

# Cats and Desks: a recommendation on future cat-centric smart desk designs from cat-owner relationship implications

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## **Abstract**

In a future with more integrated smart home technologies, the interactions involving pets can influence the working, benefits and effectiveness of these technologies. This paper explores how technology can facilitate intentional interactions between humans and their cats in a home office setting. Current trends in productivity tools and smart desks enhancements support an improved work-life balance. Our research focuses on incorporating a cat-centric design into smart desks to explore human-pet cohabitation in remote work environments. Through need finding and cultural probes, initial qualitative data was gathered on the relationships between cats and their owners and on people's desks and their expectations on future smart desks. Through this a research artifact was created and deployed in a pilot study to find how the changing of technology might affect the interaction between technology, humans and cats. Through this pilot a recommendation was created on how to research this topic on a larger scale.

## **Introduction**

In the context of an increasingly digitized society, smart home technologies play a significant role in enhancing productivity and well-being. However, the presence of cats introduces unique interactions which can influence our behavior [1], such as leaving the heating on in the home for pets when owners leave the house [2]. These interactions are made even more unique by the singular and divergent relationship between humans and pets [1].

Alongside this trend there is ever increasing innovation in the realm of productivity and work-life balance. Human computer interaction (HCI), technology, and ergonomic advancements have resulted in tools such as voice commands, hand gestures, standing desks, ergonomic chairs, and

cycling workstations which aid productivity and health in workspaces [3]. Companies now allow employees to bring their dogs to work [4][5] to help them feel less stressed and more efficient at work [6][7]. Technology and pets provide better working experience for the employee and (regarding pets at work) increases pet cohabitation.

To support pets in the workplace and at home, companies and people construct their offices and homes with pet-friendly materials in mind. Smooth, hard surfaces are preferred in pet-friendly offices and homes for easier cleaning of dog hair and urination incidents [8][Figure 1]. These choices are part of a broader pet-centric, more-than-human design process that incorporates pets as stakeholders in the decision-making process.

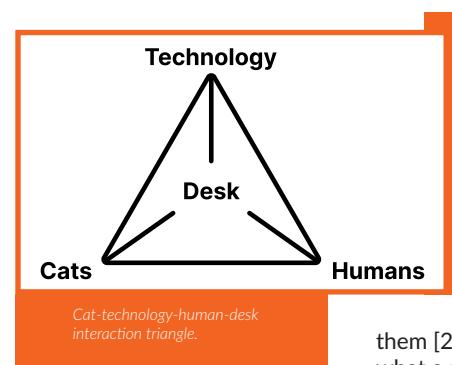
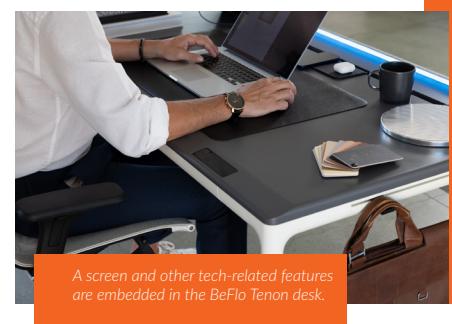
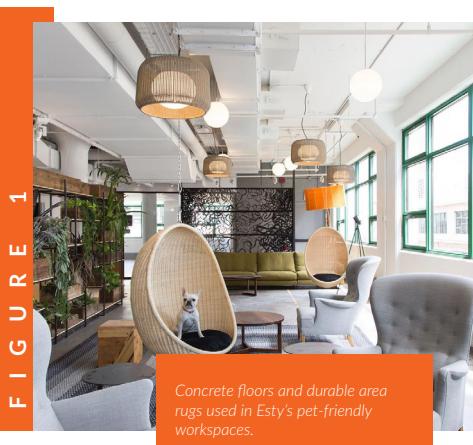
The goal of our research is to make a recommendation for future designers of how technology incorporated into cat-centric design can facilitate more intentional interactions between pets and their owners within the context of a home office. With our research question being: “Can technology be used to facilitate human-pet cohabitation in a work-from-home environment and what design implications could be gained from this in order to accommodate for cats within smart desk design?”

### The Future of 2039

The future will present us with many opportunities within the intersection of smart home technology, humans, and domestic animals. The global pet care market size is predicted to almost double within the next decade, with integrated technology and technology-driven pet care design driving market growth [9][10]. Technology includes pet wearables for owners to monitor their vitals [10][11][12][13], iPad games created specifically for cats [12][14], and video-conferencing devices to communicate with your dog from work [15]. The market growth and technological innovations illuminate the larger trend of pet inclusion with an increased focus on co-habitation design and human-pet stakeholder design.

Remote work is a trend that is holding steady after the COVID-19 pandemic with the increased digitization of work. 22% of the U.S. workforce will remain remote by 2025, double of pre-pandemic levels [16] as companies adjust their work strategy and other job sectors embrace the trend. Combined with the estimation that the remote work technologies market sector size will almost triple over the next decade [17], the remote work industry will invest in technology to make a more connected and enjoyable experience for work-from-home offices.

We also propose a future of tight technological integration. Interior smart systems and devices will no longer be separate, individual objects. Instead,



they will be tightly integrated into the furniture and foundations of houses.

This tight integration can already be seen with current marketable smart desks. Desks such as the BeFlo Tenon [18][Figure 2] and the Razer Project Sophia [19] concept desk have modular accessories and integrated solutions that make them smart in the consumer's eye. However, they are not smart in the definition that we are investigating. We are proposing smart desks to have awareness. To understand the current situation and make intelligent decisions based on it and past experiences. Currently, the idea of smartness is with integrated technology; an ecosystem of modular accessories that connect to the desk and a mobile app to control features, all of which promote ease of use. We aim to expand on these existing ideas to include some form of intelligence.

### The Cat Interaction Triangle

As cats co-habituate with humans in working environments, there are many interacting factors at play. Cats can jump up on the desk and step on the keyboard to get their owners attention while they are working. Meanwhile, the owner is trying to get work done on their computer at their desks but can end up petting or moving the cat. This highlights the linked interaction and involvement of each party. Therefore, a triangle of interaction was developed to bring clarity to the overall topic. The understanding that cats, technology, humans, and desks are all linked together serves as the foundation of the research and allows us to map interaction between the different actors [Figure 3].

### Research Methods

Using humans as an intermediary advocate for pets is common in animal-computer design. Typically, the pet's owner or caretaker interprets the pet's actions and emotions to overcome the language and cognitive barrier between animals and humans. While there are some doubts as to the inclusiveness and effectiveness of the pet's input, this is the most unobtrusive form of data collection for our participants [15]. We use the processes of need finding combined with cultural probes to generate our research artifact and conduct interviews with the deployed solution to further draw our conclusions.

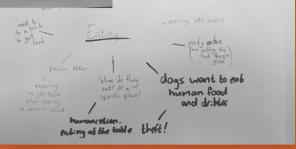
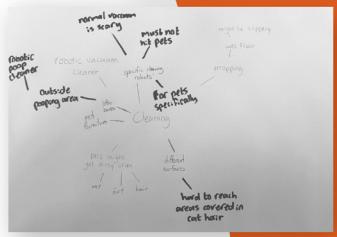
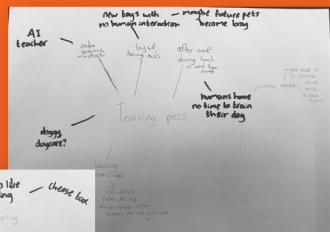
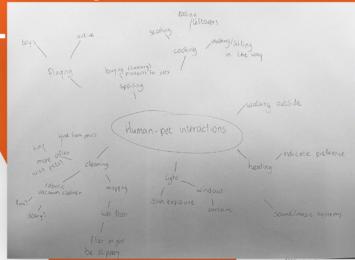
### Needfinding

Needfinding is an iterative design-research methodology to gather information about a user space. Its main objective is to find what users need most out of a certain product when those functions do not exist or when the user is unaware, they need them [20]. This was implemented to create the research artifact, identifying what a smart desk's functions users would expect in the future.

## Initial Research Process

An overview of our hands-on iterations choosing this topic.

