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Application Design for the Quantified Pet Domain from a User Centered Design Perspective

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ABSTRACT

Quantifying personal information is a rapidly emerging lifestyle that has now extended to tracking non-personal information as well. The Quantified Pet (QP) domain enables pet owners to gain insights in their pet's behavior and wellbeing. This study investigates how to design a QP application using the User Centered Design Method. To gain understanding in the inner drivers that form the human-pet relationship, five dog owners are interviewed. Three inner drivers that trigger interaction are revealed: habits, love and guilt. By surveying 104 users of existing QP applications, this study examined what motivates users to use a pet activity tracker and what sustains this usage. After performing a thematic analysis on this data, it was found that *Activities*, interest in activity data, and *Health*, improving and ensuring the dog's health, are dominantly portraited in the results. These themes provide the foundation for the establishment of two personas, of which the *Health* persona is chosen to be the primary design target. Next to user requirements following from the persona design, a heuristic evaluation is performed on one QP application (FitBark) to provide an additional set of design requirements. From these requirements, a design solution is proposed and evaluated amongst ten participants by means of a task list, semi-structured interview and a questionnaire. This revealed high usability for navigation and successful implementation of most requirements. However, design flaws, in specific of data visualization, and some misunderstanding of informational components remain. Future work proposes an improved design and provides additional suggestions for implementation and examination.

Applikationsdesign Inom Forskningsområdet Kvantifierade Husdjur ur ett Användarcentrerat Designperspektiv

SAMMANFATTING

Att kvantifiera personlig information är en starkt växande uppkommande livsstil och har nu även utökats till att följa icke-personlig information. Quantified Pet (QP) domänen möjliggör husdjursägare att få insikter i deras husdjurs beteende och välmående. I denna studie undersöks hur en QP-applikation ska designas genom att använda metoden User Centered Design. För att få förståelse för de innersta drivkrafterna till det som formar relationen mellan människa och husdjur blev fem hundägare intervjuade. Tre innre drivkrafter som triggar interactionen klarlades: vanor, kärlek och skuldkänslor. Genom att studera 104 användare av redan existerande QP-applikationer, denna studie undersökte vad som motiverar användare till att använda en pet activity tracker och vad som upperäthåller ett fortsatt användande. Efter att ha genomfört en tematisk analys av denna data visade det sig att Aktiviteter, intresse av aktivitetsdata, och Hälsa, förbättra och säkerställa hundens hälsa är de mest framträdande i resultaten. Dessa teman bidrar till grunden för etableringen av två personas, där personan för Hälsa är vald som primärt mål för designen. Utöver de användarkrav som uppkommit från personadesignen, har en hueristisk evaluering av en QR-applikation (Fitbark) gjorts för att bidra till ett ytterligare antal designkrav. Utifrån dessa krav föreslås en designlösning som evalueras bland tio deltagare genom en uppdragslista, semistrukturerad intervju och frågeformulär. Detta visade på en hög användbarhet för navigering och en lyckad implementation av de flesta av kraven. Dock existerar fortfarande brister i designen, specifikt för datavisualisering och några missförstånd över informationskomponenter. Framtida arbeten föreslår en förbättrad design och bidrar med ytterligare förslag på implementation och examinering.

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Author Keywords
Quantified Pet, Personal Informatics, human-pet relationship, user centered design, persona design, heuristic evaluation, application design.

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INTRODUCTION

'Living by numbers' is an emerging lifestyle focusing on quantifying personal information that is embraced well by the consumer market through rapidly growing numbers of enabling consumer devices [24]. A class of systems that help people to collect and reflect on their personal information is called Personal Informatics (PI) [11]. These systems enable their users to collect personally relevant information with the intent of self-reflection and gaining self-knowledge. People using PI systems operate in the domain of the Quantified Self (QS). *Quantified-Selfers*, as expressed by Choe et al. (2014) [4], are people that enthusiastically participate in self-tracking (or self-monitoring) practices. As *Quantified-Selfers*, individuals self-track biological, behavioral, physical, or environmental information [26].

Closely related to the Quantified Self is the Quantified Other (QO), which can be seen as an extension of the QS. In this situation, an individual tracks the personal information of another individual, for example family members or peers, rather than tracking oneself [7].

The QO domain opens up a new research domain when placed in the context where the individuals that are tracked are not humans, but animals. Nelson and Shih (2017) extend the concept of the QO to the context of pets, where they track information of one's pet dog and explore how collecting this data affects the human-pet relationship [14]. The Quantified Pet (QP) domain enables pet owners to gain insights and information in their pet's behavior and wellbeing. The QP domain is closely connected to Human-Pet-Computer Interaction (HPCI), where the aim is to understand "how technology can be designed and used to engage healthy human-pet interactions and relationships" [14].

