth, which could be beneficial for the cat's wellbeing. However, it could be uncomfortable information for a human to have.

This was supported through the cat perspective in the Cat Study with images and video footage allowing sensory experiences to begin to include different parts of general wellness experiences not possible through purely metrics. For example, cat behaviour observed helped make sense of information, such as assumptions made about Pickle having a treat because he was licking his lips. Where visual cues were not provided, sensory experiences helped build participant's narratives of the events occurring. For example, textural elements of an object linked with calming or wellness properties such as the feel of a soft furnishing or blanket providing comfort for the cat. This was also seen when only audio was provided. This allowed people to infer emotions about what the cat was feeling, a few saying that Dumpling sounded happy as he was purring loudly.

7.3 Insight 3: Different perspectives change how we perceive and represent beings

Different perspectives of contextualised general wellness information (metricised insights, language and graphics) can change how a being (and their relationships with different beings) are perceived and represented

CoCo's application revealed behaviours between bodies that were previously unknown. Having this contextualised information changed how multiple beings were perceived by those using the self-tracking system. For example, the character Gabriel put his cat up for adoption after seeing metricised insights that indicated his interactions with his cat were causing an increase in his heart rate. Equally, the disruption of Gina and Euan's child shown on a graph made them contemplate whether having another child was the correct choice. Selves not considered by the system were also misrepresented and perceived differently because of this misrepresentation. The presentation of Mark's slurring as a drunkenness problem, rather than a behaviour linked to his speech impediment, inferred that his condition needed fixing. While in this instance it was taken lightly, it could have harmful consequences for different people interacting with this information. It could also reiterate harmful stereotypes changing how people with disabilities are perceived by those viewing the information.

The Cat Study showed that graphics and language used in the system perspective also changed how a multiple being was represented and perceived in self-tracking systems. Words used to describe Dumpling in the metrics presented, guided people's answers about what the cat was up to. For example, when Dumpling was napping participants received a graph and some metrics about Dumpling's sleep quality (Figure 78A). On the graph, a speech bubble indicated that Dumpling was awake because he heard a dog outside, this led one participant to assume Dumpling was sleeping in a noisy environment and needed to change sleeping locations.

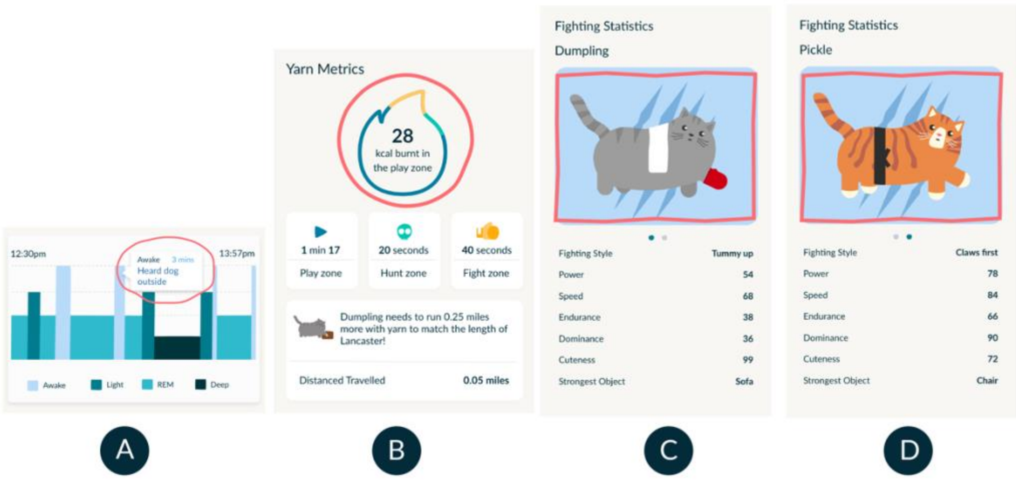

Figure 78 - Examples from system perspective that influenced how a being was perceived. A & B show how language used influenced what people believed the information was about. C & D show how graphics altered how these beings were perceived.

Words in combination with graphics were also influential when metrics about calories burnt while playing with yarn led people to believe the general wellness experience was related to keeping the cat active (Figure 78B). This was also true when representing information about the relationship between multiple beings (in this case two cats) with graphics changing the perception of the metrics provided (Figure 78C&D). Cats were assumed to be play fighting because graphics provided with the metrics, made the metrics seem more light-hearted. This supports more-than-human theory showing how the authentic connection between multiple beings can be interpreted in different ways (Hallam, 2010).

While the system perspective could change how we perceive and represent information, more-than-human perspectives could also alter narratives presented. This supports more-than-human theory through Hallam's (2010) explanation of how the intentions of human actors can change how we make sense of something, and the narratives created from this interpretation. This was seen in the Cat Study through who was viewing the information. For example, one participant said that their kids might presume the fight between the cats was a game (Figure 78C&D). This might alter how people behave with companion animals, such as trying to make the cats fight to change the metrics.

As explained in Selves and Beings, how we perceive information about an experience (subjective) can change how we reflect on events even if this is not what actually occurred (objective). For example, in the Cats Study when the cats were playing with yarn, it was assumed from the footage that the owner was playing with them. This changed the intention of the playing, rather than the cats having fun, it was assumed the owner was trying to reduce the weight of their cats. This highlights the subjectiveness of the human perspective, as we create narratives we feel are important to note, changing what we remember and reflect upon (Hallam, 2010). This might not be what is most important for multiple beings' (in this case the cat's) wellbeing. For example, a wellness experience might be about weight control but other parts of multiple being's worldlings (Haraway, 2016) such as playing with other cats could also be a vital part of their health and wellbeing. Using plurality to include diverse viewpoints can help consider alternative narratives about multiple beings' general wellness, not possible through current self-tracking system design. These narratives would provide different perspectives on a general wellness experience. This would allow people to critically think about general wellness information rather than accepting one version of events as the truth.

7.4 Insight 4: Different perspectives can capture different aspects of relationships

More-than-human perspectives that include different aspects of relationships (positive and negative) requires understanding usual behaviour between connections and what people might wish to see (over a collective understanding of relationships and behaviour)

CoCo revealed that the relationship between those represented in data, whether or not this relationship is between human and non-humans, could alter what information people wish to receive. This is because of social dynamics and structures at play that changes what is appropriate for someone to receive. For example, the character Jason's job as a teacher made CoCo's suggestion to go for a drink with a student and their parent inappropriate, as CoCo did not acknowledge the difference between professional and social connections. As noted in Selves and Beings the closeness to that connection and the temporality of relationships also changes this appropriateness level. For example, if someone is a family member or a close friend this might change what they want captured about their health and wellbeing experiences. Additionally, relationships are complicated, they can break down temporarily or permanently or people might drift apart. When including relationships in self-tracking systems about our general wellness, documenting potentially negative connections could hinder wellbeing rather than supporting it.

However, when discussing our relationships with companion animals this might be different. As shown by Haraway (2003) our relationships with our companion animals are full of waste. Western perceptions of companion animals do not represent this authentic relation but instead distort this connection. Instead, Selves and Beings explains how there is a focus on one small aspect of our relation. Haraway (2003) argues that depicting authentic connections are important to tell the truth about this relationship. This includes companion animal's stories, as well as our own, so we can co-habit active histories. Equally as discussed by Bogost (2012) in Selves and Beings, this also means considering multiple beings' relationships with each other as much as our own.

These authentic relationships are also similar for companion animals. The Cat Study highlighted the social dynamics between cats, providing insights into their own worldings (Haraway, 2016). This was either through expected behaviour of other cats they live with but also close cat friends that meet and go on walks together. This might also include cats that they might be aggressive or unfriendly towards. Therefore, when little is known about multiple beings, participants wanted to know what is usual for an individual cat, whether that is noting usual patterns in their behaviour or highlighting places they normally go. This replicates Bennett and Roser's (Tsaknaki *et al.*, 2022) point about learning from non-human's experiences, accessing unfamiliar spaces, previously inaccessible from our own perspective. This was seen as important for representing authentic relationships in self-tracking design. This can also change what information people need to know about relationships between multiple beings i.e., closeness of a connection like cats living together assumes that the behaviour is likely to be friendly based on people's knowledge of typical cat behaviour.

However, the connection between humans and non-humans can be more complicated. In current design, it is assumed that the human has all the control in the relationship with their companion animal and so provides information related to the companion animal's whereabouts and general wellness for caregiving purposes. The Cat Study revealed this relationship is much more dynamic. Cats are good at getting what they want, they might only eat food that they consider to be fresh, or they might sit and meow until a human opens a cat flap. Participant's responses revealed that they would change their behaviour to suit the cat i.e., taping open the cat flap. Therefore, capturing authentic connections involves acknowledging multiple beings' perspectives as much as the human's.

As stated in section 7.3, there are certain types of information that are deemed acceptable or inacceptable to have which can alter how we capture these authentic connections. The Cat Study found that including perceived negative information in a light-hearted way i.e., through graphics was deemed acceptable information to have. Despite human sensitivities over this perceived negative information, this format showed how more authentic connections could be represented in self-tracking system design. While this could still be seen to be distorting the authentic relationship, this insight begins to consider a potential way for authentic connections to be included in self-tracking systems, supporting multi-species flourishing in the process, as advocated for by Haraway (2016).

7.5 Insight 5: Trust in different perspectives relies on transparency and matching mental models

Trust in self-tracking systems relies on matching people's mental models and requires guidance for interpreting different perspectives (transparency can increase confidence)

All perspectives were shown in this research to come with their own biases, but how these were perceived by people meant some perspectives were considered more truthful or trustworthy than others. This trust altered their ability to understand the contextualised general wellness information provided and revealed that more transparency and guidance about how to interpret these different perspectives was needed. In CoCo this was shown through consequences of relying on short-term positive impacts of self-reported wellness. For example, alcohol consumption suggested more frequently by the system resulted in long term implications such as some characters having to retake exams. CoCo did not provide any advice for what counted as a positive behaviour and suggested no boundaries when this assumed positive behaviour could become problematic. These transparency issues were also clear in Selves and Beings, with self-tracking apps creating new health standards or norms such as neck fatness, highlighting how self-tracking systems have the power to define who a self is.

The Cat Study revealed that this undermined confidence in the information provided. Questions were raised about who decides what is cute? Revealing how power dynamics within self-tracking systems can change how companion animals are perceived as well as which voices or types of information are considered trustworthy. The system perspective was seen as less trustworthy if it contradicted mental models or knowledge of typical cat behaviour. For example, unexpected information provided about a cat fighting claws first suggested that the cat was not approachable (Figure 79A) and that cats wouldn't watch a slug because they move too slow (Figure 79B&C).

In terms of trustworthy perspectives, the Cat Study highlights an important point linked to more-than-human theory. Speculative realism questions why would humans be able to shed light on a cat's perspective? This perspective might not correlate with a human's own experiences (Lindley *et al.*, 2019b). This study revealed that this was not seen as a concern as this perspective was viewed as generated data in comparison to human and system perspectives viewed as interpreted data. Participants felt guidance was needed for how to make sense of these interpreted types but not for the cat perspective. Despite being presented with only 10 seconds of video footage or a photo this was not seen to be curated but unfiltered footage (and therefore transparent) ready for interpretation by a human or machine. Concerns related to the reliability of the information provided about cats only came from questions about peer review. This highlights problems with having to interpret different perspectives because information that contradicted this cat perspective changed people's confidence in the other information provided. However, it could also be seen as making people be more critical of self-tracking information, questioning what they are given rather than accepting it as true.

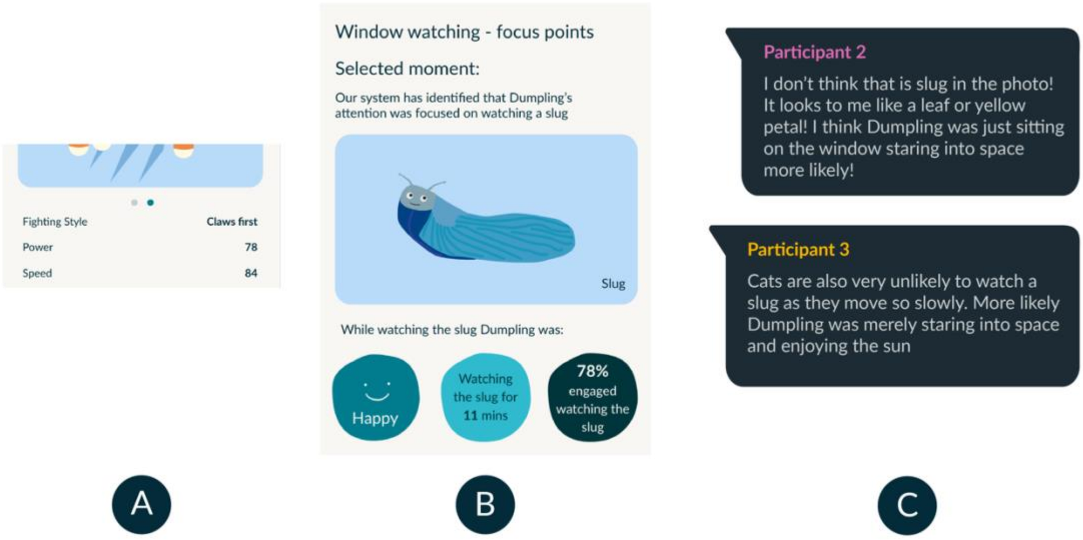

Figure 79 - System and Human perspectives that altered trust in the information provided. A – shows how language such as claws first, contradicted mental models about how cats fight. B – shows similar things with questions raised by participants about what Dumpling was actually doing (as seen in C).

7.6 Insight 6: Different perspectives capture and reveal information about beings' lives

More than human perspectives might capture or reveal information that is explicit in nature, holds a person accountable and alters relationships when this information is shared or is made accessible

CoCo highlighted challenges about where contextualised information is captured, questioning what is considered not only private information but a private space. For example, systems picking up information covered under a nondisclosure agreement or sensing biodata from different people in a swimming pool without their permission. Selves and Beings supported this further by questioning the potential implications of introducing new data types (like different perspectives) that might store more personal data i.e., conversations between people.

More-than-human theory also raises some considerations here as well. How information changes when used by different people in different contexts and the implications associated with this (Giaccardi and Redström, 2020). Additionally, with the Cat Study using companion animal perspectives, there are additional concerns as we are amongst, entangled and implicated in multiple beings' lives (Bryant, 2011). This was seen through cats accessing places people usually don't or can't which raised questions about the acceptability of what the cat's perspective could capture i.e., bathrooms, bedrooms but also neighbour's gardens and homes etc. This blur between public and private spaces was seen as something that could interfere with people's relationships. It also highlighted problems with social self-tracking as information can be captured about more than just the parties involved. For example, participants noting if this data was shared it could be used for accountability to know whether it was their cat in their neighbour's flowers. Equally they could capture explicit content such as prey captured or crimes in the area raising questions about what was acceptable to capture but also what is done with this information when it is gathered. When considering others captured in a system, more-than-human considerations of space and where context might need to be applied needs to be an important concern with the associated consequences of certain types of data.

7.7 What do these insights mean for future self-tracking system design?

The design insights discussed in this section highlight implications of introducing different perspectives of contextualised general wellness information. From these insights, a few considerations for future self-tracking system design arose. These being: different more-than-human perspectives, the way multiple beings are perceived and wellness considerations.