### Topic mindmaps



### Topic brainstorm



### Future covering the present

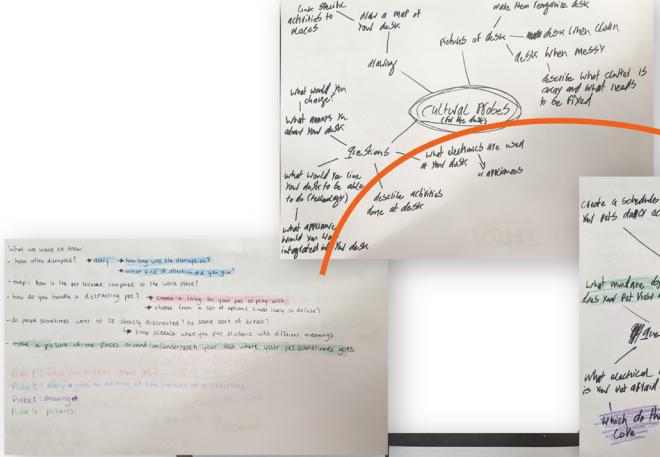


### Present organization methods

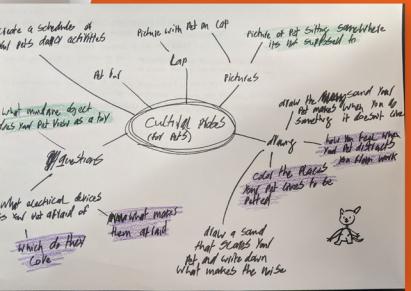


### Topic visualization board

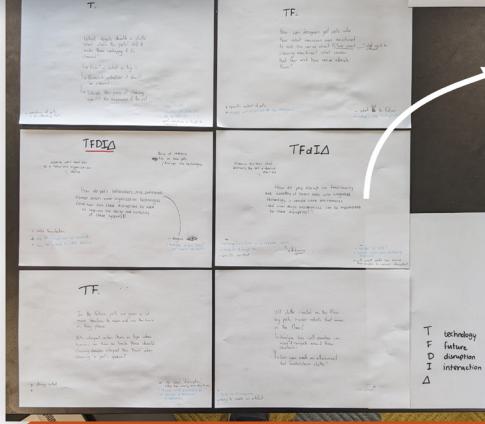
### Brainstorm research question



### Probes brainstorm



### Pointing out positive and negative aspects of each question



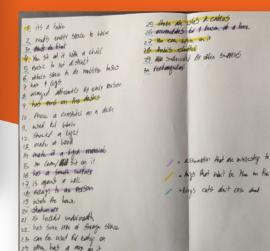
### Research methodology



Observations from assumptions:  
+ interest in the materials/shape/form of a desk  
+ cats want to...  
+ to stand to play with  
+ to see what their owners are up to  
+ find a desk  
+ to take naps  
+ large place to hide

Conflicts with what humans want:  
+ human productivity of desks called Cats can play with  
+ distract them  
+ don't want to share food with cats  
+ sometimes don't want to be disturbed by cats  
+ either let cats get to decide where shelves are

### Future product assumptions



### Future organizing products: rapid prototyping



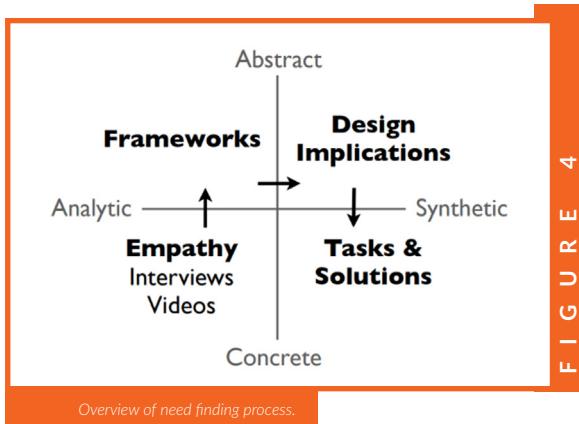


FIGURE 4

Empathy with the user is the first step of the needfinding process, typically collected through interviews. Frameworks are then developed from the abstraction of the collected information. After further discussion, design implications are formed from those frameworks. Solutions are then generated from the implications [Figure 4]. That solution is the research artifact.

#### Cultural Probes

Empathizing is done through gathering qualitative data with cultural probes within the research. Probes consist of tasks meant to keep participants engaged, and function as sources of inspiration [21].

Probes consist of a physical medium to showcase questions [22]. Typical mediums are interactive objects and manipulatable materials, giving some variety to the 2-dimensional planes of paper tasks are usually on [21]. Tasks are often open to interpretation, which gives variety in users responses. They can be created to be playful, weird, confusing, and everything in between [22]. These traits align with the physical and playful work values within the project.

Additionally, probes provide insights into users their unique perspective [22]. The characteristics of the probes give the user time to reflect with their cat and workspace as they complete the tasks. The user gets multiple days to complete the tasks, allowing for reflection.

Empathy was gathered with the user base through two sets of cultural probes: one about cats and the other about at home desks. The probes were split into separate probe kits to avoid bias that might occur towards one topic or the other.

#### Cat probes

Four probes were distributed to participants with at least one cat. The participants responded with varying degrees of effort with not all probes being completed. However, this variety in responses is expected with cultural probes.

The cat probes consisted of 6 tasks ranging using different mediums [Figures 5-7]. The participants played with soft modelling clay, visualized sounds through sketching, took pictures with their phone, and collected cat hair. Some tasks were more focused on information gathering, such as drawing your floor plan and marking your emotions when your cat is in specific areas of your house. Others were more for inspiration gathering, such as coloring in a cat by where the cat enjoys being stroked.

#### Desk probes

The desk probes went to four participants who use their desk as their primary space for work or study with the goal of learning more about the relationship between participants and their workspace. One participant worked from home while the other three were students. Two participants responded in full while the other two completed the physical probes but did not submit the online survey.



The desk probes were comprised of multiple different tasks [Figures 8-10]. Some allowed the participants to be creative and draw for example how they think a future desk would look like. Another task was dividing toothpicks between three subjects to find out about the participants' daily schedule. Finally, participants were asked to upload pictures of their desks belonging to certain prompts.

#### Probes results

By applying a thematic cluster analysis [23] to the probes, some interesting insights were gained about the relation between people, their cat(s) and their desk. This completed the framework and design implication phase of needfinding. By coding and clustering this data into sets, an overview of reoccurring aspects within all the probes was found.

For the cat probes, these data sets consisted of behavior, preferences, habits and



fears. The main insights were the preferences for either warm or cold spots. For example, some cats really liked staying on top of the radiator, or sunbathing [Figure 11].

Additionally, it appears that most people find it annoying when cats walk on the desk while they're working as it is viewed as a disturbance. However, they do like to give their cat(s) some attention once in a while (as a small break).

From these cat probes, the point was emphasized that every cat is different and unique. Due to this, and the singular relationship between cat and owner, no generalized statements can be made for all cats. All conclusions and claims rely on intersubjectivity.

The desk probe clustering sets show for instance what distracts people on their desk, what they do and do not like about their desk and their idea of a future smart desk. The main takeaway of this probe is that people like to have an organized desk, yet there is always unwanted clutter. They also picture a smart desk to have integrated features.

After analyzing these two probes, the most important statements of the cat probes to the desk probes were connected. These were divided into smaller sets and created smaller questions for each of these sets [Figure 12]. For the research artifact, we combined the fact that cats ask for attention with the fact that their owners are annoyed by their cats being at disruptive places.

### Research Artefact

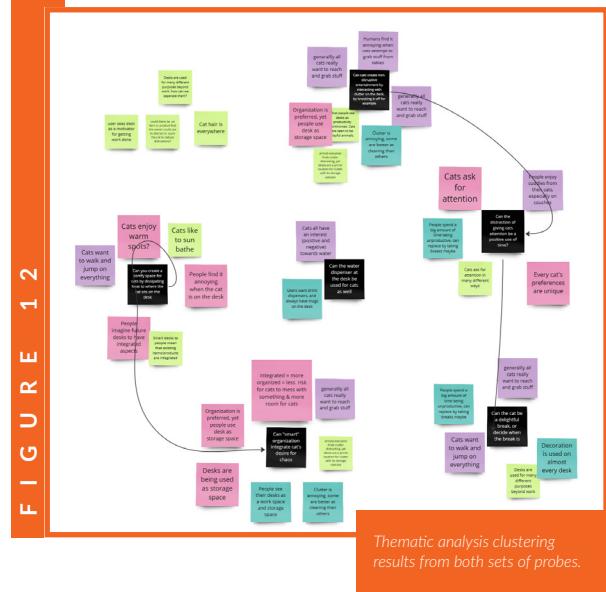
We created a research artifact to investigate the experience. The research artifact was created to investigate the experience of someone working from home and their cat(s) sharing a designated space [Figure 13]. This artifact is the final phase of the first need finding iteration, after which frameworks were created along with design implications from the cultur-



FIGURE 11

Cat probe participant basking in the sun.

FIGURE 12



al probes, leading to the solution, the artifact. To fulfill the second empathy phase, research was done through a one-day plan where a participant tests the artifact and keeps a research diary. After the processing of this diary data, and sensor data gathered by the artifact, a semi-structured interview was conducted in order to provide context to the data.

The research artifact is a miniature cat sofa. The artifact is intended to be used on top of the desk, so participants can still use some of the remaining desk space and/or place the electronics underneath. The cushion of the cat sofa has adjustable temperature Peltier devices that can heat and cool the pad [Appendix 1]. The temperature is controlled by a knob and includes a display, which shows the target temperature, whether the electronics are on or off, and the real temperature, which is measured with a temperature sensor [Appendix 2]. Besides the functionality of this



FIGURE 13

heating pad, it also collects sensor data on an SD card [Appendix 5]. The data being: date and time, the target temperature, the real temperature, and pressure sensor data, which is placed on the sofa. This data is processed in Python to gain more insights, and as a basis for the semi-structured interview.

The research diary is a qualitative way of collecting data during the deployment of the artifact [Appendix 3][Appendix 4]. The participant notes down when they sit down at the desk, and throughout their stay, they document the behavior of their cat. When the participant leaves the desk, they note that down, and when they return, they turn a new page and answer the same prompts again. The research diary also includes a character building page explaining their cat and requests to take pictures throughout the artifacts use.