While the popularity of the QS domain has led to many studies assessing the design for and collection/reflection of personal data, the novelty of the QP domain has naturally led to receiving much less attention. However, recent advances in the HPCI field show the high interest of users on collecting data on animals, for example dogs [20]. The expected increasing demand in consumer devices for the QP domain requires research that entails a thorough understanding of this yet largely unknown domain and that supports designing for this domain.

This research focusses on the design of an application for the QP domain from a user centered design perspective. It inspects the human-pet relationship, examines users of existing pet activity tracker applications and creates personas that assist in defining design requirements for QP application design. Additionally, an existing application is heuristically evaluated by involving an UX expert that inspects the dialogue elements and judges the compliance with Nielsen's

recognized usability principles for interaction design [15]. Consequently, an application design is proposed and evaluated that builds on the leading design requirements.

THEORY AND RELATED RESEARCH

User Centered Design

The concept 'User-Centered Design (UCD)' originated in 1986 by Donald A. Norman and Stephen W. Draper and is ever since widely now and adopted for system design [19]. Broadly speaking, UCD describes 'design processes in which end-users influence how a design takes shape' [1]. UCD puts great emphasis on the user and focuses on the user's needs and interest while making understandable and usable products [6]. The user should be seen as the most important element for designing usable systems with a central position in the design process [23].

An international standard (ISO 13407; Human-Centered Design Process), describes the basis for UCD methods and defines a general process for including human-centered design in the development of a product [2]. This general process is formed by four successive main activities:

1. Specifying the Context of Use: the users, use context, motivation for usage, conditions for usage
2. Specifying Requirements: goals that must be met to make the product successful
3. Producing Design Solutions
4. Evaluating Design: Usability Testing

Persona Design (Context of Use + Specifying Requirements)

A common tool that is especially valuable for specifying the context of use and user requirements in UCD, are personas. Personas are 'fictitious, specific, concrete representations of target users' that share common behavioral characteristics such as goals and behaviors [21]. They are created to help 'bringing the customer to life' and lead to an increased focus on the needs of the target users A persona is described in a narrative form that has two goals: making the persona seem like a real person, and providing information concerning the needs of the persona in the context of the product being designed [13]. By functioning as the central driver in the design process, personas provide supportive means for the integration of these needs and goals. Research by LeRouge et al. (2013) shows that personas help shaping requirements, facilitate user interface design by stimulating creativity and assist in the design decision making processes [10].

Heuristic Evaluation (Specifying Requirements)

When designing a new interface for an application, in addition to specifying requirements by personas, it is also important to analyze existing products for determining the successful factors and to allocate room for improvement [9]. Evaluating an existing interface and usability design choices provides an assistive tool for establishing (additional) design and usability requirements. A common method for determining usability requirements is a heuristic evaluation; a usability evaluation method for discovering usability problems in the design of a user interface by examining the interface and judging the compliance with recognized usability principles, also called heuristics [18]. The usability evaluation is performed by an UX expert that inspects the interface to detect usability problems [9]. The specialist performs as an evaluator that inspects the various dialogue elements and judges whether these follow established usability principles [15] [17]. Nielsen (1994a) presents a list of 10 heuristics for interaction design [15]. These heuristics are 'general rules that describe common properties of usable interfaces' [17]. The output of a heuristic evaluation is a list of usability problems with respect to the usability principles dishonored by the interface design. In addition to inspecting the compliance of the dialogue elements with the general heuristics, the evaluator is also allowed to consider any additional relevant usability principles.

Usability Testing (Evaluating Design)

Ideally, the proposed design resulting from the design solution is evaluated through usability testing with actual users. Usability testing refers to the process of recruiting test participants that represent the target audience for the evaluation of the extent to which a product meets specific usability criteria [25]. As stated by Nielsen (1994b), 'the most fundamental usability method' is user testing [16]. This method provides direct information on how people use and interact with an application and reveals their corresponding problems. Typical of a user test is that users perform tasks. These tasks are required to represent a realistic use of the system and must address the most important parts of the user interface [16]. It is important that the tasks provide the user with an achievable goal that is made actionable. Also, it is crucial that the tasks do not provide the user with unintentional cues for successful task completion [25]. Next to user testing, other usability testing methods useful for studying the interaction of the user with the application, features approval and satisfaction, are, amongst others, questionnaires and interviews [16]. These methods allow an in-depth evaluation and assessment the user's opinion on the interface.