7.7.1 More-than-human Perspectives

This research focused on companion animals as cats were accessible to study and pet tracking features overlapped with current self-tracking applications. However, more-than-human perspectives could apply to the perspective of any *thing*. This raises questions about the implications of exploring these different perspectives, especially if this data is shared with those around us. In section 7.6, it was shown how the cat's perspective could link to accountability if the cat was accused of negative behaviour i.e., interfering with a neighbour's flowers. One participant noted that a similar thing is happening with children as nurseries are now using apps to inform parents of what their child has been doing i.e., not eating their peas. As these apps share more information with us about the behaviour of those around us, what considerations does this raise for future self-tracking system design? For example, through different more-than-human perspectives, more multisensory experiences could be explored which might reveal different parts of our general wellness experiences. This might be something such as how different smells can contribute to wellbeing, maybe the smell of fresh bedding could be calming for someone. Equally, exploring our relationships with other things could show overlapping similarities or differences with the insights found from this research.

7.7.2 Perception of multiple beings

Throughout this chapter we can see that who is viewing the information, who has access to the information and who is implicated through these representations of information, changes how multiple beings are perceived and the narratives created about them. These different points are discussed in this section:

7.7.2.1 Who is interpreting the information:

As we are entangled in multiple beings' lives, including them in self-tracking systems could capture things we might consider private. It could reveal parts about the authentic connection that is different from how we perceive the relationship to be. This could alter how we relate to multiple beings but also what narratives we wish to be known. As noted in section 7.3, different people interpreting this information creates narratives from what we feel is important to note. Therefore, the information might not actually represent multiple beings' general wellness experiences but reflect a distorted connection curated by a human to capture their viewpoint rather than the 'truth'. However, concepts like plurality can begin to explore alternative narratives encouraging people to question the information they receive and think about other explanations for the information provided. This might be something such as “your cat hasn’t been as active today but 5 other people have noted that this could be because it’s cold outside”.

7.7.2.2 Access to information creates a sense of responsibility:

As information about multiple beings could be shared, who has access to the information could change how they perceive those represented in the information and how they respond or act on the information provided. For example, those not familiar with the cat might be able to see the real relationship with its owner potentially resulting in judgement about caregiving abilities. This could also be the same if this information was about a child or dependent of some kind. As explained in 7.1, people find information useful if they can respond or act on it. However, there could also be a feeling of responsibility or accountability to act on the information provided as they are now aware of it. Who was able to access this information might have associated consequences i.e., accusing people of neglect if they haven’t acted on the information provided. As a result, this could impact on our relationships, if assumptions are made from the information accessed and people are held accountable. Equally, even if the intent is to prevent harm to others, knowing that a person’s behaviour is being judged or assessed by someone might alter how people using these systems behave which could cause harm as a result.

7.7.2.3 Who is implicated through these representations of information:

As explained in 7.3, metricised insights, language used but also the style of graphics can change what behaviour, activity, event etc. we think is occurring. For metricised insights, if people have access to this information without knowing who is represented, that being represented could be perceived negatively and potentially judged i.e., if someone was able to see another person skipped their daughter’s medication because they were socialising and drinking. Equally, the way a multiple being is described could reinforce stereotypes altering how these multiple beings are perceived i.e., if one cat is described as friendly but another cat is described as timid it could change how someone behaves around them. Additionally, if graphics were used to quickly explain someone's relationships and the graphics used imply that someone's relationships were mainly negative, how would that make someone feel about themselves? Also, if this information was available, how would that change how those around them perceive that being?

7.7.3 Wellness considerations

Having these different more-than-human perspectives could make people consider things about their own general wellness or the general wellness of multiple beings that they hadn't before. This could be through the introduction of new health standards (section 7.5) which might cause people to become concerned over certain behaviours i.e., energy levels of a cat when it is playing. Given Wakkary et al's (2017) explanation about how we shape each other, information about multiple beings could impact on us. For example, increased anxiety for the owner as well as potentially increased burden about how to act on the information. Therefore, the amount of information we receive is important to consider and more work is needed to understand what this 'correct' level would be. Equally, there could be a feeling of responsibility to act on the information provided. Apart from accountability, where living beings are involved revealing information that potentially shows neglect could have consequences such as the involvement of social services or animal welfare organisations.

Following on from this point, this raises questions about including negative information or authentic connections in self-tracking systems. It has been noted that including this perceived negative information such as cat fights could be useful to include as it contributes to cat's general wellness experiences (section 7.3). However, this is assuming that this form of negative information will always have a benefit. As noted in 7.5, the designers of self-tracking systems have the power to decide what to include in these systems, but what if these systems captured patterns of abuse towards animals or children, or the cat's perspective captured information about a crime or someone in distress, who would be responsible for reporting this? Additionally, with the inclusion of subjective types of information, how is it then determined what is cause for concern and what is a misinterpretation.

Who benefits from these new considerations of contextualised general wellness experiences as well as the other points addressed above (7.7.1 & 7.7.2) require further work. This is so these future self-tracking systems support the wellbeing of all involved in the information provided.

7.8 Summary

This chapter outlines design insights for more-than-human context-aware self-tracking systems. These insights show the implications of introducing different perspectives of contextualised general wellness information. These insights have found that more-than-human perspectives visual cues allowed people to use their own logic to judge whether they needed to act on the information provided. Multisensory experiences provided through these perspectives were found to reveal more about multiple beings' general wellness, including emotions and textural experiences that have wellness properties i.e., calming. The way these perspectives present information can change how beings are perceived and represented in the information. These perspectives can capture more authentic connections with social dynamics and the closeness of different beings changing what information is considered important to receive. These perspectives could also change our trust & confidence in other information provided if viewed as unbiased. More-than-human perspectives can also capture more about the world which could result in capturing socially unacceptable things.

The themes from these sections are highlighted as considerations for future self-tracking system design. Different more-than-human perspectives, aside from the ones discussed in this thesis, could raise different implications for system design.

Who is viewing and has access to information, as well as who is implicated through representations of information changes which narratives are created about a being. This might represent a distorted reality and could increase responsibility or accountability. This is because people could be judged based on their reactions to information, as well as how people perceive those represented in the information. This could also have wellness concerns such as feeling an increased burden and maybe anxiety to act on information provided. Additionally, if capturing authentic connections and negative behaviour, who is accountable when self-tracking systems note repeated patterns of negative behaviour? These questions remain for future work, discussed in the following chapter. The following chapter will outline the main contributions of this thesis as well as the limitations of this research and the future applications for further study.

Chapter 8 Conclusion

8.1 Overview

This thesis introduces different perspectives of contextualised general wellness information to understand the implications for self-tracking system design. These different perspectives are explored in this thesis through three different chapters:

Chapter 4 CoCo – This chapter outlines the creation of a speculative health-tracking wearable (CoCo) that uses context-relevant notifications to suggest activities that could improve people's wellness when in particular 'states' i.e., drunk, stressed etc. Through this world building process, the implications of using a self-tracking system's perspective of more contextualised information could be explored. This provided motivation to introduce different perspectives of contextualised general wellness information.

Chapter 5 Selves and Beings – This chapter argues that focusing on bodily metricised goals that compare us to multiple beings lack contextualised information about our health and wellbeing experiences. This focus produces a single perspective of what it means to be healthy and well. The chapter explores how of a one-size fits all approach to wellbeing, introducing different perspectives of contextualised general wellness information could explore aspects of multiple beings' wellbeing, beyond the body.

Chapter 6 The Cat Study – This chapter introduces these different perspectives of contextualised general wellness information about multiple beings. It does this through a study that provided participants with information about my cat Dumpling's fictional activities. Through interviews, a week receiving updates from different perspectives and a workshop, participants could discuss what it was like to interact with these perspectives and what this helped them to understand about multiple beings' general wellness.

In this chapter, the contributions to knowledge developed from this research will be outlined. The chapters listed above will help provide answers of where these contributions were addressed across the thesis (section 8.2). Following this, limitations of the research are discussed (section 8.3) as well as future applications of this research (section 8.4) that were outside the scope of this thesis.

8.2 Contributions

This chapter outlines two contributions to knowledge developed from this research:

Contribution 1: Introducing more-than-human perspectives of contextualised general wellness information to understand implications for self-tracking system design (presented as design insights for more-than-human context-aware self-tracking system design)

Contribution 2: Demonstrating how design fiction methods can be applied to the design of self-tracking systems.

Through discussing these contributions, this chapter will explain the key takeaways from this research and why this research was necessary to do. The contributions also address the main research questions from this research. The overarching question being:

- What if self-tracking systems considered different (more-than-human) perspectives of contextualised general wellness information?

This includes addressing:

- What would this mean for future self-tracking system design?
    - As in, what would it be like to interact with these perspectives in self-tracking systems?

- Would there be implications with including these different perspectives?

8.2.1 Contribution 1: Design insights for more-than-human context-aware self-tracking system design

More-than-human theory has been applied to design to explore new considerations for design theory and practice (Forlano, 2017; Coulton and Lindley, 2019; Reddy *et al.*, 2021; Giaccardi and Redström, 2020; Stead *et al.*, 2022; Marenko and van Allen, 2016; Tsaknaki *et al.*, 2022). However, this theory has not yet been used for more-than-human perspectives of contextualised general wellness information in self-tracking system design until now. Therefore, this research helps to contribute to an expanding design field by applying this theory to the personal informatics and context-awareness space. It does this by showing how more-than-human theory can provide design insights (through different perspectives) for future self-tracking system design.

To create these design insights, the projects discussed in chapters 4-6 helped to develop an argument for introducing these more-than-human perspectives of contextualised general wellness in self-tracking systems. Through the creation of these design insights, chapters 4 and 5 also contributed to knowledge through providing designers in the HCI and design field with different considerations of context and selves. These contributions will be outlined, before explaining how these design insights for more-than-human context-aware self-tracking systems will help designers looking to create systems that capture different aspects of general wellness experiences.

8.2.1.1 CoCo's contribution: a system perspective requires different considerations of contextualised information

CoCo (chapter 4) highlighted that there needs to be new considerations of contextualised information. Through exploring how context is modelled, it became clear from this project that technical approaches to context assume that context can be known and designed in the same way for everyone. This relies on a system perspective of information which lacks needed contextualised information about people's general wellness experiences. This presented a problem area for designers, as this lack of context can result in harm for both direct and indirect users of a self-tracking system. This is particularly problematic for designing self-tracking systems as these systems are supposed to support rather than hinder wellbeing. A speculative approach allowed specific HCI challenges to emerge, highlighting more concretised examples for why a single perspective of information was ineffective in self-tracking systems and for capturing general wellness experiences. This methodological contribution is discussed in section 8.2.2.

CoCo posed questions about what context is to those designing these systems and highlights a gap with exploring the social implications of context-awareness in self-tracking systems. This is because of a focus on modelling more 'features' of context rather than considering how we interact in specific situations to understand information. CoCo helped to contribute to knowledge around current approaches to context-aware self-tracking systems. This was by highlighting that a system perspective ignored some of the following information and therefore needed other considerations for future self-tracking system design:

- **Ignored people's preferences or priorities** which changed whether someone could act on the contextualised information provided i.e., a crying baby takes priority over changing the light hue to reduce stress.
- **Assumed cause and effect** based on the limited information it was assumed that one action caused something else i.e., poor sleep quality because of interference from a cat rather than the location of sleep such as a sofa rather than a bed.
- **Revealed information between bodies** which could change how these bodies were perceived i.e., the disruption of a child in a graph making parents debate whether to have another child.

- **Gave no boundaries for information** people should have i.e., not acknowledging social dynamics or structures, creating inappropriate connections as well as whether a behaviour is considered harmful and therefore should not be recommended in excessive amounts i.e., recommending a teacher meet a pupil outside of work or recommending drinking wine every time someone is stressed.

This also helped to develop an argument presented in Selves and Beings (chapter 5) around different considerations of information about our general wellness.

8.2.1.2 Selves and Beings contribution: expanding notions of the self and deconstructing how a self is conceptualised

In Selves and Beings (chapter 5), it was found that relying on a system perspective to include contextualised general wellness information means focusing on metricised insights such as daily step count (indicating activity levels). A reliance on metricised insights reduces complex behaviours down to numbers. These metricised insights produce goals that focus on comparing human and non-human bodies, such as your daily step count compared with your dog's daily step count. This ignores different aspects of wellbeing and views these bodies as a collective. The way a self has been conceptualised in self-tracking design means focusing on bodies which only represent one part of who a self is. This approach prioritises certain selves' bodies and general wellness experiences over others because of assumptions that everyone's health and wellbeing experiences are the same.

Selves and Beings contributes to knowledge by deconstructing these notions of how a self is conceptualised, advocating for a move beyond metricised bodily goals by expanding the definition of the self. This is because there is little work done around who the self is that these systems are designed for. This means less understanding about who is excluded or misrepresented through normative ideas about who a self is, which needs to be understood when introducing different perspectives to consider multiple health and wellbeing experiences.

From the literature it was found that there are many assumptions made about the nature of the self, represented in self-tracking system design. These are:

The unitary self - assumes that the self is fragmented and needs unifying i.e., someone who wants to sleep better but also enjoys caffeinated drinks.

The lacking self – is the idea that the self requires improvement and needs to be worked on i.e., the self needs to be reflected upon or more knowledge is needed about the self rather than accepting that we are adequate.

The knowable self – assumes that we can know the self by measuring more about ourselves to discover more about ourselves, rather than acknowledging that we are complex, fluid and messy and cannot be 'known' in this way.

By explicitly showing how these ideas of the self have permeated personal informatics literature, Selves and Beings highlights to designers the embedded assumptions about who they are designing for, altering how selves are represented in self-tracking systems i.e., assumptions about how people behave and live. Trying to know more about the self or believing we are not enough can result in harm in self-tracking systems that are intended to support wellbeing.

Therefore, this thesis introduces different perspectives to begin to address these biases around the selves and explore implications of adding these perspectives before they exist. This is needed because as these systems progress, they start to include our social relationships and how we relate to each other. This raises questions about how future representations of relationships and connections might be included in self-tracking systems. This also includes the associated challenges with including these types of information. This means new considerations not just of the self but also those compared to the self. These are described in this thesis as multiple beings to incorporate non-human animals, but also plants and *things* such as algorithms or rocks etc. This helped to develop what more-than-human perspectives are, which were then introduced in the Cat

Study to show how these different perspectives can contribute to future self-tracking system design. Selves and Beings showed what more-than-human perspectives are by outlining ways introducing more-than-human theory would explore parts of our general wellness beyond a focus on physical aspects. This included our social circles, environment, past experiences and the way we relate to each other. This included taking into account different ways multiple beings experience the world such as:

- **Multisensory experiences** i.e., what we feel, taste, smell etc. based on animism concepts.
- **More authentic connections with our companion animals** - based on Haraway's argument that our relationships are full of waste and cruelty, not just positive elements.
- **Becoming-with our companion animals** - by including our entangled stories with them (times a dog made you laugh) as part of these self-tracking systems.

As more-than-human ignores an emphasis on the body, using this theory to introduce alternative perspectives of contextualised general wellness information can consider different aspects of our general wellness experiences. Introducing these perspectives in non-existent self-tracking systems can also present implications for designers looking to implement new types of contextualised general wellness information about ourselves as well as our relationships with multiple beings. This shows how design can contribute to future self-tracking system design, by addressing potential challenges with capturing general wellness information to indicate and therefore help prevent further harm within these systems.

8.2.1.3 Cat study contribution: what it means to introduce different more-than-human perspectives (and design insights for more-than-human context-aware self-tracking systems)

Introducing different more-than-human perspectives in the Cat Study allowed people to interact with contextualised general wellness information about multiple beings, in this case my cat Dumpling (and indirectly my cat Pickle). This helped reveal implications with including these perspectives which helped reveal key design insights, as discussed in depth in chapter 7. These have been reduced to four key points that show implications of introducing more-than-human context-aware self-tracking systems and what this means for designers looking to create future self-tracking systems.