The research artifact along with the diary are deployed at the participants home, along with an explanation of how the artifact works and what data they should collect within the diary. The deployment lasts for one day, where the artifact is being placed on top of the desk and is used throughout the entire workday, so 8:00 until 18:00. Because this is a pilot deployment, we let the participant control the temperature settings throughout the day, this is done in order to test the user friendliness of our artefact. On top of that, because the participant knows their cat the best, they might be able to guess what their cat prefers, which will give us quick insights into the cats liking of the artefact, instead of fixed variable research which would have given us accurate scientific conclusions.

After the deployment phase the artifact and research diary are collected and the data will be processed. The quantitative data will be processed in python and the qualitative data by thematic analysis. From here, the semi structured interview is adjusted to the data from the deployment and from the interview we will be able to give more context to the quantitative data.

### Artifact Results

From data collected from the artifact, the cat sat on the artifact twice. The

first time was 30 minutes after the artifact was introduced into the cat's environment. It lasted for under 3 minutes. The cat rested for a second time an hour and a half later for just over 12 minutes. According to the diary, the first instance was her exploring the artifact. The second instance, she laid down and rested while watching the neighbors from the window.



dow and cleaning herself.

Data collection graph analysis [Appendix 6].

In Figure 14, the cat sitting on the artifact is visualized in blue. In this graph is also shown a comparison between the temperature setting of the heating pad (dark green line) and the actual temperature (light green line). The temperature setting 0 to 6 determines the temperature the heating pad is set to by the user. 0 is very cold and 6 is very warm. The radical change in temperature setting between 09:30 and 10:10 was due to a technical error that was later resolved.

Findings from the qualitative data, the interview and diary, show this particular cat is very curious and sniffs around most of the time. Therefore, she wasn't scared of the artifact, however she usually needs time to get used to new things. This shows us that every cat is unique and we aren't able to make generalized statements.

Secondly, this participant, along with participants of the probes, finds it annoying when the cat makes noise and walks over her desk searching for attention. However, when the cat is sleeping next to her, she enjoys her company and the cat isn't disturbing or distracting.

## Discussion

Since the timeframe of the research only allowed for a single deployment, this singular deployment was considered as the

pilot for the research. Rather than generalizing and making claims based on the limited amount of data on a single cat and their owner, we propose how to adjust this research in order to finalize it and conduct it on a larger scale. Though it should be noted that even on a larger scale, any conclusion would still be based on assumptions due to the singular nature of the relationship between a cat and their owner.

In order to increase the amount of data gathered within the same timeframe, the research artifact should be manufactured multiple times so that multiple deployments can happen at the same time.

Due to the artifact only being in place for a single day, the cat was not able to get used to the presence of the artifact. Therefore, we can't make any conclusions for the long-term effects of the artifact. The artifact should be deployed a set number of days before data gathering starts so that the cat might get used to its presence.

Being able to adjust temperature setting introduces more variables to an environment which already includes many variables. The added value of the temperature setting does not justify the possibility of it influencing the conclusions and so a fixed temperature setting should be used.

Additionally, if the artifact is deployed more than once, with different cats, it should be thoroughly cleaned in order to prevent scents of a previous cat influencing the interaction between cat and artifact.

Lastly, due to the participant having to keep the diary, she was paying a lot of attention to her cat, which was disruptive for her workflow. Therefore, we don't know the effects of the artifact on the participant's concentration.

## Conclusion

We based our research subject on our cat-interaction triangle of cats, technology and humans, along with our interest in organization, and by creating a scenario 15 years in the future to research the following: can technology be used to facilitate human-pet cohabitation in a work-from-home environment and what design implications could be gained from this in order to accommodate for cats within smart desk design? The foundations of this research lie in the need finding process, which aims to find what the user might want when it does not exist yet. With the user being the cat owner and the

cat itself. More than human design is implemented throughout the project to take the cat perspective into account, this is especially relevant considering our view of increased co-habitation and reduced anthropocentrism as our future scenario.

We deployed cultural probes to gather empathy, to explore the design space of desks, and to explore specific characteristics of cats. We combined the results after analyzing the probes and concluded that when working from home cats are mostly disruptive when they ask for attention. With this in mind we created a research artefact that we conducted further research on. It is a heated cat sofa, which was deployed for one work day to a participant with a cat and an at-home workspace, along with a research diary to give context to the data that is collected through the artefact. Because this artefact was only deployed to one participant for one day, there is not enough data to conclude our research question. Instead, we have an indication of some of the results if this were complete research, and we have a recommendation on how to conduct this research fully. This includes an indication that certain cats are attracted to a heated personal space near the working space of their owner, and that this interaction does improve the positive reactions towards the cat and decrease disruptions to a certain degree. In order to conduct this research fully the following changes must be prioritized. The artefact must be deployed multiple times to different owners with cats, to be able to generalize the data as much as possible. The deployment must last some days longer, to increase the cat's familiarity with the artefact. The temperature settings must be set and have no influence from the cat owners, so there is only one variable being measured, which is if the cat is sitting on the heated sofa. Other small changes are also recommended, such as removing the research diary entirely, to decrease distraction.

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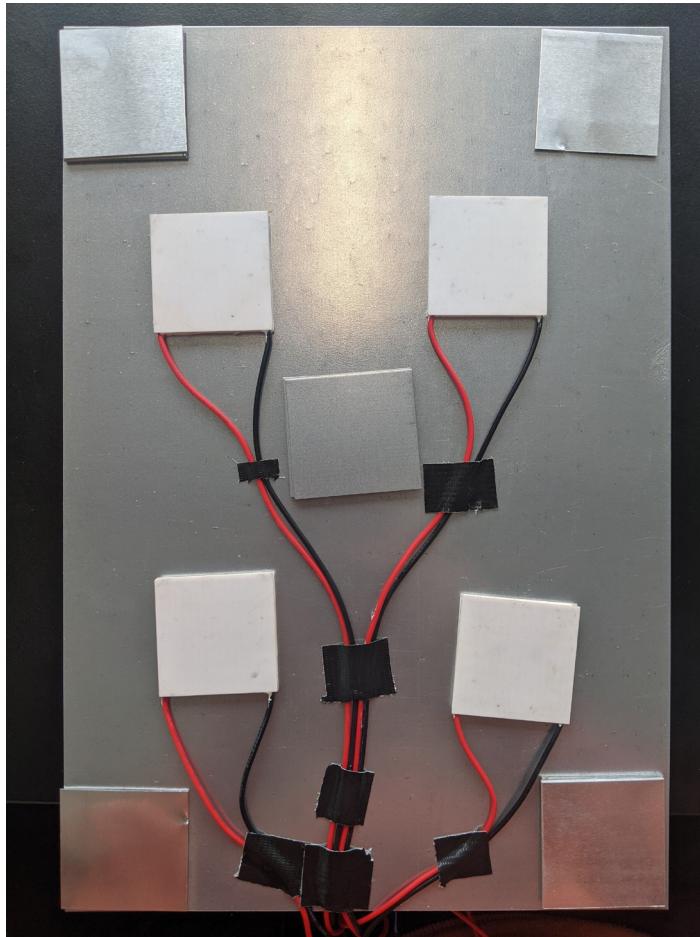
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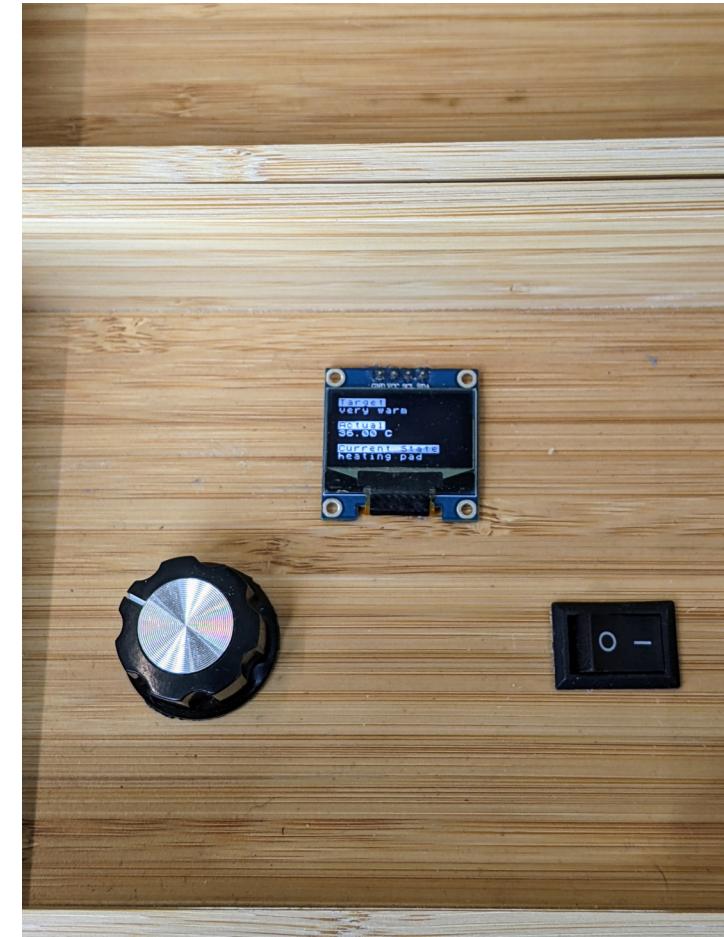
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## Appendix

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**Appendix 1** - Inside heating pad, showing wired-up peltier devices.