Quantified Self

Unfortunately, limited research in the Quantified Pet domain prevents a good academic understanding of the motivation leading to (a sustained) usage of activity trackers. Therefore, to gain closest academic understanding of the use context, literature from the Quantified Self domain should be examined. Several studies perform research to discover motivations in the QS domain. Epstein et al. (2015) found that there are three initial motivations for tracking: the desire to change behavior, rewards or social engagement, and curiosity regarding data and habits [8]. Li et al. (2010) discovered that reasons for collecting and reflecting personal information are: 'natural curiosity, interest in data, discovery of new tools, suggestion from another person, and trigger events' [11]. Rooksby et al. (2014) noticed that there are different styles of tracking: directive tracking (goal-driven), documentary tracking (only documenting activities),

diagnostic tracking (finding links between things), collecting rewards, and fetishized tracking (interest in the gadget/technology) [24]. Choe et al. (2014) classify Q-Selfers' motivations to track into three main categories: to improve health, to improve other aspects of life, and to find new life experiences [4].

Quantified Pet

While activity trackers for the QS domain are most often presented as wearable devices to be worn on one's wrist, activity trackers for the QP domain are designed to be attached to the pet's collar. These collar devices have an integrated accelerometer that collects data of the pet's movements. The motion data is analyzed by self-learning algorithms and compared to a (self-established) database consisting of breed-specific movement patterns. This analysis enables to distinguish movements such as resting, walking, running, and even more complicated behavior, such as playing. All this data retrieved by the device is transferred to an application installed on the pet owner's smartphone, where the owner can view, explore and monitor the retrieved data. Communication between the smartphone and the collar device is established via Bluetooth. In addition to automated activity tracking, most activity trackers also enable the user to manually log information in the application that the tracker is not able to detect, such as logging meals and medication. Some pet activity trackers also have a built-in GPS system or cellular technology that enables real-time tracking of the pet's location.

Research within the QP domain focuses on the impact the pet activity tracker has on the owner and the human-pet relationship. Nelson and Shih (2017) propose *CompanionViz*, 'a personal information visualization prototype that is designed to inform pet owners on their dog's caloric input/output, as well as exercise and movement habits' [14]. Through a use case study, the authors found that monitoring the dog's activity and health leads to increased awareness on the dog's health, habits and needs; motivation to act upon the dog's need and health requirements; and curiosity towards data change over time. Mancini et al. (2012) examined how tracking a dog's position impacts the human-dog relationship [12]. The authors found that reasons for tracking dogs are that it enables dog owners to protect and care for their dog better and that it supports in reassuring their dog's safety. Other than being notified on the dog's location, they found that dog owners use information provided by the tracker to anticipate the dog's actions and provide feedback to the dog on its behavior.

Research Question and Purpose

The purpose of this study is to examine the human users in the Quantified Pet domain and their corresponding design requirements for application design. Furthermore, it examines how to translate these requirements to an application design that suits the needs of these users. Throughout, the research follows a User Centered Design method.

The research question is *'How can a useful application for the Quantified Pet domain be designed by making use of a User Centered Design approach?'*.

METHOD

As mentioned in *Theory and Related Research* the User-Centered Design process consists of four phases that function as the guidelines of the research. The first UCD Phase, Specifying the context of use, is supported by research towards the human-pet relationship, research towards the usage of activity trackers and persona design. Qualitative data retrieved from user studies is thematically analyzed via an inductive approach [3]. The second phase, Requirements specification, derives design requirements resulting from the persona design and a heuristic evaluation on activity trackers. Phase three, Design solution, specifies the design that stems from the requirements. Phase four, Usability testing, evaluates the application design.

Ethics

As the User Centered Design approach emphasizes the central role of the user, several user studies are conducted. It is important to ensure the privacy of the participants and to involve them in the studies with full consent. Before each user study, participants are asked for their consent on the data gathering. The data of all participants for all user studies is either gathered anonymously or anonymized.

UCD PHASE 1: SPECIFYING CONTEXT OF USE

Specifying the context of use requires an extensive analysis of the behavior, motivation, and situation of the (potential) users.

User Study 1: Human-Pet Relationship

QP applications aim to provide the user with insights in their pets' behavior and wellbeing. Therefore, it is important to examine how dog owners currently interact with their dog and how they gain awareness on their needs and wellbeing. To understand the basics of the Context of Use, this pure human-pet relationship, without interference of technology, is studied. In the form of a qualitive user study, structured interviews were held via phone or Skype. The goal of this research was to gain understanding in the inner drivers that form the human-pet relationship. The participants were gathered via convenience sampling by requesting all interested and available dog owners within the researcher's network to participate in the research. In total, five people (3 females, 2 males) participated in the interview, on average being 32 years old. Three participants carry the Swedish nationality, two the Dutch nationality.

Performing a thematic analysis on the data brings up three inner drivers that trigger human-pet interaction: habits, love and guilt. The participants' habits trigger performing routine-based activities, such as feeding. Their love for their dog is the emotion that drives most interaction initiated by the participants themselves. Closely connected to love is guilt, an emotion that is triggered when not being able to cater to the dog's needs as desired, for example when leaving the dog

alone at home for a longer period of time. Guilt is often followed-up by an intensified expression of attention.