1. **More-than-human perspectives showed new types of experiences linked to wellbeing (beyond bodily metrics).**

As these new types of general wellness experiences are discussed under concretising more-than-human theory (section 8.2.2.1), this section briefly shows the relevance for designers looking to create future self-tracking systems.

The Cat Study confirmed that adding multisensory properties can reveal different aspects about multiple beings' general wellness experiences. For example, participants referring to textural objects like blankets in their narratives about a cat's wellbeing, linking padding behaviour to stress relief, given the calming properties of the blanket. This supports more-than-human theory showing how we are connected to things via multisensory properties (Lupton, 2020). The Cat Study showed that these are important for narrating multiple being's wellbeing. For designers looking to implement future self-tracking systems, this highlights parts of an experience that contribute to wellbeing and therefore should be explored for inclusion in self-tracking system design.

Visual cues such as height and location were found to provide information to help judge what was happening to my cat Dumpling. This was not possible through a system perspective as participants used observation to build narratives of the events occurring, based on their understanding of cat's behaviour and contextual elements in the space. Through the cat perspective, participants were also able to access unfamiliar spaces helping them to be-with companion animals, in ways that were previously inaccessible through a system perspective. This allowed participants to learn more about different worldlings and more-than-human experiences of the world and how this altered wellbeing i.e., the ability to react to information if suggested the cat was in danger like high up in a tree. For designers these visual cues showed how this perspective supported sense making of the information they were provided with.

Adding multiple diverse positionalities using the concept of plurality can help promote unequal voices, helping to include multiple selves' perspectives rather than a singular perspective. The Cat Study found that these multiple perspectives could distort information, providing inconsistent narratives. For example, the human perspective stating the cat was hungry and the system perspective stating the cat wanted attention. However, this helped people question information they received about a cat's wellbeing experience and become more critical of self-tracking information, rather than just accepting information they were given as true. For designers, plurality showed how multiple perspectives can help with sense making and incorporate underrepresented voices within self-tracking system. This means including individual narratives rather than relying on a singular collective view that is unrepresentative of complex areas like wellbeing experiences. It also raised questions for designers looking to expand on this work, by understanding how to deal with inconsistent perspectives and narratives which conflict ways of relying on information.

2. **More-than-human perspectives showed how information is displayed changes how people sense make and act on the information provided.**

The Cat Study revealed that interacting with these more-than-human perspectives of contextualised general wellness information had implications linked to the information itself. This includes *how* information is displayed in these self-tracking systems and how this changes people's abilities to act on the information provided.

Information considered to be more negative such as fighting between cats, was deemed more acceptable to receive if represented in a positive way i.e., through cartoon pictures of cats. This shows designers that the way information is displayed can alter the type of information people wish to receive about those around them. Additionally, certain visual cues from some more-than-human perspectives allowed people to judge whether to act on the information given. Clues such as height and location could be determined from the cat's perspective. This was used to see if a cat was somewhere it shouldn't be i.e., in a tree and react to safety concerns. Equally, this also highlighted *when* this information was given changed people's abilities to act. Part of this was *where* multiple beings were in relation to each other i.e., knowing the cat's location from the visual cues provided and their proximity to the person with the ability to help i.e., if they are at work or on holiday.

This showed that when more-than-human perspectives are applied to self-tracking design, the information can impact ourselves, because we shape each other (Wakkary *et al.*, 2017). For designers looking to include these relationships in self-tracking system design, the Cat Study showed how there are nuances in the type of information we receive including the frequency and situation we receive the information in. The insights from this study show how more work is needed to understand the correct level of information to support multi-species flourishing. This will better support the wellbeing of all involved in self-tracking system design.

3. **Multiple perspectives revealed different societal expectations which impose boundaries about what information is acceptable to receive.**

More-than-human perspectives revealed issues about what is acceptable for self-tracking systems to capture. Participants interacting with these perspectives raised questions about what counts as a private place with cats being able to access neighbours' homes and gardens and capture information about these spaces and the beings in them. This was seen as something that would make them accountable for their cat's behaviour and change their relationships with those around them, such as their neighbours. This is useful for designers to note how types of information can alter how we act around each other and therefore the implications of introducing these types of information need to be thought about when creating these systems. As this study shows how different types of information can result in accusations for anyone involved in this information, designers need to be able to provide guidance about what to do with different types of information. The introduction of these perspectives is particularly useful for designers to consider aspects of multiple being's worldlings that differ from our own which wouldn't be included in human-centric practices. This helps to highlight not just what is viewed as useful to receive in self-tracking systems but also the boundaries surrounding what information is not acceptable to capture. This is important so that people use these new types of information to make sense of information and support wellbeing.

As explained in point 2, the acceptability of types of information can change based on the way it is presented. The Cat Study found that presenting negative information in a light-hearted way, such as fighting displayed through pictures of cartoon cats, was deemed acceptable information to have. This means that more authentic connections can be included if presented in a positive way, helping to support human sensitivities while also better supporting multi-species flourishing (Haraway, 2016). This finding shows an approach to capture information that better represents multiple beings, helping provide designers with information that is viewed useful to have creating self-tracking systems that people will use. This shows better ways to represent these complex relationships and helps present a less distorted connection to those around us.

4. **Multiple perspectives can alter people's confidence in the information provided (intervening with trust in information used in self-tracking systems).**

Through the introduction of more-than-human perspectives, participants revealed that trust and accuracy were viewed as important for both accepting information and relying on the information provided. If people could not trust this information, this altered their confidence in the contextualised general wellness information provided. For example, the system perspective's inaccurate judgement that a slug was in a photo, decreased people's confidence in different information provided across the study, because it conflicted with the information provided in the cat perspective. The cat perspective was viewed as trustworthy as it was seen as generated and therefore 'transparent' information, in need of interpretation. Compared with the human or system which were seen as interpreted types of information with the potential for bias or taking a certain point of view. For designers looking to create future self-tracking systems, there needs to be clearer explanations of how decisions are made. This is because, as participants explained, a lack of transparency meant they could not trust the metrics provided. This alters the usefulness of contextualised information to support multiple beings' wellbeing.

8.2.2 Contribution 2: Design methods for introducing more-than-human perspectives of contextualised general wellness information

In this research, practice helped inform theory, using an RtD approach to conduct research through making things, helping develop research and create contributions to knowledge by developing new methods to explore implications of different perspectives. The design methods developed as part of this research helped to do two things: concretise more-than-human theory to explore what this would mean for contextualised general wellness information in self-tracking system design and helped implement contextualised information earlier on in the development process.

8.2.2.1 Concretising more-than-human theory

In this thesis, using design practice helps advance understanding of how more-than-human theory can provide different considerations for self-tracking system design. Selves and Beings outlines a few ways this can be explored through speculative inquiry outlining a few app screens applied to a few more-than-human theory aspects. For example, the inclusion of a cat's hunting routine into a pet tracking system based on Haraway's (2003) argument that Western perceptions of our relationship with companion animals ignores negative parts of our relationship. Ignoring these aspects, distorts the reality of multiple beings' wellbeing. CoCo helped to reveal specific problems with relying on a system perspective through the use of fictional narratives. However, it was the process developed in the Cat Study that revealed a few different insights for what it means to apply more-than-human theory to design practice.

In the Cat Study, creating fictional artefacts to represent different perspectives of contextualised general wellness information revealed how more-than-human theory can support information about general wellness experiences, aside from bodily metricised goals. Different perspectives developed such as the cat perspective revealed aspects of multisensory experiences, derived from animism concepts (Lupton, 2020), with visual cues from the footage allowing participants to infer cat behaviour and emotions. Equally, audio clips provided also helped to explore how aspects such as scent and texture can add to our general wellness experiences. For example, a cat purring and kneading, assumed that the cat was padding on something comforting like a soft blanket or someone's leg. These perspectives also allowed more-than-human theory to be applied through exploring more authentic relationships with companion animals (Haraway, 2003). Visual cues provided participants with access to unknown or inaccessible spaces, providing multiple beings with a voice, allowing us the opportunity of being with our companion animals (Tsaknaki *et al.*, 2022). For designers these new worldlings present the opportunity to represent complex entangled narratives to better represent all species involved in self-tracking information.

The process of providing these perspectives also proved important for applying more-than-human theory to design practice. Combining these perspectives revealed how more-than-human perspectives can result in people questioning the truth of information provided from a system perspective. This shows how these alternative perspectives can make us more critical of the information we are provided with about our general wellness. This can, however, show how introducing more-than-human perspectives can decrease trust in self-tracking systems. This shows the challenges for designers looking to implement more-than-human context-aware self-tracking systems, to make sure guidance is included to help people make sense of information. As well as increase confidence in the information about general wellness so it is viewed as useful and something people can rely upon.

Equally, using plurality concepts (D'Ignazio and Klein, 2020) to create a better understanding of the world from multiple human perspectives (through different participants responses), helped to give several different understandings of the information given. It also helped to reduce researcher bias in the process, as I could not assume what different people would interpret from the information provided.

Discussing this experience in a workshop also allowed richer conversations to emerge around more-than-human theory. For example, aspects of more-than-human theory, such as fighting metrics presented in the system perspective, made it clear that the way this information was presented, as well, as who was interpreting it and their intentions, can change whether these types of information in self-tracking systems would be adapted. This is important for designers to consider when introducing different perspectives. This is because for this information to be useful for people it has to be accepted by those using these systems. Equally, the use of these cartoon representations of the cats showed how this could change how multiple beings are represented and therefore how they are perceived. However, as this information was deemed more acceptable it also shows a way that more authentic connections can be included in future self-tracking system design, to better represent selves and multiple beings within these systems. These kinds of discussions about more-than-human theory arose from the artefacts presented to reveal new considerations for future self-tracking system design, concretising this theory into design practice.

8.2.2.2 Introducing contextualised information in a preliminary design phase before implemented in the real world

The speculative artefacts created across the thesis show how design fiction methods can be used to quickly test people's interactions with contextualised general wellness information. Within the context-awareness space, the literature review makes it clear that technical approaches to context make it hard to test context early on because of insufficient data. The design approaches presented in this thesis tackle interaction-based problems with contextualised information instead. This allows these speculative artefacts to be created and tested much earlier before these systems are implemented with the ability to interfere with people's lives. This is defined in this thesis as testing contextualised information in a preliminary design phase. The design methods used and developed in this thesis helped understand potential ways that unintended consequences might arise. This was through exploring the implications with introducing different perspectives whether these were opportunities or challenges for self-tracking system design. This approach helps respond to problems with current system design that can reinforce systemic inequalities and perpetuate harm, the opposite intention of self-tracking systems, by providing methods to explore implications at the start of the development process. But how did these methods help create these different perspectives in a preliminary design phase to explore contextualised information?

CoCo used design fiction as world building, presenting several artefacts through the use of a fictional paper. The fictional paper developed could test potential negative implications of new self-tracking context-aware features. While the use of a fictional paper is not a new method, this method has not yet been used as a way to explore new self-tracking features that could impact on people's wellbeing. A fictional paper meant rather than having actual people use and test the prototype, fictional user narratives could explore implications of self-tracking systems. This means they could note how these designs might cause harm for both direct and indirect users (i.e., cat adoption!) without having to interfere with people's lives and potentially harming their wellbeing.

Additionally, these artefacts gave access to certain expertise that might not have been possible through a traditionally design framed research paper i.e., machine learning diagrams to access technical audiences. Therefore, these methods helped evaluate future implications through world building by provoking debate among experts with differing viewpoints. Focusing on near future technologies also drew attention to the importance of this space, with real world examples appearing shortly after the publication of CoCo that continued to show existing design problems. Reflecting on the effectiveness of speculation to explore concerns around context-awareness and self-tracking design, it became evident that design methods were needed to explore these issues in a preliminary design phase as it was clear this was not being considered.

The Cat Study explored interactions with these different perspectives of contextualised general wellness information with actual participants. This was done without needing lots of contextualised data by simulating a working system through pre generated fictional artefacts that could plausibly exist in a self-tracking system. By using my own cat rather than participant's cats it could be understood how a person might make sense of data about multiple beings they lacked initial contextualised information about. This approach outlined a way that participants could be used to test new types of information while reducing the potential to harm wellbeing in the process. This was because they could not act on the information provided, other than reporting on what was happening, as it was not their cat. Participants could reflect or relate this information to their own cat and use this to make sense of the information provided. The degree of separation helped to mitigate changing their relationship with their own cat, before potential implications of the information could be tested. It also meant lots of information was not needed about the participants to interact with these different perspectives. This was important to understand possible implications for both those using and represented in self-tracking systems.

8.3 Limitations

This research was conducted in the northwest of England meaning general wellness discussed throughout this research and assumptions about the design of self-tracking devices relates to devices used and available within the UK. Therefore, design insights about more-than-human context-aware self-tracking systems might differ from similar research conducted elsewhere in the world.

There are a few factors that might have influenced people's opinions of self-tracking information that are important to explain here. Firstly, the structure of the national health service (NHS) might influence people's thoughts about what health and wellbeing means to them and also what information they find useful to have about multiple beings in self-tracking systems. It should also be noted the time period when this thesis was completed. My research started during February 2020, meaning just a few weeks in the COVID-19 pandemic brought the country into lockdown. Given that people might not have been able to leave their homes except for exercise; their behaviours, routines and actions might have altered significantly. This means their interactions with self-tracking devices may have altered as well as what information they consider useful to have about their own wellness but multiple beings' wellness as well.

During this time, digital technologies such as contact tracing apps which could track people's whereabouts and exposure to the virus became a topic of public debate (Sweeney, 2020). Additionally, research using smartwatches to detect when a person had COVID-19 (Mishra *et al.*, 2020) and people self-monitoring vitals at home made these self-tracking technologies more desirable (Eadicicco, 2022). While the Cat Study involving participants happened in 2022 after restrictions had eased, self-tracking concerns might have been more known to participants given the attention around self-tracking general wellness. While unclear whether these were the reasons, participants involved in this research seemed to be quite familiar with self-tracking design issues. The participants in this research seemed to critique and question information they were given, not accepting everything as truth. They were also aware of the underlying issues related to data i.e., biases and societal structures and norms present in self-tracking system design. This could be because some worked with data but whatever the reason, this means the perspectives of these participants do not represent all views about understanding of contextualised general wellness information. Therefore, the results from the Cat Study are not generalisable. However, it highlights a need for more research to explore understanding not just about our own but multiple being's general wellness information.

Equally, the sample size for this project was relatively small (6 people) mainly consisting of white and female individuals. While similar studies have noted that small sample sizes are common for similar studies (Wang *et al.*, 2017; Brombacher *et al.*, 2022; Ng *et al.*, 2022), the diversity of this sample could have been improved. This could impact the generalisability of the findings from this study. However, this project provides a method that can be replicated by other researchers to explore different more-than-human perspectives of information about multiple beings. While this thesis provided a starting point for including new viewpoints within a system design, conducting this research online might provide access to people and multiple beings from all over the world. This could also improve understanding of multiple being's health and wellbeing from differing experiences to provide new considerations for self-tracking system design.

Additionally, this research introduces the idea of different perspectives of information but this does not have to be applied to cats, multiple beings or even self-tracking design. Therefore, it might be useful for exploring different interpretations of any type of information provided i.e., social media content or productivity levels. It is also worth noting that this means there could be different ethical considerations not explored in this research but would need to be addressed in future research.

8.4 Future applications of this research

Given the scope of this PhD there are limitations. However, through these limitations a few areas for future applications of this research have emerged. This section highlights some of challenges that remain, summarising these at the end through brief recommendations for future research.

8.4.1 Explore different more-than-human perspectives

While this research focused on cats, introducing the idea of more-than-human perspectives of self-tracking information creates possibilities to explore any *thing's* perspective of information. A couple of examples are provided here as potential starting points for exploring more-than-human perspectives of general wellness information. However, these more-than-human perspectives could also be applied to different types of information.