**Appendix 2** - Heating pad control box, holding the user interface and electronic components.

Date: \_\_\_\_\_



Highlight when you sit down at your desk

00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
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Write down whenever you have an interaction with your cat and what this interaction was:

01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----

01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----

01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----

01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----

Did any of these interactions disturb you? In a positive or negative way?

01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----

Take a picture of what your cat is doing



**Appendix 3** - Research diary template

Write down when your cat goes on top of the heating pad and for how long:

01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----

01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----

01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----

01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----

What was the temperature setting of the pad?



01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----

What was your cat doing during the period you sat at your desk?

01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----

Highlight when you leave your desk:



00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----

**Appendix 4** - Research diary template

```

#include <OneWire.h>
#include <SPI.h>
#include <SD.h>
#include <DS18B20.h>
#include <BTS7960.h>
#include <U8x8lib.h>

#include <DS1307RTC.h>
#include <Wire.h>
#include <TimeLib.h>

// --- VARIABLES TO ADJUST ---
// current time
tmElements_t tm;
long timestamp = 0;

// control amount of power sent to peltier modules
// pwm signal sent to h-bridge
uint8_t pwm = 0;

// how often the data is collected and saved
#define COLLECTION_INTERVAL 5000 // ms

static uint8_t *ucBackBuffer = NULL;

// --- ALL THE PINS ---
#define PIN_POT A0
#define PIN_PRESSURE A1
#define PIN_TEMP 2
#define PIN_SWITCH 3

#define EN_POS 14 // left
#define EN_NEG 15 // right
#define PWM_POS 4 // left
#define PWM_NEG 5 // right

// --- OTHER CONSTS ---
#define COLD 0
#define HOT 1
#define OFF 2

// temperature probe
OneWire oneWire(PIN_TEMP);
DS18B20 temp_probe(&oneWire);

// h-bridge (powering peltier devices)
BTS7960 peltier(EN_POS, EN_NEG, PWM_POS, PWM_NEG);

// OLED display
//SSOLED oled;
const char DEGREE_SYMBOL[] PROGMEM = { 0xB0, '\0' };
const String temp_strings[] = {
    "very cold", "cold", "slightly cold", "off", "slightly warm",
    "warm", "very warm"
};
U8X8_SSD1306_128X64_NONAME_HW_I2C oled(/* reset=*/0
U8X8_PIN_NONE);
String current_state;

```

```

String last_state;

// data from temperature sensor (actual)
// and potentiometer (target)
int last_target_temp;
int last_actual_temp;
int temp_state;
int temp;
int target_temp;
int target_temp_string;
String temp_strings[] = {
    "very cold", "cold", "slightly cold", "off", "slightly warm",
    "warm", "very warm"
};

// on/off switch state
bool is_device_on = true;

uint32_t timer;

// sd card
File myFile;

void setup() {
    Serial.begin(115200);

    // Temperature probe
    temp_probe.begin();

    // OLED screen - booting up text
    oled.begin();
    oled.setFont(u8x8_font_chroma48medium8_r);
    oled.setCursor(3, 4);
    oled.print("Starting ... ");
    delay(1000);

    // initialize SD card, csv file, clock
    setupDataCollectionBoard();
}

void loop() {
    // determine if the switch has been switched on or off and
    // turn the peltier modules on/off
    checkButton();

    // check the potentiometer to determine the heat/cold setting
    int target_temp = map(analogRead(PIN_POT), 0, 1023, 0, 6);

    if(analogRead(PIN_POT) > 1020) {
        target_temp = 6;
    }

    String target_temp_string = temp_strings[target_temp];

    // adjust variables based on the target temperature
    switch(target_temp) {
        case 0:
            temp_state = COLD;
            pwm = 220;
            break;
        case 1:
            temp_state = COLD;
            pwm = 165;
            break;
        case 2:
            temp_state = COLD;
            pwm = 135;
            break;
        case 3:
            temp_state = OFF;
            pwm = 0;
            break;
        case 4:
            temp_state = HOT;
            pwm = 105;
            break;
        case 5:
            temp_state = HOT;
            pwm = 120;
            break;
        case 6:
            temp_state = HOT;
            pwm = 135;
            break;
    }
}

```

```

case 2:
    temp_state = COLD;
    pwm = 135;
    break;
case 3:
    temp_state = OFF;
    pwm = 0;
    break;
case 4:
    temp_state = HOT;
    pwm = 105;
    break;
case 5:
    temp_state = HOT;
    pwm = 120;
    break;
case 6:
    temp_state = HOT;
    pwm = 135;
    break;
}

// ping the temp probe for the surface temperature of the
metal
float actual_temp = getActualTemp();

// only power the peltier when the switch is on and no error
in the temperature sensor
if(is_device_on && actual_temp > 0) {
    switch(temp_state) {
        case COLD:
            if(actual_temp < 28) {
                Serial.println("COOLING");
                peltier.Enable();
                peltier.TurnRight(pwm);
                current_state = "cooling pad";
            }
            else {
                peltier.Stop();
                current_state = "cooling down ... ";
            }
            break;
        case HOT:
            if(actual_temp > 18) {
                //Serial.println("HEATING");
                peltier.Enable();
                peltier.TurnLeft(pwm);
                current_state = "heating pad";
            }
            else {
                peltier.Stop();
                current_state = "warming up ... ";
            }
            break;
        case OFF:
            peltier.Stop();
            current_state = "device off";
            break;
    }
}

```

## Appendix 5 - Data collection code

```

    }

else if(!is_device_on && actual_temp > 0) {
    peltier.Disable();
    current_state = "device off";
}

// refresh OLED screen only when values change
if (last_target_temp != target_temp || last_actual_temp != (int)actual_temp || last_state != current_state) {
    Serial.print("Target temp: ");
    Serial.print(target_temp);
    Serial.print(" | Actual temp:");
    Serial.print(actual_temp);
    Serial.print("C | Current State: ");
    Serial.println(current_state);

    oled.setFont(u8x8_font_chroma48medium8_r);
    oled.clearLine(1);
    oled.clearLine(4);
    oled.clearLine(7);

    // String target_temp_final_string = "Target Temperature: " +
    target_temp_string;
    // const char *target_temp_char =
    target_temp_string.c_str();

    //Target temperature
    oled.setInverseFont(1);
    oled.setCursor(0, 0);
    oled.print("Target");

    oled.setInverseFont(0);
    oled.setCursor(0, 1);
    oled.print(target_temp_string);

    //Actual temperature
    String actual_temp_final_string = String(actual_temp) + " C";
    // const char *actual_temp_char =
    actual_temp_final_string.c_str();
    // oled.drawString(4, 12, actual_temp_char);

    oled.setInverseFont(1);
    oled.setCursor(0, 3);
    oled.print("Actual");

    oled.setInverseFont(0);
    oled.setCursor(0, 4);
    oled.print(actual_temp_final_string);

    //current state
    // String current_state_final_string = "Current State: " +
    current_state;
    // const char *current_state_final_char =
    current_state_final_string.c_str();
    // oled.drawString(4, 24, current_state_final_char);

    oled.setInverseFont(1);
}

```

```

oled.setCursor(0, 6);
oled.print("Current State");

oled.setInverseFont(0);
oled.setCursor(0, 7);
oled.println(current_state);

// only collect data at specific intervals
if(timer + COLLECTION_INTERVAL < millis()) {
    // get other values
    int pressure = analogRead(PIN_PRESSURE);

    writeToFile(target_temp, actual_temp, pressure);

    // update the timer
    timer = millis();
}

//save the last temperature readings
last_target_temp = target_temp;
last_actual_temp = (int)actual_temp;
last_state = current_state;

}

// peltier functions
void stop_device() {
    peltier.Stop();
    peltier.Disable();
}

void start_device() {
    peltier.Enable();
}

// function to get the temperature from the temp probe
float getActualTemp() {
    temp_probe.requestTemperatures();

    // wait until sensor is ready
    while (!temp_probe.isConversionComplete())
    {
        delay(1);
    }

    float tempC = temp_probe.getTempC();

    // Check if reading was successful
    if(tempC == 0 || tempC == -0.0625 || tempC == -128 || tempC == -127)
    {
        stop_device();
        current_state = "TEMP ERROR";
        Serial.println("Error: Could not read temperature data.");
        Turning off device for safety.");
        }
        return tempC;
    }

```

```

// function to check what state the switch button is in
// turn off peltier device if switch is off
// turn on peltier device if switch is on
void checkButton() {
    // switching power button off
    if(digitalRead(PIN_SWITCH) == HIGH && is_device_on == true) {
        stop_device();
        is_device_on = false;
        Serial.println("Device turned off!");
    }

    // switching power button on
    if(digitalRead(PIN_SWITCH) == LOW && is_device_on == false) {
        start_device();
        is_device_on = true;
        Serial.println("Device turned on!");
    }
}

/* The circuit:
SD card attached to SPI bus as follows:
** MOSI - pin 11
** MISO - pin 12
** CLK - pin 13
** CS - pin 9 for Robodyn board
*/
/* This is different for other boards such as Arduino Mega
*/
// const int chipSelect = 10; // Important to check; this is
Arduino dependent. Mega uses 53, Uno 9

// #define debugled 8

const char *monthName[12] = {
    "Jan", "Feb", "Mar", "Apr", "May", "Jun",
    "Jul", "Aug", "Sep", "Oct", "Nov", "Dec"
};

void setupDataCollectionBoard() {
    // blink1();
    Serial.println("_____");
    Serial.print("Initializing SD card ...");

    delay(1000);
    pinMode(53, OUTPUT); // Set Chip Select pin to "output"
    otherwise the routine will not work
    pinMode(10, OUTPUT);
    delay(1000);

    if (!SD.begin(10)) {
        Serial.println("wa failed!");
        delay(1000);
        return;
    }
    else {
        Serial.println("initialization done.");
    }
}