A very prevalent phenomenon throughout is that, concerning their dog's wellbeing, all participants indicate that they mainly judge their dog's wellbeing based on observations and estimations. They observe their dog's behavior and estimate if they spot any changes over time. This leads to them *thinking* they see changes in behavior, *thinking* their dog shows different activity levels, and *thinking* their dog is healthy, without having data to verify these thoughts. Subjective observations and estimations are leading in judging their dog's needs and health. As a consequence, all participants express an uncertainty in not knowing if they are delivering to their dog's needs and therefore, not always feeling that they are good dog owners. For this reason, they all see an added value in quantifying their pet, as this would provide them with verified knowledge on their behavior and the ability to use this consciousness to cater for their dogs' needs in a better way.

User Study 2: Usage of Activity Trackers

To gain understanding in what motivates dog owners to use an activity tracker for their pet and what sustains this usage, a second (anonymous) pilot user study, has been performed through the means of an online questionnaire. This survey targets users of two existing products for the QP domain: FitBark and PitPat. Both activity trackers inform the users in real-time about their dog's activities (such as being active, playing, or resting) and their health (calculated on behalf of the activity levels), and enable them to see their dog's own statistics and comparing this data to other dogs.

To targets real users, a post was placed to advertise the research and to request for participants in the informal Facebook group of FitBark users, called *FitBark Friends*, and the verified Facebook community of PitPat. The participants were gathered via convenience sampling, meaning that all those interested and available could click the link to the online questionnaire. In total, 104 people (87 females, 16 males, 1 'other') participated in the questionnaire, on average being 39 years old. 89 participants use a FitBark, divided in 68 participants using FitBark 1 and 21 participants using FitBark 2. 13 participants use a PitPat. 2 participants answered this question invalidly, making their data unusable and are therefore left out of consideration in this question. On average, participants have been using their pet activity tracker for 13 months.

In addition to introductory demographic questions, the questionnaire consists of four open-ended questions and five multiple-choice questions. All interview questions are listed in Appendix A. The open-ended questions are thematically analyzed via an inductive approach for identifying patterns and themes within the data without trying to fit the coding in a pre-determined coding frame [3].

This extensive dataset requires the first phase of the thematic analysis to consist of studying the data to become familiar with it and to get an overall idea of potential patterns. To get a grip of the data, the answers to the questions (typically formulated as lengthy sentences) are shortened down to (multiple) characteristics that express a compressed version of the main message and ease the coding process that follows. These characteristics are systematically coded and grouped into categories. The coded categories are gathered in comprehensive themes. In total, 80 categories are coded and collated to 23 themes.

The open-ended questions and the top 3 of most occurring thematically coded answers, including their occurrence, are:

1. *What was your motivation to buy your activity tracker?*

Activities: 31% *(57)*, Health*:* 27% *(48)*, Compare data: 7,7% *(14)*.

2. *What is/was your reason(s) for collecting information of your pet?*

Health: 52% *(97)*, Activities: 23% *(43)*, Fun: 5,9% *(11)*.

3. *What do you love most about tracking your pet?*

Activities: 39% *(59)*, Health: 9,9% *(15)*, Goals: 9,9% *(15)*.

4. *What keeps you motivated to continue tracking your pet?*

Health: 36,6% *(52)*, Personal: 12% *(17)*, Activities: 6,3% *(9)*.

The data shows that the themes *Activities* and *Health* are by far the most mentioned themes for question 1 and 2, and still individually dominate the first position in question 3 and 4. All answers to the open-ended questions and supporting theme explanations are provided in Appendix B.

The *Activities* theme implies interest in specifics of the activity data that provides general information of the dog's behavior. Categories in this theme are: activity levels, details of activities, and activities of the dog when being absent/when taken care of by others. *Health* is about using the activity tracker to improve and ensure the dog's health for sustaining a healthy lifestyle and expresses an interest in all related activity data. Examples of categories in *Health* are: providing the correct amount of exercise, monitoring health, weight, and calorie burn. *Compare data* entails the ability of the activity tracker to compare data and has categories such as comparing data tracker to other dogs, to the dog's own data of other moments in time, and even to the owner's data that has a compatible tracking device. *Fun* is a category and theme that altogether concerns the fun participants experience when using the activity tracker. *Goals* follows from the ability of the application to show the activity data in the form of goals and has subsequent categories as (non)achieving goals, breaking goals and obtaining streaks with the activity data. *Personal* concerns reasoning that directly relates to and reflects on the owner and his/her responsibilities, with categories such as: being kept accountable for fulfilling the dog's needs, maintaining a personal healthy lifestyle, and love for the dog.