If a plant's perspective was included in self-tracking systems, would it help people care for their plants by revealing more about how plants respond to their environment? Or maybe as Rolighed et al's (2022) work into posthumanism and plants reveals, plants share information with neighbouring plants and maybe tracking these social behaviours alters our relationship with them. Part of this could be decentring human's control over the plants by providing information based on the plant's schedule rather than the human's.

Equally, the authentic relationship we have with our food could reveal insights about our general wellness. People with allergies or eating disorders may have a more negative relationship with food. Maybe noting sensory experiences when those with a milk allergy consume dairy could begin to understand our general wellness experiences better. Using more-than-human theory to explore this connection could provide different considerations for future self-tracking system design and understand more about including general wellness experiences in these systems.

8.4.2 Alternative methods for developing more-than-human perspectives

In the duration of this thesis, advances in generative AI models have led to the creation of systems like Open AI's DALLE-2 or Stable Diffusion for image generation. As this thesis acknowledges that advances in machine learning are viewed as a way to create more contextualised information, it is reasonable to assume that these types of tools might be used in future self-tracking systems to provide additional contextualised information. Image generation tools could be used to quickly generate the cat perspective images or other multiple being's perspectives that might be harder to recreate i.e., a bird, stick insect, plant, tomato, or a sleep tracking mat.

However, these might not be accurate, as found when asking DALLE-2 to generate some images of a cat staring at a slug on a windowsill (replicating DAY 3 AM prompt participants were sent in the Cat Study) showed that these systems can plausibly generate cats (if you don't look too closely). There were some problems with the size of slug produced (Figure 80 A,B,E) and specifying the type of cat (British blue shorthair) or dog (Pomeranian) produced more accurate results (Figure 80 D,E). Equally, it should be noted that using these tools to represent more-than-human perspectives can reinforce existing biases and societal norms and amplify them (Nicoletti & Bass, 2023). For example, when stating 'from a cat perspective' in the text prompt, assumptions built into the model assumes the cat has to be in the picture or a viewpoint from the floor (Figure 80 C, F), limiting the effectiveness of the images produced. It can be argued that biases will also exist from researchers recreating a more-than-human perspective but unlike the machine they can reflect on their positionality and consider this when creating these different perspectives.

Figure 80 DALLE-2 generated images related to the update sent to participants on day 3 (watching out of the window). Generated prompt descriptions on 2/06/2023 to produce these images. A – 'Fish eye lens showing an orange cat watching out of a window with a slug on the window'. B – 'A picture of an orange cat watching out of a window with a slug on the window'. C – An image from a cat's perspective. Watching a leaf that looks like a slug on a windowsill.. D – 'Fish eye lens from the perspective of a british blue shorthair cat watching a slug on a window ledge'. E – 'Fish eye lens showing a Pomeranian watching out of a window with a slug on the window'. F – 'A cat's perspective watching a slug'.

8.4.3 Terminology and language used across this thesis

Certain language was used across the PhD to explain concepts related to self-tracking. When discussing these concepts in relation to multiple beings, it could be debated about the terms chosen and used in this work. This is because they may reflect human values and priorities and do not reflect non-human animal's experiences. Firstly, self-tracking, or the broader term focusing on personal informatics, both refers to a 'self' or a 'person', emphasising that this information is about a human for a human. As briefly mentioned in Selves and Beings, companion animals are included under these terms as they are already included in these systems, so even if not acknowledged, they are described under these pre-existing terms.

While it was outside the scope of this work, more work is needed around establishing an accepted term within the personal informatics field. Reflecting on how language used excludes those already involved in our tracking systems, also supports the need to move beyond the body. This is especially important as human beings might not always be the focus of the relationship, only forming one part of these complex networks of data. Two different terminologies written here might provide a starting point for more inclusive terminology:

Lived informatics: Rooksby's (2014) early definition of lived informatics is currently focused on human lives but acknowledges the messiness of tracking within our lives and relationships. Therefore, it can apply to any being through focusing on life rather than the 'person' or 'self'.

Interspecies information systems: Van der Linden's (2021) work around interspecies information systems acknowledges that these systems include multiple species.

8.4.4 Perceptions of identities and values and the potential impact on our relationships

From research we know that the way multiple beings are presented in systems can alter our relationship to them. Feighelstein et al., (2022) state that studies show dogs with features similar to human babies are more likely to be adopted. They found CLIP, an image classification model, reflects these human biases, stereotypes, and perceptions of dogs. CLIP perceives an adoptable dog as a white dog, over mixed-breed and black dogs. Equally the model had high certainty that a specific dog breed was considered a 'bully breed'. This is particularly relevant to this research, as the final project discusses one participant's comment about 'who decides what is cute?' and the impact this has on non-humans included in these systems. If these assumptions are embedded into our systems and used to create data-based insights related to our companion animals, how does this impact our connection with those around us?

Maybe if a system is used to define our companion animal's behaviour based on similar assumptions, what might be considered playful for one breed might be considered aggressive for another. This would change how these non-human animals are represented in our systems but also how we respond to these data-based insights. It also highlights the challenges with including different perspectives that we can't directly access i.e., the cats' perspective discussed in the Cat Study. More research is needed to acknowledge how multiple beings' wellbeing needs different considerations in self-tracking systems separate from human priorities.

8.4.5 Wellbeing for whom

Advances in industry, means computer vision models can detect objects in images to provide data-based insights from photos and videos (IBM, 2023) and algorithms can scour video streaming platforms to detect and flag inappropriate or sensitive content (Google, 2023). While this research has found that photos and videos provide meaning not possible through metrics and quantified suggestions, it was also noted that certain information could be harmful for those viewing the content i.e., cats catching prey.

However, focusing on those interacting with these new perspectives ignores implications of those involved in monitoring and moderating content who decide what could be harmful for people to see. These jobs are often outsourced by companies and crowdsourcing platforms to workers in vulnerable situations. They are paid very little to make these important social, ethical and sometimes political decisions (Miceli & Posada, 2022). They require people to look at endless pictures and videos potentially containing violent and explicit content to help clean training datasets. Exposure to this content was found to be traumatic for data workers and they were not offered helpful counselling support such as one-to-one support to help with the involved labour of these roles (Perrigo, 2023). This raises questions about wellbeing discussed within this thesis, with it being clear that even if these different perspectives support end users in their sense making of general wellness information, the different types of information included could have implications for workers involved in this process. Research cited above provides recommendations for how these processes might be improved to incorporate these worldviews and better support all involved in this process. Therefore, more research is required to understand how to support wellbeing in self-tracking systems without causing harm to data workers in the process. Potentially, considering processes aside from machine learning to include different perspectives of information might provide a starting point.

8.4.6 Summary of recommendations for future self-tracking system design research

This thesis introduces the idea of including different perspectives of contextualised general wellness information in self-tracking design. Design insights have been found for context-aware more-than-human self-tracking systems and has developed design methods for exploring these perspectives. However, given the introduction of these new considerations for self-tracking systems means future work remains that was outside the scope of the PhD. These have been summarised in 3 short points below, given the discussion in 8.4.

More inclusive terminology - of those included in self-tracking systems both humans and multiple beings.

Research into different more-than-human perspectives – that can help provide new considerations for future system design.

How to better support wellbeing - of everyone involved in self-tracking systems, not just the end users (either directly or indirectly involved).

8.5 Summary

This research introduced more-than-human perspectives of contextualised general wellness information to explore implications for future self-tracking system design. This produced design insights for more-than-human context-aware self-tracking systems. The insights discussed highlight the complexities with moving past a singular perspective of self-tracking information. These singular perspectives have led to a dismissal and exclusion of multiple beings' experiences and resulted in self-tracking design that hinders rather than supports wellbeing. This thesis provides a starting point for those wishing to explore how more-than-human theory can be applied to design practice. I hope this research will help advance self-tracking system design and create information that supports all general wellness experiences.

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Appendix A - CoCo Design Fiction artefacts

A.1 CoCo User data

All quotes created for the user study in the fictional paper. These were created and discussed with supervisors and then a few were chosen for the actual paper.

Household 1: Middle Aged Couple

Philip Turner - Doctor, 50 years old

As a doctor, Philip's life is quite hectic and can sometimes be stressful but he works long hours, does plenty of exercise, and has an optimistic outlook. Despite the stress in his life 'if I keep healthy, keep busy, I will be good'. He's interested in self tracking as he's had an increase in patients using such devices. He's not sure if such things will act as preventative care, or whether the might cause harm, so wanted to test himself.
He likes the idea of activities to improve mood as he's found people generally don't know how to improve health and get stuck on what they don't do i.e. I haven't walked enough steps which may not be possible because of injuries, mental health etc.

"I could see this being really useful for some of my patients who want to improve their health but often turn to wearables like FitBit and get stuck on not walking enough steps, when really they need personal activities to achieve this goal because of injuries or mental health problems they have"
"I liked it. I exercise everyday, and during the times when the system learned I was stressed, it would often remind me that I might relax more if I went for a run. Usually that wasn't possible (when you're in the middle of a COPD clinic you can hardly put on your tracksuit and dance out the door), but what I found was that just remembering that I'd have my wind-down time after work was relaxing"

"It didn't like me drinking espresso. Obviously, initially I thought that was because it could detect the caffeine, and as most people know, it can increase stress... so I thought it was preprogrammed to do that. Apparently it doesn't work that way, so, I'm not sure. Maybe it learned that on the days when I had more coffee I reported being less happy. It'd be good to see that data somehow, to know why it made a particular decision or suggestion? At the end of the day I just love the taste of coffee, and I'm trying to teach myself latte art, so, it's a bit of a hobby (although I'm not very good, so, that winds me up as well)."

"In general I think that anything that makes people move more is good. We live very sedentary lives, and it's terrible for our cardiovascular systems... particularly when combined with a bad diet. So, if it can do that, then great. However I'm not sure this is the solution. A good friend of mine had heart surgery and, essentially needed to cut out all saturated fats and do more exercise. His answer to the AI-powered learning health device? A combination of his wife nagging him, and me going around his house on my daily run to pick him up! We're a social animal, and sometimes I think social solutions are the best. I do worry about obsession with technology, so often there are more simple solutions."

Kat Turner – Swimming Instructor, 47 years old

Kat often uses a wearable when she goes swimming and found it frustrating that previous wearables would confuse her swimming activity with a run etc. When using CoCo she found it hard to tell an app what she was doing when teaching at the pool, as she had the wearable on but her phone was kept in the locker room. She needs her devices to be able to work without her interacting with a phone constantly.

"Because it learns through use, I thought CoCo might be the solution to my problem. I've wanted a health wearable for years, because I spend so long at the pool – it'd be interesting to see how many miles I clock up in a week. I'm sure I must have broken a record or something. It was a non-starter though, I needed to use the app via my

phone to tell the thing what I was doing. Phones aren't allowed in the pool, so, basically I just had the thing asking me to go and get my phone for months. So, that side of it didn't work out very well. By the way, our pool has actually banned any electronic devices in the pool now (not just phones). The pool is supposed to be a private space, even though it's shared, and people were worried about cameras and recording and stuff."

"Outside of work, it basically seems to work. I'm not sure if I took against it because of the constant nagging to get my phone while at work, but I found the prompts asking me whether I was happy or not, and what was doing, to be a bit annoying. Isn't this what the AI is supposed to figure out? I definitely wouldn't buy one, but I know that my brother would. He loves gadgets".

Household 2: Family with baby girl and 5 year old

Euan Colins – Veterinarian, 30 years old

Euan liked CoCo wearable more than Fitbit because it showed more than general statistics. Previously could never compete with wife who wore wearable all the time compared with just using it for exercise but CoCo gave contextualised prompts so was much more useful.

"So much better than Fitbit, stopped using that thing after it compared me and my wife's stats even though I only wear it for runs, I could never compete! At least with this I have a chance of improving my health with simple things, I'm definitely going to use this more. FitBit was just about raw numbers, and Gina always had twice as much. But CoCo links the benefits to the activity, so I can see because of running I'm destressing significantly. On the other hand, I think it might have made Gina think twice about having another baby, seeing all the disruption that Darlene causes in a graph was quite startling."

Gina Colins – Mum and part time barista, 28 years old

Being able to see other people's workdays caused family conflict because she could see how stressed Euan was in his job. App is ok at recommending activities when it's things you're in control of, but when you're in control of two other lives as well it doesn't take that into account.

"The app is good at recommending activities if it's only your life impacted but it doesn't seem to understand that you're in control of two other lives as well.It doesn't take that into account… yes I'm stressed (referring to Figure 5a) with a baby crying and Darlene hitting her head on the wall after pretending to be a fairy but I can't choose mood lighting,listen to whale noises, or spontaneously meet my friends for a coffee - these things have to be dealt with now."

"I'm not sure I'd want anyone else to see the alcohol consumption graph. I'm aware of the risks of drinking – so is Euan – but, if you just look at that it looks like we spend half our lives pissed while looking after the kids... even though I think we're just normal. That stressed me out a bit, which I then reported to the app when it asked. I think that confused it a bit... it seemed to correlate 'Give Darlene her meds' (because that is what was in my calendar at the time I looked at the alcohol graph) with being stressed out, so it said 'Consider giving Darlene her meds after chatting with friends'. Not. An. Option. I think it's very clever, but, still a bit dumb."

"In fact some of the correlations are quite mad. Because I usually have a glass of wine after putting Darlene to bed – that's the time we relax – it thinks that I should constantly be drinking and watching I'm a Celebrity."

Household 3: elderly couple

Ron Gray – Retired, 80 years old

^going for grumpy old man 'vibe'

Got rid of cat because Ron normally falls asleep on sofa and would get woken up by cat falling asleep on lap and then scratching him to check he's awake – noticed from app he was kept awake 10 times because of the cat (Muffin) in a week!

"I like the sleep charts, the wife keeps nagging me that the sofa isn't good for my health but it was that damn cat. It had to go, ten times it's woken me up in the past week! If it wasn't for the app Doris would have convinced me it was the sofa but now I have proof, Muffin (the cat) is to blame."

Cat only thing that affected Ron as he doesn't drink coffee and doesn't drink/rarely gets stressed so didn't get notifications that often – irritating typing in what you're doing all the time to get hardly any recommendations but did like looking at information – amazing what technology can do these days

"I don't really understand all this technology constantly beeping and buzzing, asking me what I'm doing, how I'm feeling. Isn't it supposed to know all that anyway from the wrist thing (wearable)? It's asking me more than my own family, like that isn't bad enough! I like the information on the app, but I don't drink coffee or alcohol so I don't get a lot of use out of it."

Dorris Gray – Retired, 76 years old

^maybe Dorris comes back at Ron's comments about the cat:

"I couldn't convince him but it was actually the TV waking him up. Every . Single. Day he'd refuse to go to bed saying he's not tired and then he falls asleep. I gave up in the end, he'd wake up at 5am when the theme tune of Friends would blast out of the TV. It just so happened Muffin was on his lap at the same time and CoCo helped fulfill his conspiracy theories. At least my daughter would take her (Muffin) so I can still go see her regularly but I think you have to be very careful what you believe on the app."

Initially did not know enough about me so was recommending activities I couldn't do like mountain climbing, made me more social as I go to knitting club more often now when caffeinated – get so many jumpers made for my grandchildren!

"Well to start with I wasn't convinced, the app said that when I was stressed I should go mountain climbing! Imagine me with my leg at the top of a mountain, it did make me chuckle. But now I've become a lot more social, it recommended I go to knitting club when I've had a coffee. I've finally learnt how to cable knit, think my grandchildren will be sick of jumpers by the end of this year."