```

#### Appendix 5 - Data collection code contd.

```

// open the file. note that only one file can be open at a time,
// so you have to close this one before opening another.
myFile = SD.open("database.csv", FILE_WRITE);

// if the file opened okay, write to it:
if (myFile) {
    Serial.print("Initializing database.csv ... ");
    myFile.println("Real Date:" + timestamp);
    myFile.println("Timestamp, Target Temperature, Actual
Temperature, Pressure, Peltier On, Current State");
    // close the file:
    myFile.close();
    Serial.println("done.");
} else {
    // if the file didn't open, print an error:
    Serial.println("error opening database.csv");
}

pinMode(LED_BUILTIN, OUTPUT);
// blink1();

// Initialize sensor
bool parse=false;
bool config=false;

// get the date and time the compiler was run
if (getDate(__DATE__) && getTime(__TIME__)) {
    int day = tm.Day;
    int hour = tm.Hour;
    int min = tm.Minute;
    int sec = tm.Second;

    parse = true;
    config = true;
    RTC.read(tm);

    int rtc_day = tm.Day;
    int rtc_hour = tm.Hour;
    int rtc_min = tm.Minute;
    int rtc_sec = tm.Second;
    Serial.println(String(hour) + ":" + String(min) + ":" +
String(sec));
    Serial.println(String(rtc_hour) + ":" + String(rtc_min) +
":" + String(rtc_sec));
    //RTC.write(tm);
    // if(day > rtc_day) {
    //     Serial.println("updating from day");
    //     RTC.write(tm);
    // }
    // else if(hour > rtc_hour) {
    //     Serial.println("updating from hour");
    //     RTC.write(tm);
    // }
    // else if(min > rtc_min) {
    //     Serial.println("updating from minute");
    //     RTC.write(tm);
    }
}

```

```

        // }
    }

    if (parse && config) {
        Serial.print("DS1307 configured Time=");
        Serial.print(__TIME__);
        Serial.print(", Date=");
        Serial.print(__DATE__);
    } else if (parse) {
        Serial.println("DS1307 Communication Error :-{");
        Serial.println("Please check your circuitry");
    } else {
        Serial.print("Could not parse info from the compiler,
Time=");
        Serial.print(__TIME__);
        Serial.print(", Date=");
        Serial.print(__DATE__);
        Serial.println(")");
    }
}

bool getTime(const char *str)
{
    int Hour, Min, Sec;

    if (sscanf(str, "%d:%d:%d", &Hour, &Min, &Sec) ≠ 3) return
false;
    tm.Hour = Hour;
    tm.Minute = Min;
    tm.Second = Sec;
    return true;
}

bool getDate(const char *str)
{
    char Month[12];
    int Day, Year;
    uint8_t monthIndex;

    if (sscanf(str, "%s %d %d", Month, &Day, &Year) ≠ 3) return
false;
    for (monthIndex = 0; monthIndex < 12; monthIndex++) {
        if (strcmp(Month, monthName[monthIndex]) == 0) break;
    }
    if (monthIndex ≥ 12) return false;
    tm.Day = Day;
    tm.Month = monthIndex + 1;
    tm.Year = CalendarYrToTm(Year);
    return true;
}

String get_timestamp()
{
    tmElements_t tm;
    String output = "";
    if(RTC.read(tm)) {
        output += to2digits(tm.Hour);

```

```

        output += ':';
        output += to2digits(tm.Minute);
        output += ':';
        output += to2digits(tm.Second);
        output += '-';
        output += to2digits(tm.Day);
        output += '/';
        output += to2digits(tm.Month);
        output += '/';
        output += tmYearToCalendar(tm.Year);
    }
    else {
        output = millis();
    }
    return output;
}

String to2digits(int number) {
    String output = "";
    if (number ≥ 0 && number < 10) {
        output += "0";
    }
    output += number;
    return output;
}

void writeToFile(int target_temp, float actual_temp, int
pressure) {
    myFile = SD.open("database.csv", FILE_WRITE);
    if(myFile && getDate(__DATE__) && getTime(__TIME__)) {
        //timestamp();
        myFile.print(get_timestamp());
        myFile.print(F(" , "));
        myFile.print(target_temp);
        myFile.print(F(" , "));
        myFile.print(actual_temp);
        myFile.print(F(" , "));
        myFile.print(pressure);
        myFile.print(F(" , "));
        myFile.print(is_device_on);
        myFile.print(F(" , "));
        myFile.println(current_state);
        myFile.close();
        delay(500);
        Serial.println("saved data successfully");
    }
    else {
        Serial.println("error opening database.csv");
    }
}

```

#### Appendix 5 - Data collection code contd.

```

import numpy as np
import pandas as pd
import datetime as dt
import matplotlib.dates as mdates

# next command ensures that plots appear inside the notebook
%matplotlib inline
import matplotlib as mpl
import matplotlib.pyplot as plt
import seaborn as sns # also improves the look of plots
sns.set() # set Seaborn defaults
plt.rcParams['figure.figsize'] = [10, 5] # default hor./vert.
size of plots, in inches
plt.rcParams['lines.markeredgewidth'] = 1 # to fix issue with
seaborn box plots; needed after import seaborn

# hide FutureWarnings, which may show for Seaborn calls in most
recent Anaconda
import warnings
warnings.filterwarnings('ignore', category=FutureWarning)

# reveal a hint only while holding the mouse down
#from IPython.display import HTML
#HTML('<style>.h,.c{display:none}.t{col-
or:#296eaa}.t:active+.h{display:block;}</
style>')
raw = pd.read_csv('VERYGOODDATABASE.csv')

#raw.dropna(inplace=True)
#raw.isnull().sum()
raw['datetime'] = pd.to_datetime(raw['millis()'])
raw['time'] = raw['datetime'].dt.time
data = raw
# data = raw.set_index("datetime")
# data[' Target Temperature'] = data[' Target Temperature'].\
astype(float)
#pd.to_datetime(df_phoneusage['Date'], format= '%d-%m-%Y')

#sitting down = [0,1,1,1,0,0,1]
plt.plot(data["datetime"], data[' Pressure'],
color='darkorange');
plt.title('Pressure on the cat sofa', size=16, weight='bold')
plt.xlabel('time')
plt.ylabel('Amount of pressure')
plt.legend(['Pressure']);
#plt.facecolor('whitesmoke')
plt.savefig('pressure.png', dpi=600)

```

---

```

sitting = data[' Pressure'] ≥ 150

data["sittingcat"] = sitting
data["sittingcat"] = data["sittingcat"].astype(int)
plt.plot(data["datetime"],data["sittingcat"], linestyle='')
plt.xlim([dt.datetime(2024,5,6, 8, 0, 0),dt.datetime(2024,5, 6
, 18,0,0)])
plt.fill_between(data['datetime'],data["sittingcat"],

```

**Appendix 6 - Data analysis code.**

```

color='lightblue')
#plt.get_facecolor('whitesmoke')
#rcParams['figure.facecolor'] = 'white'
#plt.figure.set_facecolor('white')
xformatter = mdates.DateFormatter('%H:%M')
plt.gcf().axes[0].xaxis.set_major_formatter(xformatter)
data["sittingcat"].head(500)

fg, ax1 = plt.subplots()
#dates = data['datetime']

ax2 = ax1.twinx()
ax1.plot(data['datetime'], [i for i in data[' Target Tempera-
ture']], 'g-', marker='8')
ax1.set_ylim(0, 7)
ax2.plot(data['datetime'], [i for i in data[' Actual Tempera-
ture']], 'lightgreen')
ax2.set_ylim(0, 50)

ax1.set_facecolor('whitesmoke')
ax1.set_title('Temperature setting vs Actual temperature',
size=16, weight='bold')
ax1.set_xlabel('Time')
ax1.set_ylabel('Temperature setting', color='g')
ax2.set_ylabel('Actual temperature (C*)', color='limegreen');

xformatter = mdates.DateFormatter('%H:%M')
plt.gcf().axes[0].xaxis.set_major_formatter(xformatter)

plt.savefig('temperature.png', dpi=600)

fg, ax1 = plt.subplots()
dates = data['datetime']

ax2 = ax1.twinx()
ax1.plot(dates, [i for i in data[' Target Temperature']], 'g-')
ax1.set_ylim(0, 7)
ax2.plot(dates, [i for i in data[' Pressure']], 'darkorange')
ax2.set_ylim(-50, 300)

ax1.set_facecolor('whitesmoke')
ax1.set_title('Temperature setting vs Pressure', size=16,
weight='bold')
ax1.set_xlabel('Time')
ax1.set_ylabel('Temperature setting', color='g')
ax2.set_ylabel('Pressure', color='darkorange');

xformatter = mdates.DateFormatter('%H:%M')
plt.gcf().axes[0].xaxis.set_major_formatter(xformatter)

fg, ax1 = plt.subplots()
#dates = data['datetime']

ax2 = ax1.twinx()
ax1.plot(data['datetime'], [i for i in data[' Target Tempera-
ture']], 'g-')
#axcombined = ax1.plot( [i for i in data[' Target Tempera-
ture']], 'g-')