The multiple-choice questions are based on research performed in the QS domain and aim to verify similarities or differences in the motivation and reasoning of tracking information of a pet. These verifications stem from the work on the motivations for tracking found by Epstein et al. (2015) and Choe et al. (2014) [8][4], reasons for collecting and reflecting information discovered by Li et al. (2010) [11], and styles of tracking noticed by Rooksby et al. (2014) [24]. A visualization of the results is also provided in Appendix B.

Persona Design

As mentioned, the themes *Activities* and *Health* are dominantly portraited by being mentioned most often and exceeding all other themes greatly.

When taking a closer look at the *Health* theme and the corresponding subcategories, it exposes that this theme highly relies on the details of the *Activities* theme. Logically, subcategories, such as 'losing weight' and 'providing the correct amount of exercise' directly relate to the dog's activities. *Activities* subcategories such as 'activity levels' and 'tracking activity information' provide information on the dog's activities that impact the establishment of the dog's health. The *Health* information is based on an analysis performed on the retrieved data from the activity tracker, mainly considering activity data. Therefore, the *Health* theme is a theme on its own but is built by information resulting from the *Activities* theme. Consequently, it cannot be stated that participants that indicated that they find *Health* the most important theme throughout, are not interested in or triggered by *Activities* information. *Health* is the main driver, but *Activities* goes hand in hand with it.

However, the *Activities* theme does not necessarily have to overlap with the *Health* theme and can also stand on its own. Many participants indeed mentioned both themes alongside, but there is also a group of participants that only answered according to the *Activities* theme and never mentioned *Health*. Taking a closer look at these participants points out that this group uses the activity tracker for performing activities together with the dog, connecting the owner's activity tracker and comparing data, and gaining insights in the dog's activities while being absent. These participants separate themselves and form a standalone group highlighting specific interest in activities only.

This introduces the foundation for two personas. Persona 1, *Health Guru*, finds *Health* most important and is guided by *Activities* information. Persona 2, *Data Enthusiast*, is solely interested in *Activities* information. Accordingly, the characteristics, needs and goals of both personas are presented in Table 1 *Persona Design: Health Guru* and Table 2 *Persona Design: Data Enthusiast.*

Miaskiewicz and Kozar (2011) explain how describing a persona serves two goals [13]. The persona design of this research focusses and elaborates on the second goal, 'providing information concerning the persona's needs and personal goals in the context of the product being designed'.

Table 1 Persona Design: Health Guru

Health Guru
Triggered by: - Getting the dog to a healthy weight - Providing the dog with the correct amount of exercise - Tracking activities and seeing the dog's activity levels - Getting motivation to become more active
Favorite tracking properties: - Knowing what the dog is doing when being absent - Achieving goals - Seeing the dog's activity levels - Getting motivation to become more active
Goals: - Having a healthy dog - Providing the dog with the correct amount of exercise - Maintaining the dog's weight, reaching a healthy weight - Maintaining the dog's health and monitoring threatening changes

Table 2 Persona Design: Data Enthusiast

Data Enthusiast
Triggered by: - The curiosity to see and track activity data - Tracking the dog's activities - The compatibility of one's own activity tracker to the dog's activity tracker
Favorite tracking properties: - Knowing what the dog is doing when being absent - Tracking activities during the day - Seeing detailed information and specifics for all tracked activities
Goals: - Competing and scoring points in the competitive environment of the application - Redeeming the curiosity of seeing and understanding the dog's activity data - Gaining insights in the dog's activity data - Having fun with the application

UCD PHASE 2: REQUIREMENT SPECIFICATION

Following from the first UCD phase are the personas that describe the needs of the users and provide the foundation for specifying the design requirements for the QP application. In addition to listing requirements from personas, a heuristic evaluation is performed to detect usability problems on an existing application and to list design requirements for new application design accordingly.

Requirements from Persona Design

The persona design from UCD Phase 1 reveals that the personas differ from each other and have minimum similarities. It is cumbersome to create a design solution that serves the needs of both personas. Therefore, the personas must be prioritized for determining the primary design target. The primary persona is selected on behalf of being able to completely satisfy its needs and goals without dissatisfying any of the other personas [5]. Putting this in the perspective

of both personas and how they are established, persona 2 addresses parts of persona 1 but will only succeed partially in satisfying the needs and goals of persona 1, since it is missing out on health-related information that's crucial to persona 1. Persona 1 does however portraits activity information, hereby satisfying almost all needs and goals of persona 2 but builds on this by adding an additional health perspective. The needs of Persona 1 subsume the needs of Persona 2. Making persona 1 the primary persona will lead to satisfying the needs and goals of persona 1 and is the best trade-off in satisfying the needs of the other persona. Additionally, the largest part of the researched community (76%) is represented by the health persona.