Household 4: female who lives by herself

Kelsie Boswell – Botanist, 55 years old

Coffee shop started going out of business with people cutting down on amount of coffee

"Looking at the caffeine chart was alarming, I didn't realise I was drinking that much coffee so I stopped going to my local café on the way to work. I had to start going again though, the manager is my friend and I didn't realise but with more people becoming aware of their caffeine intake they were struggling to survive. One coffee a day won't hurt, I don't want local businesses to go as a result of my actions".

App confuses every time she goes to bar as wanting alcohol but actually going to work – frustrating because the app presumes she has an alcohol problem - doesn't have her work calendar on same phone as CoCo app.

"I couldn't have a wearable for years because of the tattoos on my arm, which I know was a problem for others at the gym. I actually improved at MMA (mixed martial arts) thanks to CoCo, it showed me how much MMA decreased my stress levels so I upped my training regime. I was quite offended though, it suggested going to the doctor for

an alcohol problem, I work at a bar! It's not my fault it doesn't recognise bars as a workplace, it makes me question the accuracy of other suggestions it's giving."

Household 5: student household

Encouraging all of them to drink more alcohol as they're happiest at pub hanging out with friends – even though they have hangovers and increases caffeine intake and decreases work quality

Cecilia Lewis – Biology student, 22 years old

Interested in the field of bio technology and using physiological states to infer things about health and wellbeing.

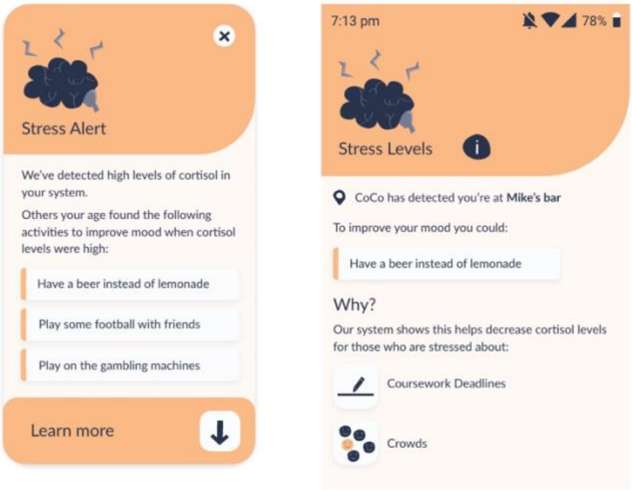
Didn't like it interrupting social situations – annoying when trying to have a conversation and your phone is buzzing you

"It's so annoying, I was trying to catch up with Alice, I hadn't seen her in months and CoCo kept buzzing and buzzing asking what I was up to. I don't like it being so needy, I'll tell it what I'm doing when I want to not the other way around."

Later on impact – worse grades as spent a lot of time in the pub socialising so having to retake all exams for the year

"I felt a lot happier after using CoCo, I caught up with Becky, Liv, Angie, all the mates I hadn't seen in forever. Looking at the charts it seemed like a scary amount of alcohol but I don't think I drink more than a typical student. Sure, I have to retake all my exams because CoCo suggested going to the bar a lot…but BIO212 and 204 was a nightmare, everyone said the same, so I'd have probably done bad anyway."

Mohammed Azam - Computing student, 19 years old



^could be potential example

Doesn't trust security around wearables and what they're doing with my data, especially when it can access everything on my phone. Doesn't like technology being in control of his decisions.

"I've never used a wearable before, I don't like the idea of these health companies taking all this data from you. It's the same reason I don't use social media, they know more about me than I do, it feels so invasive. That was my first thought when trialing CoCo, this app is trying to control all my decisions and I don't feel comfortable giving it the power to change and dictate my life".

For people who don't fit the apps dataset I.e. most people drink it might make wrong assumptions that everyone drinks and so recommends wrong behaviours based on biased data set – before data has learnt enough about person uses model as suggestions - "others your age drink beer to ease stress about upcoming exam

Behaviour: try a beer over lemonade

Context: when at the pub with friends

Wellness: to help ease stress about upcoming deadline

"I don't drink for religious reasons but my flatmates do, so I go with them to the pub to be involved. Crowded places have always made me feel uneasy and on top of coursework deadlines CoCo rightly detected my stress levels. What I didn't expect was the app suggesting having a beer instead of lemonade, probably because most people my age drink but this seems to contradict the whole positive behaviour change thing".

Russell Foster - Psychology student, 18 years old

Social butterfly – likes hanging out with friends, usually at the pub – CoCo 'works' as it even though they have hangovers and increases caffeine intake and decreases work quality.

Russel was very much looking for more social activities during the time he was using CoCo – he was disengaged from his studies and had high expectations for the social activities that would accompany his time at unviersity. He really appreciated the encouragement it gave him to spend more time making friends, drinking, at the pub. CoCo identified that Russel was anxious when at home, but became relaxed and far happier when 'with friends' at the pub. The hangovers were identified, but 'solved' with caffeine intake. The impact on Russel's studies and authentic social connections are beyond the scope of what CoCo can capture.

"At first CoCo completely amazed me, rather than telling me to exercise more and eat better, it encouraged me to spend more time socialisng and meeting new people and helped me feel less guilty for making time for this during my first year at university"

"In the end I had to kind of stop using it. The time spent making friends was great, but it also made the end of term very stressful with deadlines – it kept telling me to go back out! It was funny (and fun) at first, but in the end it got me down when I had loads of work to do."

Perhaps too plain a statement of this issue of modelling underlying intent / needs:

"Now I know more about how CoCo works I understand that it was trying to help me be less stressed, but perhaps the stress of my first term at university wasn't a bad thing – I needed to feel some pressure in order to properly take on the challenge of university."

Household 6: male author lives by himself in a flat

Gabriel Alvarez - Author, 33 years old

Also got rid of cat as stress levels increased around cat and raised heart rate so was concerned for health due to high blood pressure (hypertension)
Heating bills also rose as works from home and every time he was stressed raised the heating to lessen stress
^did decrease caffeine because more stressed in coffee shop environment but became more isolated living by himself, occasionally leaving for a walk

"The past six months has been deadline after deadline, and I seem to be more productive when working in Costa but CoCo showed me how stressed the amount of coffee was making me. I decided to try working from home but this caused even more problems, my heating bills increased as the Nest whacked up the heat whenever I was stressed and I became even more stressed because I wasn't talking to anyone. It's a vicious cycle!"
"That's when I realised I needed to adopt Pickle [the cat]. The cat interference showed how much he was increasing my heart rate, picking up dead birds, knocking over lamps and plant pots – I've never realised the effect on my health before! I've got problems with hypertension you see and I couldn't stop thinking what if Pickle ends up being the death of me."

"But now Pickle is gone I'm not sure it was the right thing. Yes all that stuff was stressful, but I'm so much more lonely now. According to CoCo my average wellness since I got rid of Pickle has decreased, but the app seems to think it's to do with my coffee intake and how hot my house is. I'm not sure it's working."

Household 7: young professional couple

Mark Green – Software Engineer, 26 years old

Mark has a speech impediment, in its decision-making BLOOM determined that Mark was drunk based on a few factors including time and detecting slurring as drunk related behaviour. However, this was actually just Mark working late and slurring his word due to his condition.

"I didn't notice it at first but I've been working late the past couple of weeks, getting ready for the new website launch and I started getting notifications about alcohol problems. Initially I ignored it thinking it was just a glitch but they kept appearing. I looked at the word cloud and noticed the slurred words (see Figure 6b) and that's when it hit me, the system thinks I'm drunk because of my speech impediment! I thought the system would have taken this into account but clearly not, it didn't bother me too much but that could really affect someone."

Issues with audio meant it picked up on projects and things that are confidential

"I stopped using CoCo though, I didn't realise it was recording my audio and suggested when caffeinated I work on a project that's currently under NDA. I couldn't find a way to use the app and not have it using my audio, I can't risk losing my job because of privacy issues with an app."

Jason Green – Teacher, 27 years old

Missed several staff meetings as CoCo told him it would stress him out but as a result got into trouble with work

"On Tuesdays I teach year 7's all day and then have an all staff meeting. Trying to follow CoCo's advice, I started skipping these meetings, wanting to ease my stress levels. I didn't think I had missed many but it turns out I hadn't been to one in 2 months and had to explain all this to the head, which I can tell you now, increased my stress levels a lot more than attending the staff meeting. The app seems to try its best but it's not clever enough to consider the consequences of following some of these tips"

Because calendar had meetings with students and parents, activities were being suggested to hang out with them

"Last week we had parents evening, and I must have told CoCo I was feeling good at some point because this week I saw a notification appear suggesting I meet one of the parents and their child for a drink. I'm presuming this is because it was in my calendar that I was meeting them when I felt happy…maybe because they're the one child in the class behaving well…but highly inappropriate, it needs some kind of filter so I can say do not under any circumstances suggest this again!"

Appendix B - Ethics Documents

B.1 Consent Form - Understanding data perspectives through insights about cats

(Please tick the boxes to the right to confirm you have read the information below)

1. I confirm that I have read the information sheet and had the opportunity to consider the information provided, ask questions and have had these answered satisfactorily. ☐
2. I understand that participation is voluntary and I am free to withdraw from the study at any time by September 2022. If I am involved in any workshop and later decide to withdraw from the study, my data will remain a part of the study. ☐
3. I understand that the information given in interviews, the week experience and workshop will be used for future publications, presentations and funding applications by the researchers but my personal information will not be included and steps will be taken to protect the anonymity of the participants involved in this project. ☐
4. I understand that my name will not appear in any reports, articles or presentation without my consent. ☐
5. I understand that the interview will be conducted using Microsoft teams and will be recorded with both video and audio. This interview will be transcribed, and the data will be protected on encrypted devices and kept secure. I agree that this interview can be recorded and transcribed for research purposes. ☐
6. I understand that I will be sent notifications and prompts via WhatsApp on my smart phone and asked to respond to questions sent about this information during the week long experience. I am aware that my responses will be used for research data but that I do not have to respond or engage with any data insights received that make me feel uncomfortable. ☐
7. I agree that I am over 18 and agree to take part in the above study. ☐

Name of participant: Signature: Date:

B.2 Poster for advertising the final project

B.3 Participant information form

Understanding data perspectives through insights about cats

We are a group of researchers from Imagination Lancaster, a design research lab at Lancaster University. The members of this team include:

Kim Snooks, PhD researcher, k.snooks@lancaster.ac.uk

Dan Richards (Lecturer) Roger Whitham (Lecturer) and Joe Lindley (Research Fellow)

We would like to invite you to take part in 'Understanding data perspectives through insights about cats,' please take time to read through the information below and decide whether you would like to participate in this project.

What is the project about?

This study is about self-tracking technologies focusing on health and wellbeing data gathered about an individual or another person or non-human i.e. a pet. This study forms part of a PhD project around the future of health tracking technologies. We're looking for people who uses some kind of self-tracking device that tracks data about themselves or their cat i.e. FitBit, Apple watch, Tractive etc. The aim of this project is to understand people's perceptions of the data insights they receive about an 'other', in this case one of the researcher's cats called Dumpling. From this study we would like to see whether we could shape data insights in future health and wellbeing tracking technologies.

Why have you been invited?

You are invited because you have tracked data about yourself and your wellbeing such as step count. Alternatively, you have tracked data about your cat's health and wellbeing, through a self-tracking device. These self-tracking devices can include smart watches, pet collars or an app etc. We believe this experience in self-tracking makes you an ideal participant and your contribution will be invaluable to this project.

What will you be asked to do if you take part?

If you decide to take part, there will be 3 stages to this project:

Stage 1: Interviews - You will be asked to take part in a recorded interview via Microsoft Teams to gain a general understanding about both you and your pet. You will also be asked questions about your understanding of self-tracking devices and associated data.

Stage 2: Week experience - We will send you notifications via WhatsApp related to information about the cat Dumpling. Throughout the week you will receive various forms of information related to Dumpling including photos and videos and occasionally be asked questions about your thoughts relating to this information.

Stage 3: Workshop - You will be asked to take part in a workshop with other participants that have been receiving the same data and asked to reflect on the experience of living with this information about an 'other', in this case the cat Dumpling.

What data will be collected?

Stage 1 - Initial Interviews: During the interviews you will be asked questions which will be transcribed and anonymised by the researchers and destroyed once the results of the project have been published.

Stage 2 - Week experience: During the week experience you will be asked to respond to questions via WhatsApp related to the information you receive. This information will be used as part of the study but will be made anonymous by the researchers and destroyed when the results have been published.

Stage 3 - Workshop: During the workshop you will be asked to take part in activities reflecting on your experience of living with messages relating to information about a cat.

What are the possible benefits from taking part?

By participating in this project, you will gain insights around self-tracking systems and data insights about others. As part of this project, you will have the opportunity to ask questions about these topics and have your views around the design of these future systems included. You will have the opportunity to live with new forms of information for a week and provide feedback on what the experience was like. This will contribute to research surrounding potential future applications of health and wellbeing data tracking. Participants will be offered a £50 voucher on completion of this study to thank you for your participation and reimburse you for the time taken to complete this study.

Do you have to take part?

No, participation is entirely voluntary.

What if I change my mind?

You can withdraw up to the end of the project [September 14th 2022]. However, if you have taken part in the workshop and then wish to withdraw, data collected from the workshop will not be able to be redacted from publication.

Will your data be identifiable?

In the interview stage your face and voice will appear in the video so you will be identifiable. This interview will only be shared with the researchers and when the transcript is written up, anonymised and the project published the video and audio will be deleted. You will be asked to consent to any information you give during all stages of the project, and this will be anonymised in any academic publications or articles.

How will we use the information you have shared with us and what will happen to the results of the research study?

Any ideas or opinions shared with us, as well as information from the week experience will be anonymised and then used as research data in future publications including journals/conferences and articles on the Imagination Lancaster website.

How will my data be stored?

Stage 1: The data from the interviews will be stored on Lancaster University's OneDrive. This will only be accessible by the researchers and once the interview has been transcribed, anonymised and the work published the video and audio will be deleted.

Stage 2: Any responses to the notifications via WhatsApp will be recorded by the researchers and stored on Lancaster University's OneDrive. This will only be accessible by the researchers and once the project is complete these responses will be deleted.

Stage 3: During the workshop the data relating to your views and experience of living with the data will be recorded through group activities. The data from these group activities will be captured for future research outputs such as conference publications and articles. Once the project has been published this data will be destroyed.

For further information about how Lancaster University processes personal data for research purposes and your data rights please visit our webpage: www.lancaster.ac.uk/research/data-protection'.

For further information about data related to this study or other questions about this study please contact Kim Snooks at k.snooks@lancaster.ac.uk

If you have any concerns or complaints that you wish to discuss with a person who is not directly involved in the research, you can also contact the Head of the Department: Professor Alan Marsden, a.marsden@lancaster.ac.uk, B140, B-Floor, County Main, Lancaster University, Bailrigg, Lancaster. LA1 4ZA . +44(0)1524 510817

B.4 Email invite

Do you own a cat? Does you or your cat use an activity tracker?

We would like to invite you to take part in an exciting study related to receiving different forms of data about others, in this case data about cats. We're looking for adults 18 years and older who use an activity tracker or smart watch for themselves or their cat (Fitbit, Apple Watch or Tractive as some examples) to understand people's perceptions of the data insights they receive about an 'other', in this case one of the researcher's cats called Dumpling. From this study we would like to see whether we could shape data insights in future health and wellbeing tracking technologies.

Participants will be asked to take part in:

An interview - On Microsoft teams participants will be asked questions related to themselves and their cats as well as their views on self-tracking technology and associated data.