```

```

ax1.set_xlim(datetime.date(2024,4,31), datetime.
date(2024,6,31))

ax3 = ax1.twinx()
ax3.plot(data['datetime'], [i for i in data['sittingcat']],
marker='o', linestyle=" ")
#ax3.set_ylim(-0.1, 1.1)

ax1.set_facecolor('whitesmoke')
ax1.set_title('When cats sit on desks', size=16, weight='bold')
ax1.set_xlabel('Time')
ax1.set_ylabel('Temperature setting', color='g')
ax2.set_ylabel('Pressure', color='darkorange');

xformatter = mdates.DateFormatter('%H:%M')
plt.gcf().axes[0].xaxis.set_major_formatter(xformatter)

fig, ax1 = plt.subplots()
#dates = data['datetime']

ax2 = ax1.twinx()
ax1.plot(data['datetime'], [i for i in data[' Target Tempera-
ture']], 'g-', marker='8')
ax1.set_ylim(0, 7)
ax2.plot(data['datetime'], [i for i in data[' Actual Tempera-
ture']], 'lightgreen', linewidth = '5', alpha = 0.8)
ax2.set_ylim(0, 45)
ax3 = ax1.twinx()
ax3.plot(data['datetime'], [i for i in data['sittingcat']],
linestyle=' ')
plt.fill_between(data['datetime'],data["sittingcat"], color='dod-
gerblue', alpha=0.4)
ax3.axes.get_yaxis().set_visible(False)
#plt.xlim([dt.datetime(2024,5,31, 8, 30, 0),dt.datetime(2024,5,
31 , 10, 0,0)])
plt.xlim([dt.datetime(2024,5,6, 8, 0, 0),dt.datetime(2024,5, 6
, 18,0,0)])
ax1.set_facecolor('whitesmoke')
ax1.set_title('When do cats sit on heated sofas? ', size=16,
weight='bold')
ax1.set_xlabel('Time')
ax1.set_ylabel('Temperature setting', color='g')
ax2.set_ylabel('Actual temperature (C*)', color='limegreen');

plt.legend([('The cat is sitting')])

xformatter = mdates.DateFormatter('%H:%M')
plt.gcf().axes[0].xaxis.set_major_formatter(xformatter)

plt.savefig('catssitting.png', dpi=600)

```

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### Ethical Review Form (Version 1.6)

This Ethical Review Form should be completed for every research study that involves human participants or personally identifiable personal data and should be submitted to [ethics@tue.nl](mailto:ethics@tue.nl). For more information about how this process works please click [here](#).

<b>Part 1: General Study Information</b>		
1	Project title	New Futures: Connectivity in the Home with Energy, Systems and Sound – DFP003 – B21/B22/FBP/Pro-Master/M11/M12
2	Name of the researcher/student	
3	Email of the researcher/student	Dr. ir. J.W. Frens
4	Supervisor(s) name(s) <i>Additional explanation:</i> Please write down the name of your direct supervisor. You can mention several supervisors if appropriate, but at least one supervisor should be mentioned.	
5	Supervisor(s) email address(es) <i>Additional explanation:</i> Please give the email address of the supervisor(s) mentioned in question 4.	
6	Department	
7	Are you a student and is this application for educational purposes?	<input type="checkbox"/> Yes, Bachelor. Course: <input type="checkbox"/> Yes, Master. Course: <input type="checkbox"/> No
8	Research location <i>Additional explanation:</i> Where will the data collection take place? On campus, in a company, in public space, etc.	TU/e campus, Personal homes of people, Offices and company spaces.
9	Start date data collection <i>Additional explanation:</i> Please state when your data collection will start. Please note that you do not have to provide information about your complete (PhD) project, but only on this particular sub-study that you are submitting for approval in this form.	1 <sup>st</sup> of September 2023
10	End date data collection	1 <sup>st</sup> of July 2024
11	Does your project receive external funding (e.g., NWO, relevant for special regulations from funders)?	<input type="checkbox"/> Yes. Name Funder: <input checked="" type="checkbox"/> No
12	Which internal and external parties are involved in the study? Think about sharing data or information between TU/e and other universities, commercial companies, hospitals, etc. <i>Additional explanation:</i> Describe all internal and external parties that are involved in the study or project, including: <ul style="list-style-type: none"> <li>• study participants (e.g., people being interviewed, people participating in online surveys, patients, etc.);</li> <li>• researchers or research groups at the TU/e who participate in the study;</li> <li>• (Researchers at) other universities/institutions that provide data/services, help analyzing the data, etc.;</li> <li>• (commercial) partners, companies, government bodies, municipalities, consultancy firms, hospitals or care institutions that provide data (e.g., contact details of participants, data for further analysis).</li> </ul> Indicate which role each party plays: who defines the means and purposes in the study; who will supply the data (external parties?).	For this umbrella ERB form we only include parties from the squad and participants to the study. (To the student: if your study requires data to be accessible to other parties, discuss this with your coach and file a separate request to the ERB) Squad: Student or Student group, Project coach, Teacher coach, Second examiner, Squad leader. Adult, non-vulnerable, human participants

**Appendix 7 - New Futures squad platform ERB form**

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### Ethical Review Form

13	who will process/handle the data, who will be able to access the data during and after research (only researchers of TU/e or also others)?  Have any special agreements already been made with an external party, such as a Non-Disclosure Agreement (NDA) or a data sharing agreement?	<input type="checkbox"/> Yes, namely: <input checked="" type="checkbox"/> No
14	Has your proposal already been approved by an external Ethical Review Board or Medical Ethical Review Board?  <i>Additional explanation:</i> For example, when you are collaborating with another university and the project has been approved by their Ethical Review Board, or when you received a WMO-waiver from a Medical Ethical Review Board.	<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No
15	If yes: Please provide the name, date of approval and contact details of the ERB. Please also include the registered number for your project approval. Additionally, please send in the Ethical Review Form upon which ethical approval was granted together with this form.	
16	Have you already performed a Data Protection Impact Assessment (DPIA) for this or a very similar project?  <i>Please read the information below: a DPIA is not the same as a regular privacy impact assessment. More detailed questions on privacy will follow in the section below.</i>  <i>Additional explanation:</i> A Data Protection Impact Assessment (DPIA) is a formal document that must be drafted under the guidelines of the General Data Protection Regulation (GDPR). If you process personal data that are likely to result in high privacy risks for participants. Think of research with vulnerable people, high-risk medical research, The Dutch DPA (Autoriteit Persoonsgegevens) and our website provides more information about a DPIA.	<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No  If yes: Please provide details about the DPIA here and send in the DPIA documentation together with this form.
<b>Part 2: Medical study</b>		
1	Does study have a medical scientific research question or claim?  <i>Additional explanation:</i> Medical/scientific research is research which is carried out with the aim of finding answers to a question in the field of illness and health (etiology, pathogenesis, signs/symptoms, diagnosis, prevention, outcome or treatment of illness), by systematically collecting and analyzing data. The research is carried out with the intention of contributing to medical knowledge which can also be applied to populations outside of the direct research population. If your research contains questions about health and health related parameters (such as well-being, vitality, feelings of anxiety or stress) but your research question is not primarily medical, then you can answer 'no' to this question.	<input type="checkbox"/> Yes* <input checked="" type="checkbox"/> No  *If yes or in doubt, please contact Susan Hommerson via <a href="mailto:s.m.hommerson@tue.nl">s.m.hommerson@tue.nl</a>
<b>Part 3: Use of (medical) devices in the study</b>		
1	Does your research include a device?  <i>Additional explanation:</i> A device is a complete piece of physical hardware that is used to compute or support computer functions within a larger system. Devices can be divided into input-, output-, storage-, Internet of things-, or mobile device.	<input type="checkbox"/> Yes, not self-made <input checked="" type="checkbox"/> Yes, self-made <input type="checkbox"/> No
2	Please describe your device or link to an online description of the device	Self-built prototypes with embedded electronics. These prototypes can be built from scratch or

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		utilize store bought products that are modified. Power is provided through low voltage batteries (~9V) or through unaltered, CE certified power supplies (~12V DC). The adapted or scratch built prototypes do not employ parts that operate at higher than 12V AC or DC, unless with explicit permission of /d/search lab. All prototypes are safety checked by /d/search lab.
3	Will you use a device that is 'CE' certified for unintended use (meaning you will use existing CE certified devices for other things than they were originally intended for) or use a device that is not 'CE' certified?	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No
4	If yes: Do you use a device or software that has a medical purpose such as diagnosis, prevention, monitoring, prediction, prognosis, treatment or alleviation of disease or injury?	<input type="checkbox"/> Yes, my device or software currently has a medical purpose. <input type="checkbox"/> Yes, my device or software could have a medical purpose in the near future <input checked="" type="checkbox"/> No <input type="checkbox"/> I'm not sure
<b>Part 4: Information about the study</b>		
1	What are your main research questions? <i>Additional explanation:</i> You need to provide at least one clear research question.	The squad aims 'to design for and do research to highly connected, interactive products and services that are part of IoT systems'. In the squad there are two specific types of <b>projects</b> that take place: (1) design projects, and (2) design research projects. Below we discuss both.  (1) design projects The design projects revolve around the theme of designing for interaction with the connected IoT artifacts in the smart home of the future. Typical questions that need answering in such a project concern (a) questions for expertise, (b) questions to understand the context for design and (c) questions to evaluate design concepts. This phase also knows (d) co-design activities.  (2) design research projects The design research projects study (interacting in and with) the future smart home. Formulating the specific design research questions is part of the challenge.
2	Description of the research method <i>Additional explanation:</i> For example, interview, survey, experiment, user-test, Randomized Experiment, focus groups, pilot study, observation, etc.	The squad employs the following methods:  <ul style="list-style-type: none"> <li>- (semi) structured interviews</li> <li>- (silent) observation</li> <li>- contextual analysis</li> <li>- data-enabled design</li> <li>- cultural probes</li> <li>- online surveys</li> <li>- questionnaires</li> <li>- co-design</li> </ul>