Specifying the requirements resulting from persona design leads to requirements that concern the functionalities of an application for the QP domain, derived from the needs and goals of Persona 1. The functional requirements are:

The application must

1. Provide information on the dog's activities.
2. Provide information on the dog's health.
3. Provide a tool to compare the dog's activity/health data to other moments in time (days/weeks/months).
4. Provide a tool to compare the dog's activity/health data to the data of a 'healthy' dog, enabling the user to determine if the current behavior patterns resemble healthy patterns.
5. Provide a tool to log and track weight data.
6. Enable the user to determine the status of the dog's health and activity levels with at one glance.
7. Portrait activity and/or health data relative to goals (enabling goal achievement).

Requirements from Heuristic Evaluation: FitBark + PitPat

Evaluating existing interfaces helps to establish design requirements that could have been missed by requirements following from personas. The goal of this evaluation is to gain insight in the components and aesthetics of a QP application and corresponding design requirements for increased usability. A heuristic evaluation is performed on one of the most notable products in the pet activity tracker industry, FitBark (also used by 85% of the participants from *User Study 2*) [28]. Other pet activity trackers were left out of consideration due to the scope of the project. The researcher of this study performs as the UX expert that conducts the heuristic evaluation.

The application is evaluated statically, meaning that all individual screens of the application are printed out on paper, leaving the focus completely on the aesthetics part of the usability. Therefore, all heuristics that require evaluating the application in a dynamic, interactive form (user control and freedom, error prevention, flexibility and efficiency of use, manage errors, and help and documentation) are left out of consideration in this evaluation. All screens of FitBarks application are judged on their compliance with the following heuristics: visibility of system status (informing the user about progress and process of action); match between system and the real world (design systems based on familiar ideas and concepts); consistency and standards (keep consistency within the system); recognition rather than recall (make objects, actions, and options visible); and aesthetic and minimalist design (balance between good looks and good functionality). The findings are summarized and listed per heuristic in Appendix C.

The (non-)compliance of FitBark's application to the proposed heuristics provides valuable information for establishing design requirements for QP application design.

The application must

8. Support visualizations with color coding or textual explanations, leading to a good transfer of data to the user. Good color coding or textual guidance leaves no room for misinterpretation.
9. Use consistent and accurate color coding throughout for preventing confusion of meaning and misinterpretation. Conflicts in color coding are never allowed.
10. Provide options to minimize the complexity of the visualization without decreasing the efficiency of use. Options secure user customization but also secure a minimalistic design.
11. Provide a tool that supports comparison of data in graph visualizations.

UCD PHASE 3: DESIGN SOLUTION

As *Health Guru* is found to be the primary persona, this is the focus for the design solution of the application design. As shown by FitBark, a QP application can have a distinction in functionalities of their screens, being informative screens and social connectivity screens. When examining the *Health Guru's* persona, it illustrates that this persona has the focus on the informative side of the application that provides insights in the information retrieved by the tracker. To suit the needs of this persona better, this application design focuses on the informative pages and information visualization, rather than on pages for social connectivity.

Resulting from the functional and design requirements, an application is designed using Sketch. For the simplicity of this application design, it has been chosen to narrow the number of screens down to the minimum number of screens that still support all requirements and that provide enough context to evaluate the success of this implementation. The functional requirements express the need for at least three screens: a home/overview screen, an activity information screen, and a health information screen. To support navigating through the application to other moments in time and to provide more context on how activity/health information is displayed, the number of screens is expanded to 5 screens: two for both activity and health information. *Figures 1 till 5* show the screens for the application design. Appendix D shows an enlarged visualization of the screens, as well as the reasoning behind the design choices and implementation of the requirements. Appendix E visualizes the navigation paths between the screens by showing the corresponding wireframes.

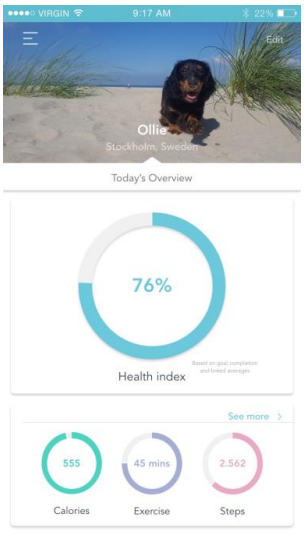

Figure 1 Home Screen

Figure 2 Today's Activities

Figure 3 This Week's Activities

Figure 4 Today's Health

Figure 5 This Month's Health

UCD PHASE 4: USABILITY TESTING

The implementation of the design requirements in the prototype is evaluated by means of quantitative and qualitative testing, to assess task completion performance and to identify the ease of use, liking, and implementation of proposed design features and requirements. Participants perform a task list and fill in a questionnaire as means of quantitative testing. Furthermore, they partake in a semi-structured interview for qualitative testing. To ensure the data quality and prevent information loss, the statements in the questionnaire consist of a 5-point Likert scale [22]. Throughout, participants reflect on their experience with the application via the think-aloud method [27]. With this method, participants think aloud as they are performing the set of tasks and provide feedback by verbalizing their thoughts. They are stimulated to express everything that comes to mind while performing the tasks and interacting with the application.