Week experience - We will send you messages via WhatsApp with information about the cat Dumpling. Throughout the week you will receive various forms of information related to Dumpling including photos and videos and occasionally be asked questions about your thoughts relating to this information.

A workshop - All participants will be asked to take part in a workshop at Imagination Lancaster to discuss the week's experience

Participants will be offered a £50 voucher on completion of this study to thank them for their participation and reimburse them for the time taken to complete this study.
Want to be involved or find out more?

Please contact k.snooks@lancaster.ac.uk

Thank you,

Kim Snooks.

PhD Candidate, ImaginationLancaster, Lancaster University

Lancaster University

www.lancaster.ac.uk

B.5 Interview guide

First section (cat information)

1. Tell us a bit about your cat? Name, breed?, Age, gender, indoor/outdoor cat, their personality – reasons for indoor or outdoor cat maybe like medical conditions
2. How long have you had [insert name of cat here]?
3. Do(es) your cat(s) have favourite things they like to do? (play, sleep, cause chaos)
4. Is there anything they don't like to do?
5. Is there anything you'd like to know about your cat(s) when you can't see them?

Second section (tracking habits)

For this section we're interested in understanding about digital tracking practices. By this we mean anything you might log either manually or automatically on an app or device about your health and wellbeing like step count, heart rate, stress levels, managing a condition etc.

6. Do you use devices or apps to track anything about yourself? i.e. Fitbit, Apple watch, Apps?
7. What do you currently track (about yourself)? i.e. apps for step count, smart watch or device for sleep etc.
8. What about any devices or apps to track anything about your cat? i.e. Tractive, Pawtrack, Tabcat
   8a. If yes, what do you track about your cat? i.e. sleep, location, medicine
   8b. If no, is there a reason you don't track anything about your cat?
9. Why do you currently track things about yourself (or your cat)?
10. How long have you tracked something about yourself (or your cat)?

Third section (thoughts around tracking)

11. Is there anything you'd like to be able to track that you can't currently track?
12. Is there anything you wouldn't want being tracked and why?
13. Do you have any concerns about the data generated by your tracker(s)?
14. If a system did track your cat(s) is there anything you would like that system to track and why?
15. If a system did track your cat(s) is there anything you wouldn't like that system to track and why?

Fourth section (understanding of data and tracking)

16. What is your understanding of how tracking devices gather data to provide insights about your health and wellbeing? For example, if your phone gave you a score about your sleep quality, explain step by step how you'd make sense of and interpet the data (including how the system made this decision about the score)
17. How do you feel about these insights being automated through algorithms such as artificial intelligence or machine learning (i.e. a device suggesting how to exercise better)?
18. Do you believe all the metrics or insights you receive about your health and wellbeing? What makes you trust or distrust these insights?
19. What would you think about your tracking device giving you data not just about yourself but other people or things like your pet? I.e. what your pet is doing, where it is maybe?
20. What do you think about tracking devices gathering data to predict where you are, what you are doing etc?

Appendix C - Cat Insight Project Images and Documentation

C.1 Images from the cat insight project

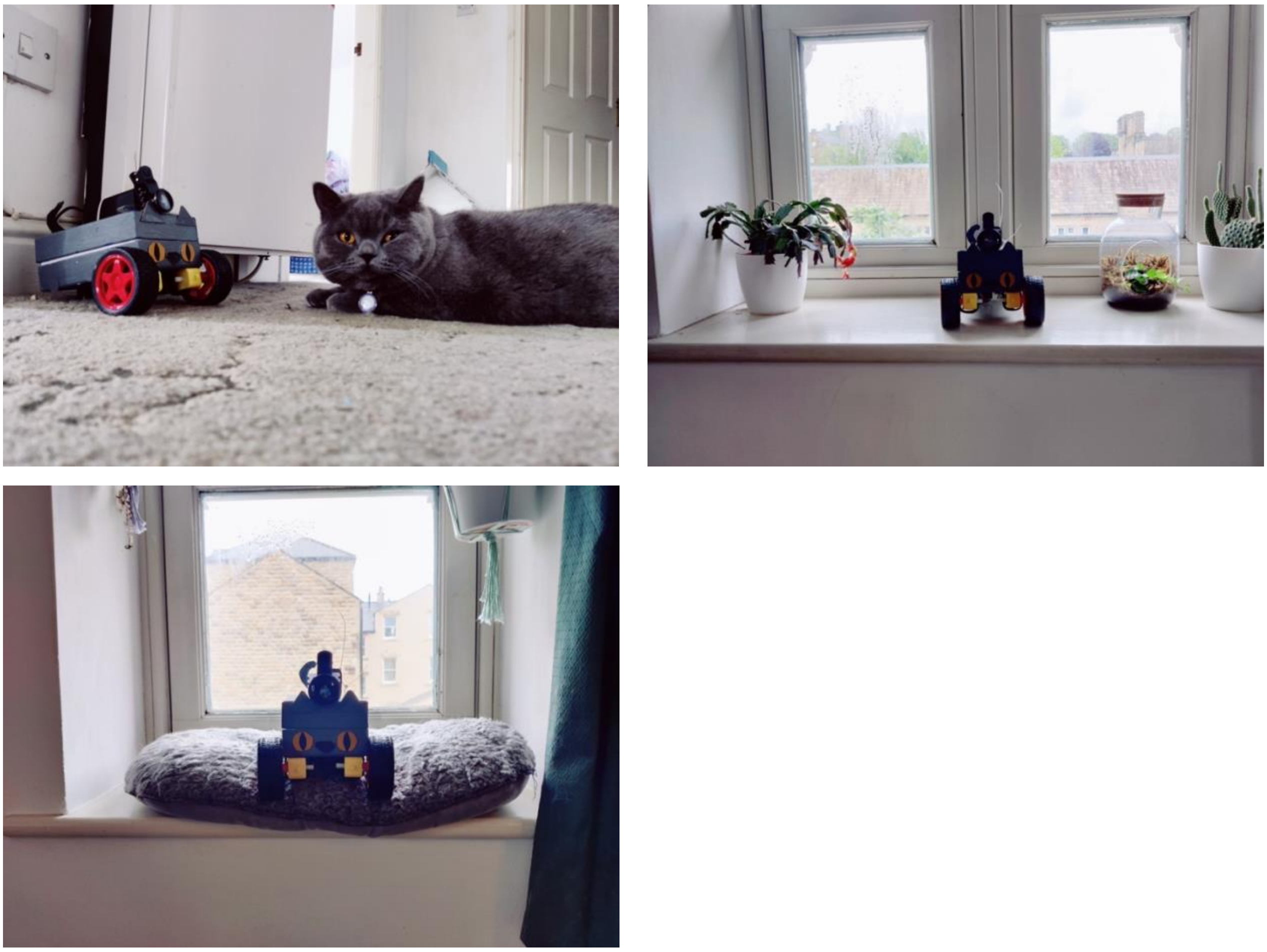


Figure 81 - Photos showing some of the places the cat bot was placed to gain the video and photos used for the 'week in the life of Dumpling'

C.2 Workshop activity pictures

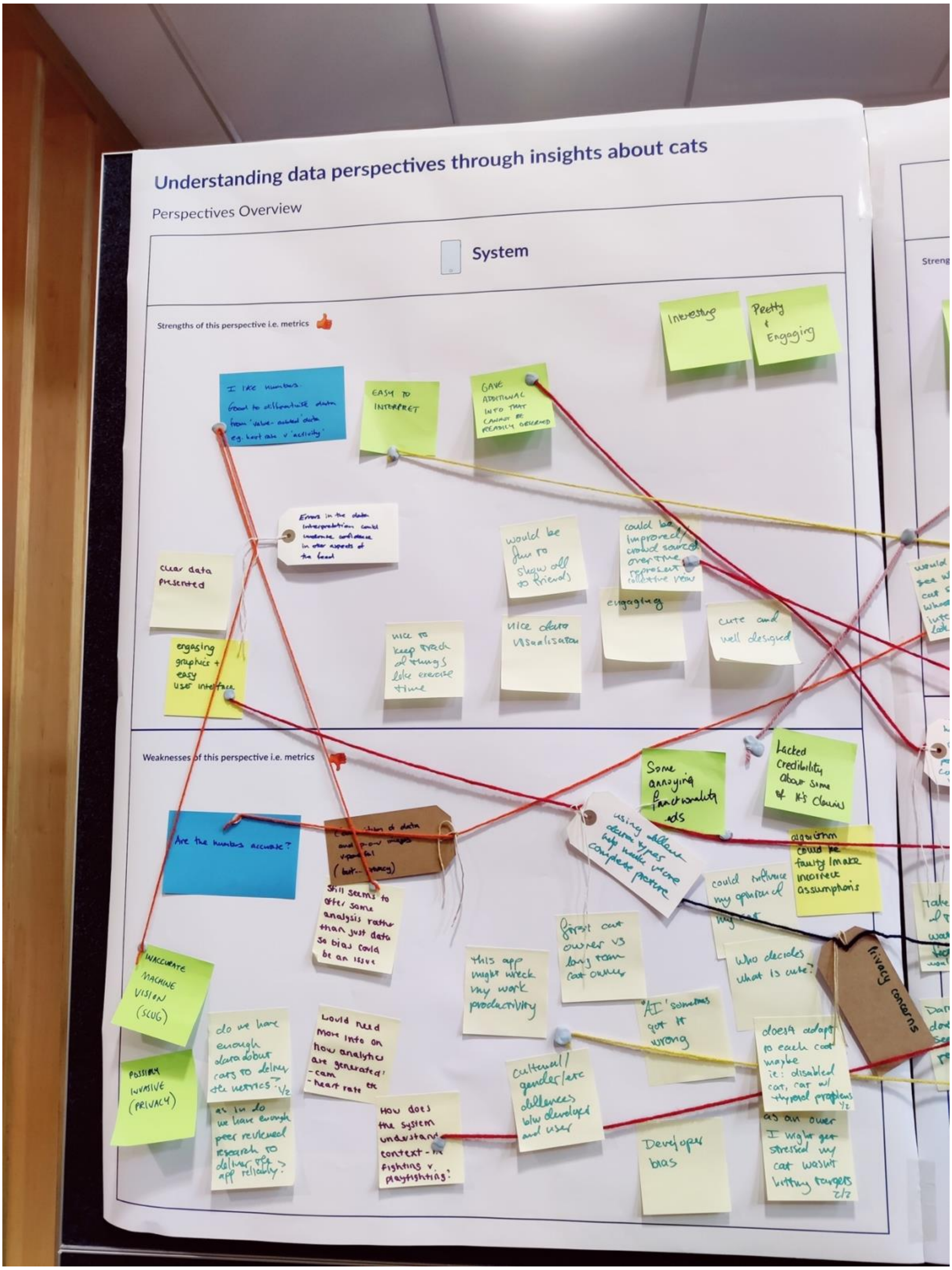


Figure 82 - Activity 2 system perspective strengths and weaknesses responses

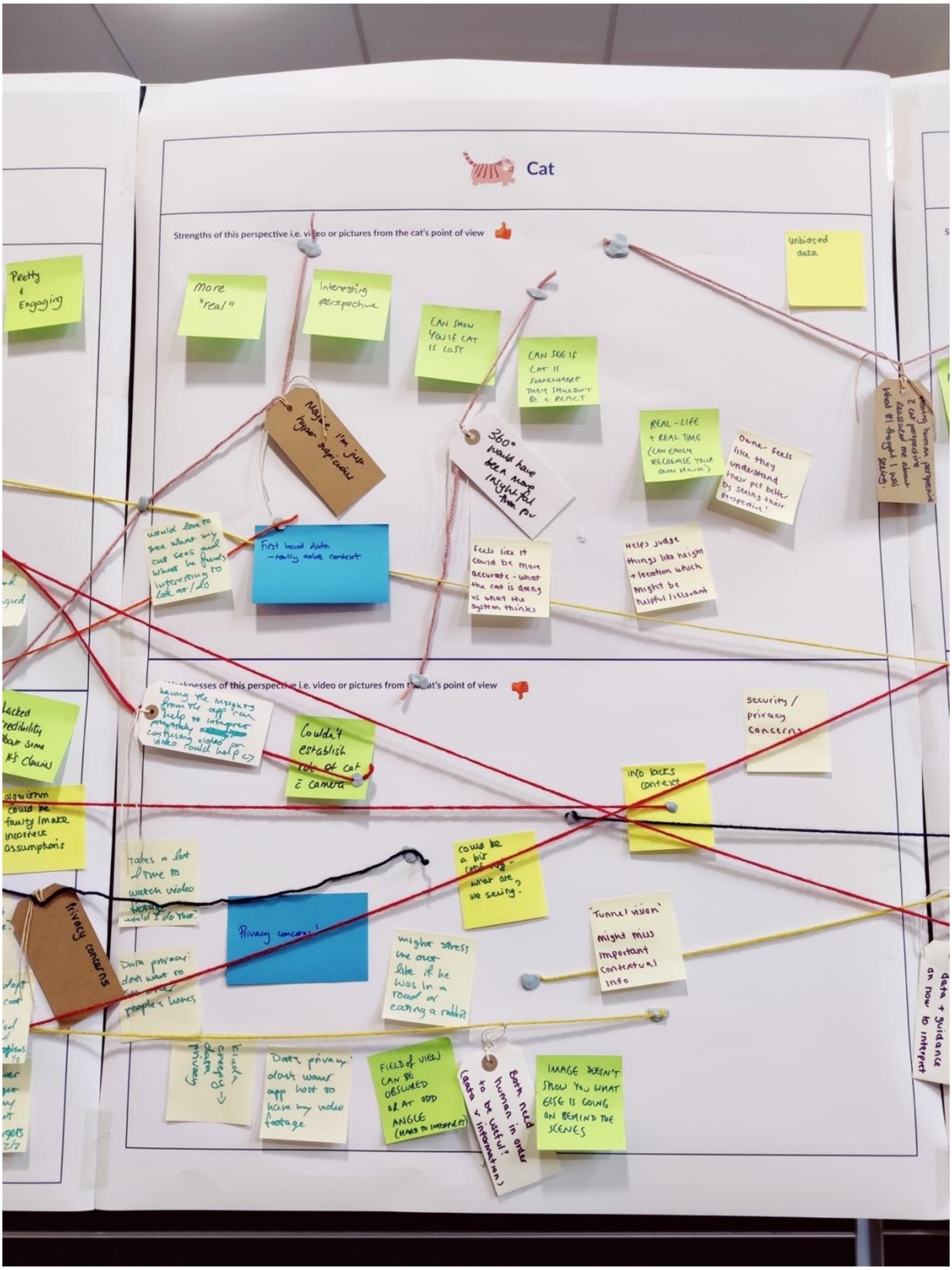


Figure 83 - Activity 2 Cat perspective strength and weakness responses

Figure 84 - Activity 2 Human perspective strength and weaknesses

Figure 85 - Zoomed out activity 1 showing people's responses to what they thought the messages showed