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		- futuring techniques - critical design - (auto) ethnographic methods
3	Description of the research population, in- and exclusion criteria <i>Additional explanation:</i> Please describe which persons are eligible for your study. What criteria are used to select participants in your study, and what criteria are used to exclude possible participants? For example: We will randomly select participants from the JS participant database with good vision and older than 18 years.	Our research population consist of adults, expertise or experience with smart homes or connected artifacts can be an inclusion criterion. We do not work with vulnerable groups or with children.
4	Description of the measurements and/or stimuli/treatments <i>Additional explanation:</i> Think about your outcome measures and the variables you will be collecting and describe them in a way such that another person understands what the participant will experience. For example: Participants will perform task A and see pictures from database B, and we measure validated Scale 1.	We use both qualitative and quantitative approaches in the design and design research projects. We employ the following measurements:  <ul style="list-style-type: none"> <li>- Audio recording* (for the sake of transcription)</li> <li>- Video recording* and photography* (for contextual analysis) – It is important to ensure that people are not recognizable in the video footage.</li> <li>- Prototype testing and evaluation</li> <li>- Likert scales</li> <li>- Observation notes</li> </ul> <p>* Recordings are always made by persons, we do not allow devices to record autonomously</p>
5	Describe and justify the number of participants you need for this study. Also justify the number of observations you need, taking into account the risks and benefits. <i>Additional explanation:</i> Think about if you need 3 or 30 participants for example, and why? Do they need to provide their input once, or several times, and why?	Expert sessions: 1 – 3 Experts provide specific expertise that needs no repeated sampling.  Generative sessions: 2 – 6 In generative sessions the engagement is with small groups designers. The purpose is to inspire and not to find some form of saturation of the design space.  Qualitative approaches: 1 – 10 These either aim for rich descriptions of practices, experiences, or contexts for which small amounts of participants suffice (1-4) or aim to reach saturation in answers for which somewhat larger groups suffice (2-10).  Quantitative approaches: 10 – 20 These aim for data that allows for (basic) statistical description or analysis, 10 – 20 samples suffice).
6	Explain why your research is societally important. What benefits and harm to society may result from the study? <i>Additional explanation:</i> What benefit will the results of your study have to society in general?	We explore ways of living with future technologies in a world that is rapidly changing due to (for example) climate change. To understand such future scenarios is a way of preparing and even offering insights into the solution domain.
7	Describe the way participants will be recruited <i>Additional explanation:</i> How will you recruit participants for your study? For example, by using flyers, personal network, panels, etc.	We employ a range of approaches to recruitment:  <ul style="list-style-type: none"> <li>- Posting on online forums</li> <li>- Flyers</li> <li>- Convenience sampling</li> </ul>
8	Provide a brief statement of the risks you expect for the participants or others involved in the study and explain. Also take into consideration any personal data you may gather and associated privacy issues.	We do not expect large risks. There are two points of attention:  <ul style="list-style-type: none"> <li>(1) prototypes: we build prototypes that include mechanisms and electronics. These prototypes</li> </ul>

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<p><i>Additional explanation:</i> Risks for the participants can be anything from risk of data breach to risk of safety or well-being. Describe these possible risks and describe the way these risks are mitigated.</p>		<p>are checked for safety by /d/search lab before any experiment or study can be done with them.</p> <p>(2) data: we are careful with data capturing that records personal data. Transcriptions are either done 'manually' or through Microsoft services. Audio for transcript is deleted after transcribing and Photography and Videography needs to be planned such that personal data capture is kept to a minimum. If identifiable data is captured photo or video needs to be de-identified.</p>																																								
<b>Part 5: Self-assessment checklist</b> <p>Note: answers in the blue boxes indicate that your research is eligible for fast-track approval</p> <table border="1"> <thead> <tr> <th></th> <th>Yes</th> <th>No</th> </tr> </thead> <tbody> <tr> <td>1a Does the study involve human material? (e.g., surgery waste material derived from non-commercial organizations such as hospitals)</td> <td>X</td> <td></td> </tr> <tr> <td>1b Will blood or other (bio)samples be obtained from participants? (e.g., hair, sweat, urine or other bodily fluids or secretions, also external imaging of the body)</td> <td>X</td> <td></td> </tr> <tr> <td>2 Will the participants give their consent – on a voluntary basis – either digitally or on paper? Or have they given consent in the past for the purpose of education or for re-use in line with the current research question?</td> <td>X</td> <td></td> </tr> <tr> <td>3 Are the participants outside the context of the research, in a dependent or subordinate position to the investigator? <i>Additional explanation:</i> Think about doing research on your own students or on your own employees. When there is a dependency or power imbalance between you and the research participants, you need to answer 'yes' to this question.</td> <td>X</td> <td></td> </tr> <tr> <td>4 Does the study involve participants who are particularly vulnerable or unable to give informed consent? (e.g., children (&lt;16 years of age), people with learning difficulties, patients, people receiving counselling, people living in care or nursing homes, people recruited through self-help groups)</td> <td>X</td> <td></td> </tr> <tr> <td>5 Will participating in the research be burdensome? (e.g., requiring participants to wear a device 24/7 for several weeks, to fill in questionnaires for hours, to travel long distances to a research location, to be interviewed multiple times)?</td> <td>X</td> <td></td> </tr> <tr> <td>6 May the research procedure cause harm or discomfort to the participant in any way? (e.g., causing pain or more than mild discomfort, stress, anxiety or by administering drinks, foods, drugs, or showing explicit visual material)</td> <td>X</td> <td></td> </tr> <tr> <td>7 Will financial inducement (other than reasonable expenses and compensation for time) be offered to participants? <i>Additional explanation:</i> For an explanation of what is considered a reasonable compensation, see the topic participant fees from the HTI group</td> <td>X</td> <td></td> </tr> <tr> <td>8a Will it be necessary for participants to take part in the study without their knowledge and consent at the time? 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<p><b>11</b> Elaborate on all boxes answered outside of the blue boxes in part 5. Describe how you safeguard any potential risk for the research participant.</p>																							
<p><b>Part 6: Self-assessment on privacy</b></p> <p>The following questions (1-10) concern privacy issues, as laid down in the General Data Protection Regulation (GDPR). The Data Stewards and – if necessary – privacy team of TU/e will assess these questions. In some cases, more information is required to assess the privacy risks. If this is the case, you will be notified that the Data Stewards team will contact you.</p> <p>The GDPR defines 'personal data' as any information relating to an identified or identifiable natural person ('data subject'). Personal data also includes data that indirectly reveals something about a natural person. Personal data can lead to the physical, physiological, genetic, mental, economic, cultural or social identity of a natural person. There are two main categories of personal data: regular personal data and special category personal data.</p> <p>If you are not sure whether some of these questions below should be answered with a Yes or No, please contact a Data Steward first through rdmsupport@tue.nl.</p> <p>Note: answers in the blue boxes indicate that your research is eligible for fast-track approval</p> <table border="1"> <thead> <tr> <th></th> <th>Yes</th> <th>No</th> </tr> </thead> <tbody> <tr> <td>1 Will the study involve discussion/collection/processing of regular personal data, or will you collect and (temporarily) store video or voice recordings for the purpose of conducting interviews? <i>Additional explanation:</i> For example, name, address, phone number, email address, IP address, gender, age, video or interview recordings? If you are not sure whether your data contains personal data, please contact the Data Stewards Team rdmsupport@tue.nl.</td> <td>X</td> <td></td> </tr> <tr> <td>1A If yes: Please describe which regular personal data you will collect in this study? We might make audio or video recordings and/or take photos.</td> <td></td> <td></td> </tr> <tr> <td>2 Will the study involve discussion/collection/processing of special category personal data or other sensitive data? <i>Additional explanation:</i> Examples of special category personal data are race, religion, health information, political views, genetic or biometric data for the unique identification of a person, sexual preference, etc. Health information concerns the state of the physical and mental health of a person, including the provision of health care. Examples of other sensitive data is information such as communication data, financial records or credit scores, camera surveillance data, location/GPS data, internet-of-things data, employee monitoring, observing or influencing behaviour, criminal records, data of vulnerable persons (children, people with disabilities, refugees), BSN number etc. Please be aware that the use of special category personal data in research requires extra security measurements in order to safeguard the privacy of data subjects and to comply with the GDPR. Processing of this special category data is prohibited, except for specific purposes and under certain circumstances. If you need to process special category data, please consult the data stewards at rdmsupport@tue.nl</td> <td>X</td> <td></td> </tr> <tr> <td>2A If yes: Please describe which special-category personal data and/or sensitive data you will collect in this study?</td> <td></td> <td></td> </tr> <tr> <td colspan="3"> <p>If you answered yes to either question 1 or 2, please answer the questions below. If you answered no to both questions, you can skip this part and continue onto part 6. Also, if an answer to any of the following questions is 'yes', please contact a Data Steward at rdmsupport@tue.nl</p> </td> </tr> <tr> <td colspan="2"> <p>3 Will your project involve the processing of personal data on a large scale? <i>Additional explanation:</i> In general, any processing that involves more than 10.000 data subjects should be considered 'large scale'. 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	<p>be considered large scale. In that case, besides the number of persons involved in the study, one should also assess (i) the amount of data collected from these persons taking into account the type/risk level of the personal data, (ii) the duration of the data processing, (iii) the geographic scope or extent of the processing. For example, if you would collect and process data across several European countries with 10+ socio-economic data items of 1200 individual persons for several years, this may likely be "large-scale processing". Other examples of a large-scale processing activity are:</p> <ul style="list-style-type: none"> <li>• Collecting data of Covid patients</li> <li>• A hospital that processes patient data as part of its usual operations</li> <li>• A transport company that processes travel information of people who travel by public transport in a certain city. For example, by tracking them through travel maps.</li> </ul>	
4	<p>Does this processing activity involve the use of new or innovative technologies?</p> <p>Examples of a new technology: combining fingerprints and facial recognition for physical access control, the use of bodycams in public spaces, the use of new technical methods in conducting research such as AI. This question also refers to new technologies that have not been deployed by TU/e so far.</p>	X
5	<p>Does your study involve systematic (c.p. automated) monitoring of persons?</p> <p>Additional explanation: Consider data processing activities that have the purpose of observing, monitoring or controlling individuals, for example in circumstances where the individuals are not aware by whom their personal data is collected and how it is used. Examples of such activities are using camera systems to monitor driving behavior on highways, monitoring email inactivity or employee phone use, certain applications of machine learning and artificial intelligence.</p>	X
6	<p>Does the study involve collaborations (with third parties) in which data are shared or exchanged in order to link or combine data?</p> <p>Additional explanation: This may often apply in a collaboration between the university and a commercial party, contract research, etc. It is important to assess this for all data in the entire project, not just your own data. An important consideration in this situation is whether the person whose data is involved could have expected that data from these different databases or sources of information were to be combined. For example, it is less likely for data subjects to expect that databases from different parties will be combined and the results are used for different purposes than one could reasonably expect; this may apply for example in a collaboration between the university and a commercial party.</p>	X
7	<p>Will the study include processing activities that prevent data subjects from exercising their rights or using a service or contract?</p> <p>Additional explanation: Examples include processing operations carried out in public places that people cannot avoid (train station, airport, shopping mall, public university premises, etc.) or processing operations whose purpose is to allow or not allow data subjects to use a service or enter into a contract (examples: by refusing to pay a benefit, not being able to apply for a loan, etc.).</p>	X
8	<p>Will the study process personal data to score, rank or profile persons?</p> <p>Additional explanation: Examples: monitoring (highway) roads to give road users a "score" based on their detected driving behavior, a bank assessing its customers based on their creditworthiness, or an organization building behavioral and marketing profiles based on use of their website or navigating their website.</p>	X
9	<p>Does your data processing include activities that involves composing "blacklists" – and, in particular, in relation to sensitive or special category data, such as communication data, financial records or credit scores, genetic data, biometric data, health data, camera surveillance data, location/GPS data, internet-of-things data, employee monitoring, observing or influencing behaviour, etc.</p> <p>Additional explanation: This situation will not be a common occurrence in research, but you may indirectly be involved in this. In general, this typically concerns processing operations involving personal data relating to criminal convictions and offences, data relating to unlawful acts, data concerning unlawful or annoying behaviour or data concerning bad payment behaviour by companies or individuals are processed and shared with third parties (blacklists or warning lists, as used, for example, by insurers, hospitality companies shopping companies, telecom providers as well as blacklists relating to unlawful behavior of employees, for example in the healthcare sector or by employment agencies, etc.).</p>	X
10	<p>Will any raw or anonymized personal data or any other sensitive data or research results from the project possibly be transferred to a high-risk country?</p> <p>*High risk countries: China, Russia, Iran, Turkey, and North Korea.</p> <p>If personal data or other potentially sensitive data is exchanged with one of these countries, or if part of the data processing takes place in one of these countries: an advice from the Data Protection Officer, the Kennisveiligheidsteam (Knowledge Security team), and the CISO (Chief Information Security Officer) is ALWAYS required.</p>	X