Participants

The participants were gathered via convenience sampling by making use of the researcher's social network. Also, a post was placed to advertise the research and to request for participants in the informal in two informal Facebook groups of residents in Stockholm; *Lappis* and *Nederlanders in Stockholm*. In total, 10 people (7 female, 3 male) participated in the usability testing of the proposed design for the QP application, with an average age of 32 years. Nationalities vary from Swedish (3), Dutch (5), Turkish (1) to American (1). All participants are dog owners and potential users of pet activity trackers. Unfortunately, it was not possible to assess the application with actual users. Many of these users are based in the United States, requiring remote user testing via Skype that impacts the assessment of the interface interaction, dynamic verification and overall evaluation.

Setup

First, the participants are introduced to the Quantified Pet phenomenon and pet activity trackers, together with an explanation of the technology that enables the tracking and distinguishes the behavioral patterns. The actual user test consists out of three elements. After an introduction to the application and providing the necessary context, the participants are asked to perform six tasks, each of them read out loud to the participants after completing the previous one. The task list is followed up by a semi-structured interview. In this interview, all five screens of the application are discussed sequentially for gaining feedback on the participant's opinion and satisfaction regarding the interface design and usability of the application. The usability testing concludes with a questionnaire consisting of 8 statements to which the participants indicate their corresponding level of agreement.

Task List

The participants are instructed to complete six tasks (presented below) after being read to them out loud. The goal

of the task list is to determine if the intended navigational path is followed by the participants and to expose alternative routes. Therefore, the metric for task completion is their chosen route for task accomplishment. Additionally, usability problems and design flaws brought up by the participants via the think-aloud method are noted and discussed in the semi-structured interview and presented in these results. A visualization of the intended and alternative navigational paths is provided in Appendix E.

1. *Find how much the dog has played today.*

Intended route: Press 'See more'.

Outcome: All participants pressed either exercise or steps. None pressed 'see more', as was originally intended.

2. *Find the number of steps taken on Saturday.*

Intended route: Press 'This week'.

Outcome: Five participants used the intended route, four participants used an alternative route and pressed 'Steps'. One participant pressed the 'Back' button, got stuck on the *Home Screen* where he could not find his way out and eventually needed clues to complete the task.

3. *Go back to Today's Activities.*

Intended route: Press 'Today'.

Outcome: Seven participants pressed 'Today', three participants pressed the 'Back' button to return to the previous page, *Today's Activities*.

4. *Find the number of calories for today.*

Intended route: Press 'Health'.

Outcome: Seven participants used the intended route. Two participants pressed the 'Back' button twice to return to the *Home Screen*, where the calories are listed as well. One participant first pressed 'Activities', then pressed 'Health' to find the calories listed there.

5. *Find what the dog's weight was 10 days ago.*

Intended route: Press 'this month'

Outcome: Four participants pressed 'This month', four other participants pressed 'Weight'. The two participants that returned to the *Home* Screen in task 4 started their route here as well and both went back to 'Activities'. Here both pressed 'Health' and 'Weight' (one after pressing 'Activities' very often). They declared that they got in navigational trouble by not knowing where to find the dog's weight on this screen.

6. *Go back to Today's Health.*

Intended route: Press 'Today'.

Outcome: Seven participants pressed 'Today', one participant pressed 'Health', and one participant pressed the 'Back' button. One participant pressed 'Calories', knowing that this was shown on *Today's Health*.

Conclusion

The data shows that for Task 1, none of the participants were triggered to press 'See more' for revealing more information on the information presented in the circles on the *Home Screen*. The participants explained to have pressed either 'Exercise' or 'Steps' because this comes closest to their assigned task, therefore expecting that pressing this would provide more (and hopefully the desired) information.

It appeared that participants do not always use the intended navigation path for Task 2 and Task 5. Originally, the application was designed to assist the user in navigating by creating tabs in the header that expose the user to the available options. This navigation focusses on navigating through 'time' by using the headers and requires the user to press the desired timeframe (this week/month) for more information. However, four participants appeared to navigate by 'activity information' (steps/weight). When given the task to expose more information on a specific activity, these four participants navigated here by pressing on the activity on which detailed information is desired. The participants mentioned they were driven by the expectation that pressing a specific activity would provide more information on that activity, whereas pressing a timeframe could also provide additional information belonging to that timeframe.