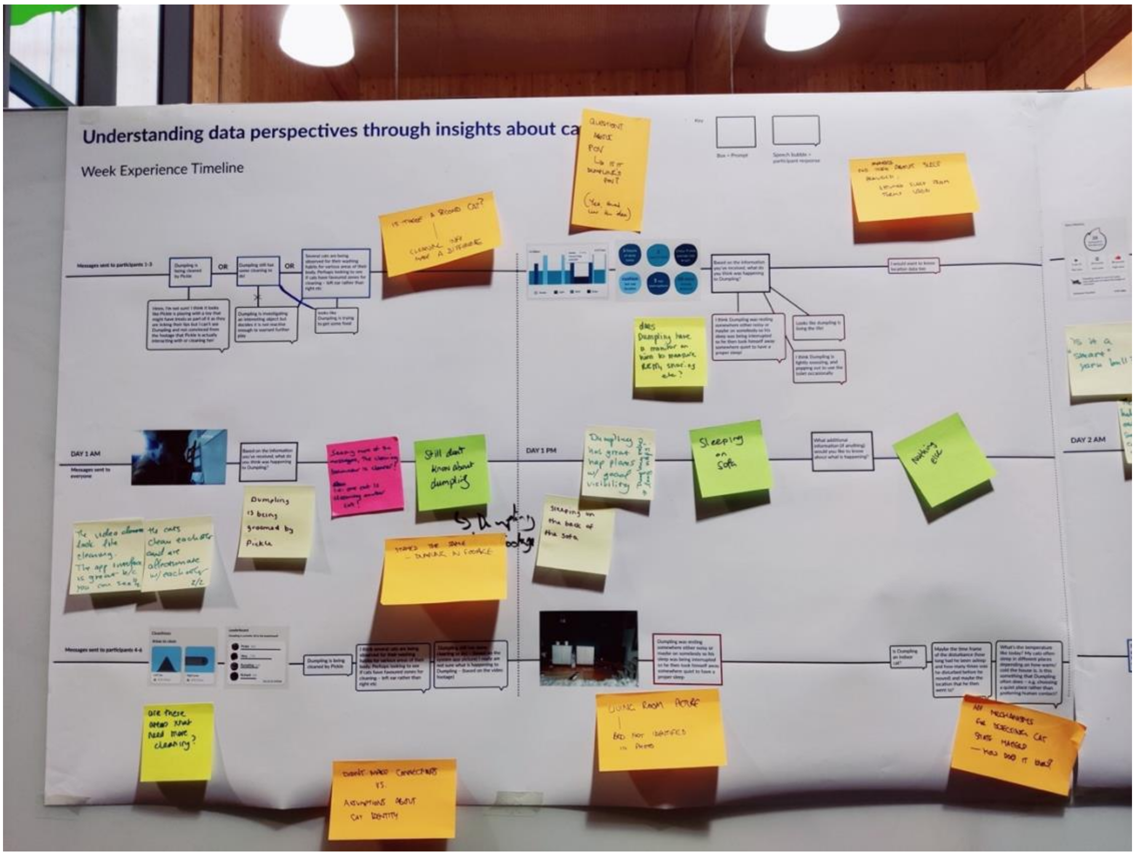


Figure 86 - Activity 1 day 1 am and pm responses

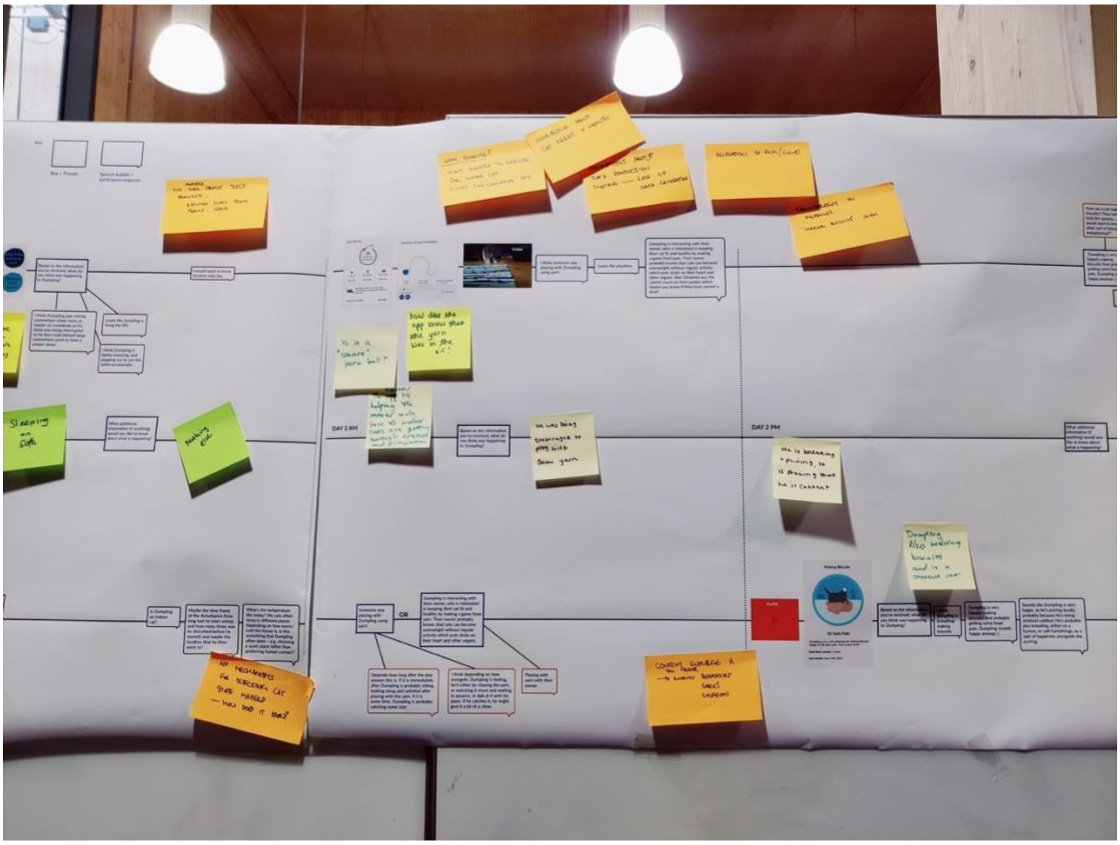


Figure 87 - Activity 1 day 2 am and pm responses

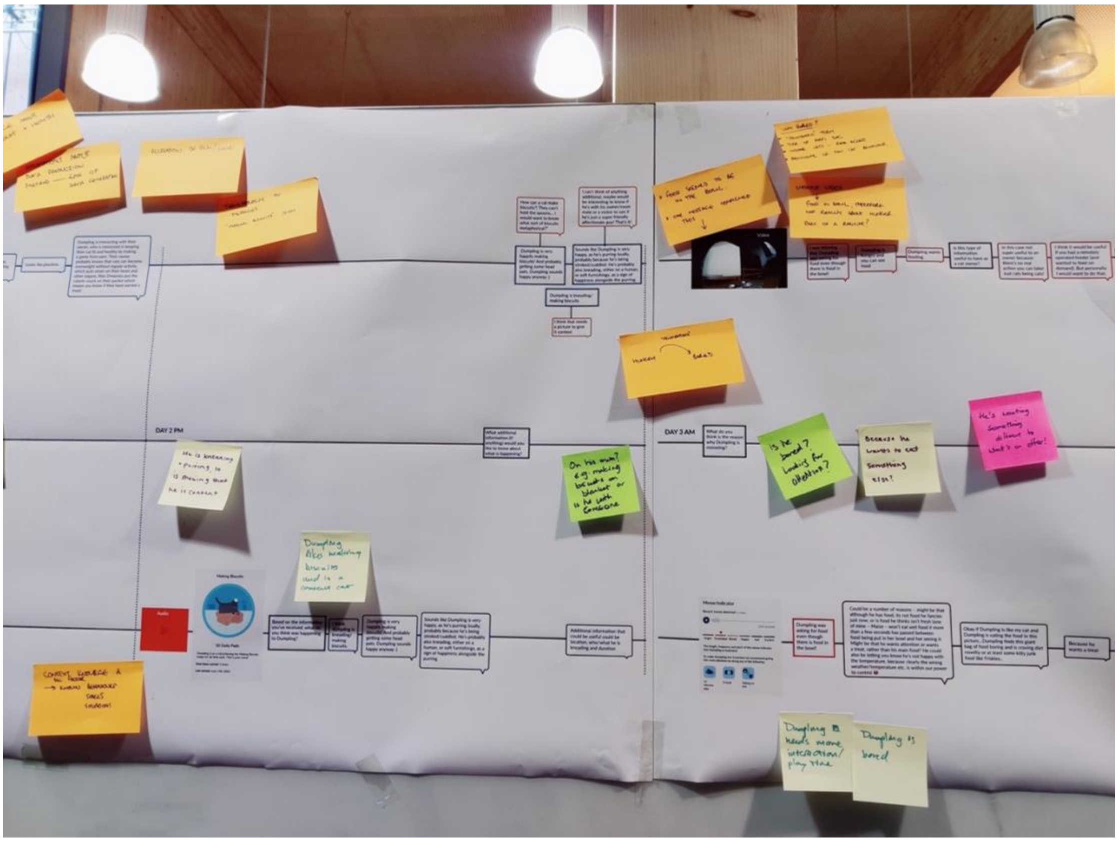


Figure 88 - Activity 1 day 2pm and 3am responses

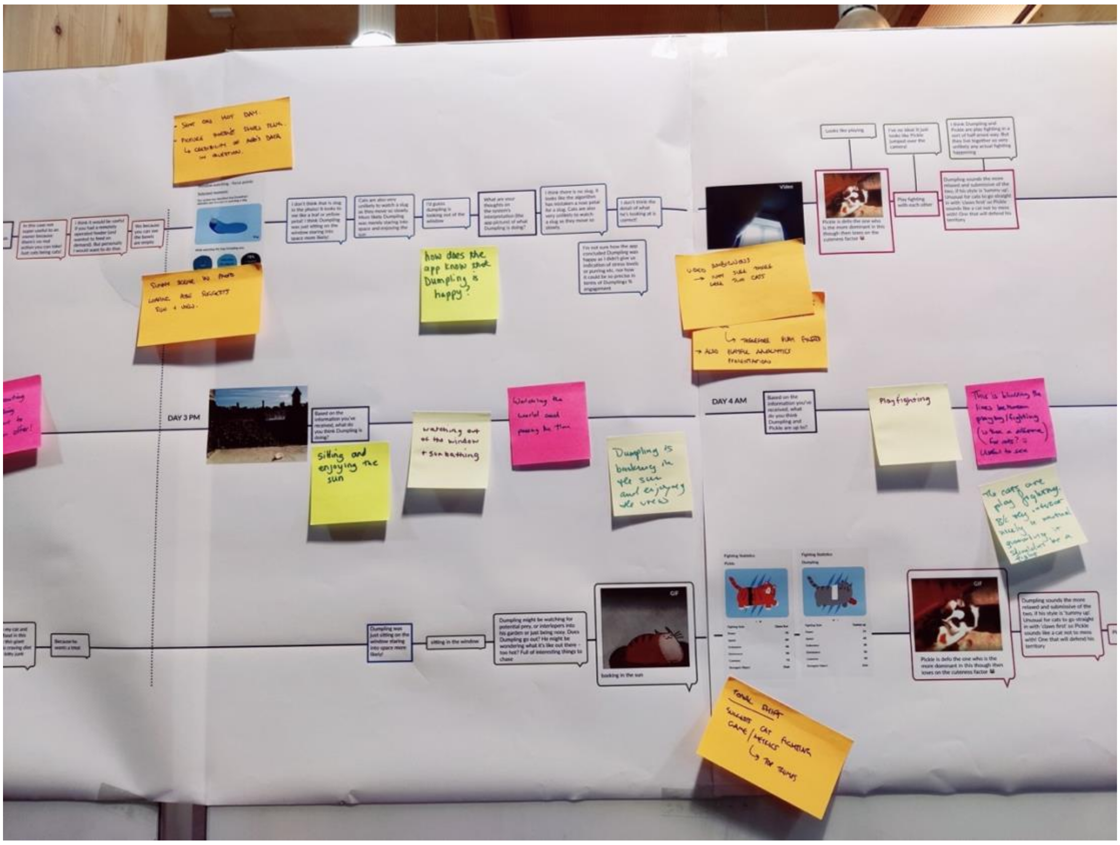


Figure 89 - Activity 1 day 3pm and day 4am responses

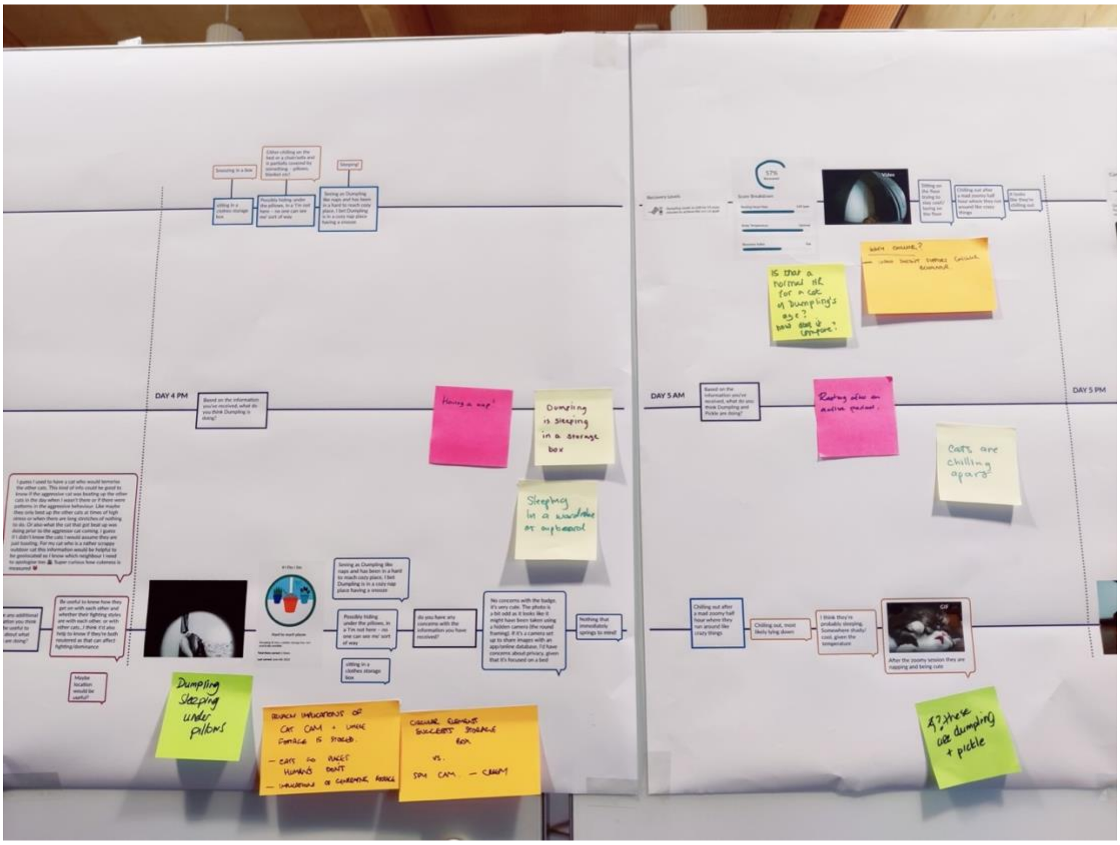


Figure 90 - Activity 1 Day 4pm and Day 5am responses

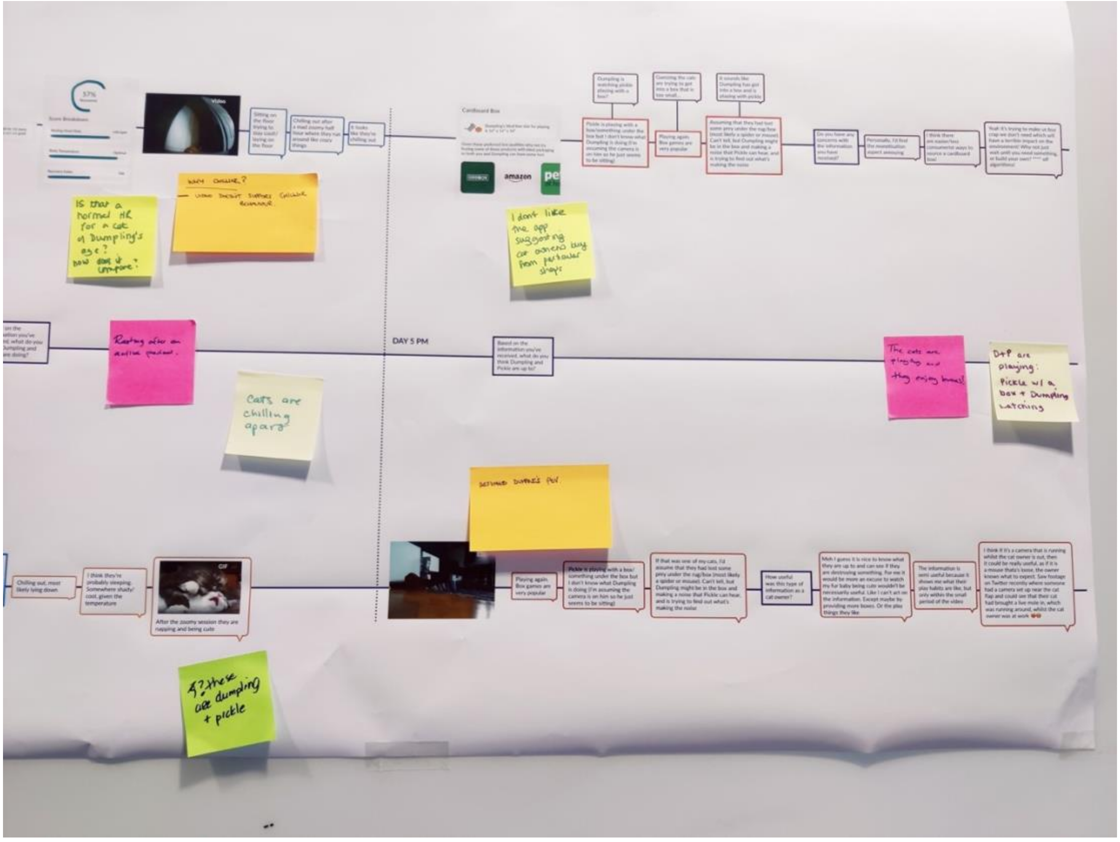


Figure 91 Activity 1 Day 5pm responses

C.2.1 Typed up versions of workshop activities (activity 1)