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<p><b>Part 7: Data processing, storing and archiving</b></p> <p><b>1a</b> Is consent your legal basis for processing the personal data in your study?</p> <p><i>Additional explanation: What is a legal basis? One of main principles in the GDPR is to ensure that personal data is processed lawfully, fairly, and transparently. To comply with this principle, the processing of personal data also requires that you have a valid legal basis for the personal data processing activity. In research projects, the legal basis is often but not always consent. However, it is possible that it is not clear or not possible to establish whether to use consent as a legal basis.</i></p> <p><i>Some examples where consent may not be applicable as legal basis are covert research, data collection in public spaces, secondary data analysis of existing data, data that are transferred to you by a third party, consent is not possible or would require disproportionate effort, etc. In that case, please indicate which legal basis you think that applies or (preferably) contact a data steward first.</i></p>	
<p><b>1b</b> If yes: Please briefly explain how you will obtain consent from participants and send in your draft of the information letter and consent statement together with this form. You can download a suitable template <a href="#">here</a>.</p> <p>Different sessions/studies require different consent mechanisms:</p> <p>Expert sessions &amp; Generative sessions: When consulting experts or communicating in group sessions, for example when carrying out collaborative data collection, for example when documenting the results of the session or study in the project report or paper, experts or participants to generative session need to sign an informed consent. This informed consent is based on the template. Names of experts can only be named after they explicitly consent to this. Participants of generative sessions are not named, but their work is ALWAYS credited anonymously.</p> <p>Qualitative approaches: Participants sign an informed consent. This is either based on the template, or when part of a survey as a tick-box at the start.</p> <p>Quantitative approaches: Participants sign an informed consent. This is either based on the template, or when part of a survey as a tick-box at the start.</p>	
<p><b>1c</b> If no: Please briefly explain on which legal basis - other than consent - you will process the personal data in your study.</p>	
<p><b>2</b> In which way will you collect and process the (personal) data?</p> <p><i>Additional explanation: Please describe which software (e.g., LimeSurvey, Atlas Ti, Qualtrics), tools (electronic lab journals, information management systems, etc.)</i></p> <ul style="list-style-type: none"> <li>- Microsoft products (Forms etc.)</li> <li>- Recording devices (phones etc.) – we follow the TU/e guidelines for audio</li> </ul>	

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3	<p>technologies, apps or devices (Internet-of-Things, Fitbit, etc.), techniques (monitoring, interview, survey), special data environments (e.g., Living Lab), etc. you will use to collect or process data?</p> <p><i>Additional explanation: Please address the following:</i></p> <ul style="list-style-type: none"> <li>• Where will your data during the study and after you have completed the study? University-supported storage facilities are SURFdrive, SURF Research Drive, Ceph, departmental drives (this includes BE Project Drive), and the TU/e instance of Microsoft OneDrive. For most personal data, the use of SURF Research Drive, departmental drives (including BE Project Drive) and SURFdrive is required.</li> </ul>
4	<p>Where will the data and in particular the personal data be stored during and after completion of the study? If you have already uploaded your Data Management Plan, you can refer to your Data Management Plan.</p> <p><i>Additional explanation: Please address the following:</i></p> <ul style="list-style-type: none"> <li>• Is access to your [personal] data restricted? If yes, how (access control, password protection, etc.)?</li> <li>• Who will have access to the data during and after completion of the study?</li> <li>• Will you anonymize or pseudonymize the data?</li> <li>• Is BitLocker (Windows) FileVault (Mac) or similar hard-drive encryption active on your laptop?</li> <li>• What will you do with the data after your project has come to results? Do you need to keep all data?</li> <li>• How long will you store the data after completion of the project, or can/will you delete it?</li> <li>• Will you share the data with others to keep the data for new or future research/reuse? Will you share (raw) data with others? If yes, how and how do you ensure that this is secure?</li> <li>• If access restrictions are required during and after the study, please explain how this is arranged.</li> </ul>
<b>Part 8: Closures and Signatures</b>	
1	<p>Enclosures (tick if applicable):</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Informed consent form;</li> <li><input type="checkbox"/> Informed consent form for other agencies when the research is conducted at a location (such as a school);</li> <li><input type="checkbox"/> Text used for ads (to find participants);</li> <li><input type="checkbox"/> Text used for debriefings;</li> <li><input type="checkbox"/> Approval other research ethics committee;</li> <li><input type="checkbox"/> The survey the participants need to complete, or a description of other measurements;</li> <li><input type="checkbox"/> Any other information which might be relevant for decision making by ERB;</li> <li><input type="checkbox"/> Data Protection Impact Assessment checked by the privacy officer</li> <li><input type="checkbox"/> Data Management Plan checked by a data steward</li> </ul>

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2	<p>Signature(s) Signature(s) of researcher(s) Date:</p> <p>Signature research supervisor (if applicable) Date:</p> <p style="text-align: right;">25.07.2022 Dr. ir. J.W. Frens (squad leader - New Futures squad)</p>