To make these pictures easier to read tables with these post it notes are included here with reference to the post it note where positioning of the post it notes might be useful to see.

Post it note colour, shape, location	Event	Post it note description
Yellow square next to video	Day 1 AM Messages sent to everyone	the video doesn't look like cleaning. The app interface is great b/c you can see the cats clean each other and are affectionate w/ each other
Yellow square near video	Day 1 AM Messages sent to everyone	Dumpling is being groomed by Pickle
Red square	Day 1 AM Messages sent to everyone	Seeing more of the messages, the cleaning behaviour is clearer! i.e. one cat is cleaning another cat!
Green square	Day 1 AM Messages sent to everyone	Still don't know about dumpling
Orange arrow	Day 1 AM Messages sent to everyone	Stayed the same – Dumpling in footage
Purple square	Day 1 AM Messages sent to 4-6	Are these areas that need more cleaning?
Orange arrow	Day 1 AM Messages sent to 4-6	Don't make connections vs assumptions about cat identity
Darker yellow square	Day 1 AM Messages sent to 1-3	Not sure what Dumpling is doing but he has done some grooming

Orange arrow	Day 1 AM Messages sent to 1-3	Is there a second cat? – cleaning info made a difference
Yellow square	Day 1 PM Messages sent to everyone	Dumpling has great nap places w/good visibility -> Dumpling makes long naps
Yellow square	Day 1 PM Messages sent to everyone	Sleeping on the back of the sofa
Green square	Day 1 PM Messages sent to everyone	Sleeping on sofa
Green square	Day 1 PM Messages sent to everyone	Nothing else
Purple square next to metrics	Day 1 PM Messages sent to 1-3	Does Dumpling have a monitor on him to measure REM, snoring etc?
Orange arrow	Day 1 PM Messages sent to 1-3	Questions about pov – is it Dumpling's pov? (yes that was the idea)
Orange arrow	Day 1 PM Messages sent to 1-3	Analytics – no info about sleep provided, assumed sleep from terms used
Darker yellow square next to human responses	Day 1 PM Messages sent to 1-3	Dumpling is napping and moving from place to place between naps
Orange arrow next to picture	Day 1 PM Messages sent to 4-6	Living room picture – bed not identified in photo
Orange arrow	Day 1 PM Messages sent to 4-6	App mechanisms for detecting cat state

		mattered – how does it know?
Yellow square	Day 2 AM Messages sent to everyone	He was being encouraged to play with some yarn
Yellow square next to metrics	Day 2 AM Messages sent to 1-3	Is it a ‘smart’ yarn ball
Yellow square next to metrics	Day 2 AM Messages sent to 1-3	Monitor/the app is helping the owner make sure the indoor cats are getting enough exercise and stimulation
Purple square next to metrics	Day 2 AM Messages sent to 1-3	How does the app know that the yarn was in the air?
Darker yellow square next to video	Day 2 AM Messages sent to 1-3	Pickle was playing yarn with his owner but Dumpling has also played a bit
Orange arrow	Day 2 AM Messages sent to 1-3	Why exercise? Stats related to exercise for indoor cat. Owners role confirmed this
Orange arrow	Day 2 AM Messages sent to 1-3	Knowledge about cat needs and health
Orange arrow	Day 2 AM Messages sent to 1-3	Assumptions about production method – ease of data generation
Orange arrow	Day 2 AM Messages sent to 4-6	Context knowledge a big factor – known

		behaviours, spaces, situations
Yellow square	Day 2 PM Messages sent to everyone	He is kneading & purring so is showing that he is content
Darker yellow square	Day 2 PM Messages sent to everyone	Dumpling is very happy and kneading a soft blanket or furnishing before having a nap
Green square	Day 2 PM Messages sent to everyone	On his own? E.g. making biscuits on blanket or is he with someone
Orange arrow	Day 2 PM Messages sent to 1-3	Recreation of film/events
Orange arrow	Day 2 PM Messages sent to 1-3	Terminology in messages “making biscuits” idiom
Yellow square	Day 2 PM Messages sent to 4-6	Dumpling likes making biscuits and is a content cat
Green square	Day 3 AM Messages sent to everyone	Is he bored? Looking for attention?
Darker yellow square	Day 3 AM Messages sent to everyone	Dumpling wants food or treats maybe because he is actually bored
Yellow square	Day 3 AM Messages sent to everyone	Because he wants to eat something else?
Pink square	Day 3 AM Messages sent to everyone	He’s wanting something different to what’s on offer?
Orange arrow	Day 3 AM Messages sent to everyone	Hungry – ‘frustrations’ -> bored

Orange arrow	Day 3 AM Messages sent to 1-3	Food seemed to be in the bowl - One message confirmed this
Orange arrow	Day 3 AM Messages sent to 1-3	Why bored? -'frustrated' term - Size of food bag - Indoor cats – food access - Reminding of past cat behaviour
Orange arrow	Day 3 AM Messages sent to 1-3	Without video -> Food in bowl, therefore not really about hunger. Part of a routine?
Yellow square	Day 3 AM Messages sent to 4-6	Dumpling needs more interaction/play time
Yellow square	Day 3 AM Messages sent to 4-6	Dumpling is bored
Purple square by picture	Day 3 PM Messages sent to everyone	Sitting and enjoying the sun
Darker yellow square by picture	Day 3 PM Messages sent to everyone	Sitting on the window watching the world go by & dozing
Yellow square by picture	Day 3 PM Messages sent to everyone	Watching out of the window & sunbathing
Red square by picture	Day 3 PM Messages sent to everyone	Watching the world and passing the time
Yellow square by picture	Day 3 PM Messages sent to everyone	Dumpling is basking in the sun and enjoying the view

Orange arrow	Day 3 PM Messages sent to 1-3	Sunny scene in photo Loafing pose suggests sun & view
Orange arrow	Day 3 PM Messages sent to 1-3	- Sent on hot day - Picture doesn't show slug – credibility of data also in question
Purple square	Day 3 PM Messages sent to 1-3	How does the app know that Dumpling is happy?
Darker yellow square	Day 4 AM Messages sent to everyone	Both cats play-fighting with dominance established a long time ago
Yellow square	Day 4 AM Messages sent to everyone	Play fighting
Red square	Day 4 AM Messages sent to everyone	This is blurring the lines between playing/fighting (is there a difference for cats? ☺) useful to see
Yellow square	Day 4 AM Messages sent to everyone	The cats are play fighting b/c they interact nicely i.e. mutual grooming it shouldn't be a fight
Orange arrow next to video	Day 4 AM Messages sent to 1-3	Video ambiguous – not sure there were two cats
Orange arrow	Day 4 AM Messages sent to 1-3	A week of data suggests the cats like each other – therefore play fighting – also playful analytics presentation

Orange arrow next to metrics	Day 4 AM Messages sent to 4-6	Tonal shift – suggests cat game/metrics – top trumps
Darker yellow square	Day 4 PM Messages sent to everyone	Dumpling is in a dirty clothes box napping
Red square	Day 4 PM Messages sent to everyone	Having a nap!
Yellow square	Day 4 PM Messages sent to everyone	Sleeping in a wardrobe or cupboard
Yellow square	Day 4 PM Messages sent to everyone	Dumpling is sleeping in a storage box
Green square by picture	Day 4 PM Messages sent to 4-6	Dumpling sleeping under pillows
Orange arrow	Day 4 PM Messages sent to 4-6	Privacy implications of cat cat & where footage is stored -cats go places humans don't -implication of generating footage
Orange arrow	Day 4 PM Messages sent to 4-6	Circular element suggests storage box vs spy cam - creepy
Darker yellow square	Day 5 AM Messages sent to everyone	Relaxing & chilling out after activity hot cats need to cool off
Darker red square	Day 5 AM Messages sent to everyone	Resting after an active period
Darker yellow	Day 5 AM Messages sent to everyone	Cats are chilling apart

Purple square	Day 5 AM Messages sent to 1-3	Is that a normal hr for a cat of Dumpling's age? How does it compare?
Orange arrow	Day 5 AM Messages sent to 1-3	Why chilling? Video doesn't support chilling behaviour
Darker yellow square	Day 5 PM Messages sent to everyone	Dumpling & Pickle playing with discarded delivery box
Red square	Day 5 PM Messages sent to everyone	The cats are playing and they enjoy boxes!
Yellow square	Day 5 PM Messages sent to everyone	D+P are applying: Pickle w/a box & Dumpling watching
Purple square	Day 5 PM Messages sent to 1-3	I don't like the app suggesting cat owners buy from particular shops
Orange arrow	Day 5 PM Messages sent to 4-6	Assumed Dumpling's pov

Important to note – orange arrows are **NOT** participants answers but notes made by Roger during the activity summarising the discussion

C.2.2 Strengths of perspectives responses (Activity 2 responses)

System	**Cat**	**Human**
I like numbers. Good to differentiate data from 'value-added' data e.g.	Real-life & real time (can easily recognise your own house)	Interpretation based on realistic cues and has power of logic

heart rate v ‘activity’ (links to weakness of system ‘still seems to offer analysis rather than just data so bias could be an issue’)		
Gave additional info that cannot be readily observed	Can show you if cat is lost	Humans know cat behaviour well and can extrapolate (better than machine)
Clear data presented	Can see if cat is somewhere they shouldn’t be and react	More humble then system
Nice to keep track of things like exercise time	Interesting perspective	Little extra thoughts & feelings and a nice touch
Engaging graphics & easy user interface	More real	You get a perspective/interpretation of the data to help/guide
Easy to interpret (has a line to weakness of system?)	Would love to see what my cat sees and what he finds interesting to look out/do	Able to take different data into consideration
Would be fun to show off to friends	First hand data – really adds context	Provides more comprehensive info
Nice data visualisation	Feels like it could be more accurate – what the cat is doing vs what the system thinks	If the human knows the cat it is useful
Engaging	Helps judge things like heights & location	Inciteful but subjective

	which might be helpful/relevant	
Interesting	Owner feels like they understand their pet better by seeing their perspective?	
Pretty & engaging	Unbiased data	
Could be improved/crowd sourced over time represent collective view (goes to weakness of human 'cultural/gender differences')		
Cute and well designed		

C.2.3 Weaknesses of perspectives (Activity 2 responses)

System	Cat	Human
Inaccurate machine vision (slug)	Couldn't establish role of cat & camera	Humans can make mistake by misreading or scanning things quickly
Possibly invasive (privacy)	Takes a lot of time to watch video footage – would I do this?	Would you hire actual humans to wrangle the data? Expensive! (+ time consuming)
Are the numbers accurate?	Data privacy: don't want to see other people's homes	This is not necessarily accurate & can distort the data?
Do we have enough data about cats to deliver the metrics? As	Kinda creepy -? Data privacy	Depends how much info the human has

in do we have enough peer reviewed research to deliver the app reliably?		
Still seems to offer analysis rather than just data so bias could be an issue	Data privacy – don't want app host to have my video footage	Bias/understanding awareness might be an issue
Would need more info on how analytics are generated: - Cam - Heart rate etc.	Might stress me out like if he was in a road or eating a rabbit	Cultural/gender differences
This app might wreck my work productivity	Privacy concerns!	First cat or long term owner
How does the system understand context i.e. fighting vs playfighting?	Could be a bit confusing – what are we seeing?	Struggle to image who would take the role of providing these inputs
Cultural/gender etc difference b/w developer and user	Field of view can be obscured or at odd angle (hard to interpret)	Who is the human!? Are they watching my cat videos?
Developer bias	Image doesn't show you what else is going on behind the scenes	Interpretations made of partial/flawed info
Doesn't adapt to each cat maybe i.e. disabled cat, cat w/thyroid problems as an owner I might get stressed my	'Tunnel vision' might miss important contextual info	Humans explain things in odd ways sometimes (consistency)

cat wasn't hitting targets		
First cat owner vs long term cat owner	Info lacks context	Lack of additional cues
'AI' sometimes gets it wrong	Security/privacy concerns	Imposed theories based on own cats?
Could influence my opinion of my cat		Level of experience of living with cats
Who decides what is cute?		Info could be subjective/have bias
Lacked credibility about some of its claims		Lack of additional cues
Some annoying functionality - ads		
Algorithm could be faulty/make incorrect assumptions		

C.2.4 Relations between perspectives (activity 2 strengths and weaknesses)

Red means no data for this square – black means covered in another square because of overlap on table

	Strength of System	Strength of Cat	Strength of Human	Weakness of System	Weakness of Human
Strength of System		Maybe i'm just hyper suspicious			

Strength of Cat			Having human perspective and cat perspective reassured me about what i thought i was seeing		
Strength of Human		Having human perspective and cat perspective reassured me about what I thought I was seeing			
Weakness of System	Errors in the data interpretation could undermine confidence in other	Composition of data and pov images v powerful (but... privacy) Where is this personal data going?	H. Can more accurately interpret real world cues		

	aspects of the feed			[redacted]	
Weakness of Cat	Having the insights from the app can help to interpret potentially confusing video or video could help clear up when the AI messes up like w/ the slug Cat issue is one of data generation - Human/ AI is one	360 degrees would have been more insightful than pov	No link to post it note - Human knowledge can supplement ambiguous data due to existing knowledge & empathy	both need human in order to be useful (data v information)	Need both basic unbiased data & guidance on how to interpret

	of interpretation Using different data types help make more complete picture				
Weakness of Human	Interpretation depends on strength/ awareness of human System can support human decision-making		If others need to interpret	Machines and humans both make mistakes	