The 'Back' button is used as an alternative means for navigating back to the previous page in Task 3, 4, and 6. Participants using this button stated that they remembered the information shown on the screens previously seen and that pressing the 'Back' button felt as a natural means for navigating back here quickly and easily, especially when the information was shown on the previous page.

Semi-structured Interview

The semi-structured interview aims to expose other usability problems and design flaws than brought up by the task list performance. The participants are asked to express feedback concerning their liking and understanding of the components for each screen. The extensive version of the feedback is gathered and listed per screen in Appendix F.

The design is experienced as minimalistic and aesthetically pleasing by most of the participants. The header on the *Home Screen* is perceived as welcoming and pleasant. Most participants understand the information presented in the boxes and are satisfied with the given context. All graphs, except for 'Activity timeline', are clear and understood well.

The font size and button sizes are too small for comfortable interaction. Also, the color of 'Sleep quality' is advised to be adjusted to better fit the color palette. A recommendation is to adjust the positioning of the information in the boxes to better take advantage of the offered design space.

Few participants expressed confusion on the distinction between exercising and playing and found these to be overlapping. They prefer to see more context on this division. Similar, some participants wondered to which extent and intensity resting is monitored and likewise preferred more context here. Also lacking context is 'Calories', where one participant expressed lack of context targeting calorie consumption or expenditure. Unclarity arises concerning the 'Health index' and 'Sleep quality'.

Many participants remain confused on how both are calculated/determined by lack of explanation and guidance in the design. Both require more context for successful interpretation, which could be subject of implementation in a future design, for example when pressing the items.

Unfortunately, all participants misinterpreted the activity timeline to be a stacked visualization of activities per hour. After pointing out that it is an activity timeline, almost all participants understood this and could decode it well. It is often suggested to change the graph visualization of 'Weight' to a line graph, as the current visualization is chaotic and difficult to read. A similar suggestion is given for the 'Calories' graph, to satisfy the overall simplicity and aesthetics.

Questionnaire

To verify the extent to which the design requirements are successfully implemented, the seven requirements from the persona design are translated into statements to which participants indicate their level of agreement in the questionnaire. A statement that assesses the participants' satisfaction on the design is added to this. Visualizations of all answers to the statements are provided in Appendix G.

To calculate the mean and standard deviation of the participants' answers, the answers are assigned with the value that corresponds to their position on the Likert scale. For example, strongly disagree is equal to 1, strongly agree is equal to 5.

1. *This application provides information on my dog's activities.*

Mean = 4,7 (Strongly agree) | Standard deviation = 0,48.

2. *This application provides information on my dog's health.*

Mean = 4,1 (Agree) | Standard deviation = 0,57.

3. *This application enables me to compare my dog's data to other moments in time (days/weeks/months).*

Mean = 4,8 (Strongly agree) | Standard deviation = 0,42.

4. *This application enables me to compare my dog's data to data of another 'comparable' dog.*

Mean = 3,6 (Agree) | Standard deviation = 1,17.

5. *This application enables me to log and track my dog's weight.*

Mean = 4,4 (Agree) | Standard deviation = 0,97.

6. *This application provides information on completing and/or achieving activity/health goals.*

Mean = 3,4 (Neither (dis)agree)) | Standard deviation = 1,07.

7. *The overview page of the application enables me to quickly determine the status of my dog's health and activity levels.*

Mean = 4,4 (Agree) | Standard deviation = 0,52.

8. *I am satisfied with the design of the application.*

Mean = 3,5 (Moderately satisfied/Very satisfied), Standard deviation = 0,85.

What can be derived from the questionnaire is that the majority of the requirements are successfully implemented in this application design. However, the application is not convincing in providing information on completing and/or achieving activity/health goals. Also, some disagreement appears to be presents towards the ability of the application to enable comparing the dog's data to other comparable dogs. The mean shows that just barely, participants agree with this statement. This is caused by a widespread diversity, reflected in the standard deviation, by a majority of five participants agreeing and two strongly agreeing, but also three participants disagreeing.

DISCUSSION

Research question

While the research question targets the design of a useful application for the Quantified Pet domain by making use of a User Centered Design approach, it does not cover the research that preceded this. Therefore, this question does not cover all elements of this study and has been established too narrow. Next to the application design, this study has put great emphasis on the examination of the users and personas in this domain, who are not covered in the research question. Also, this study examined and listed design requirements for QP applications, that provide the crucial foundation for the application design. Therefore, the research question should be expanded with sub-questions that address the covered material in this study. Example of sub-questions could be:

- *What are the characteristics of personas operating in the Quantified Pet domain?*
- *What are leading design requirements for application design in the Quantified Pet domain?*

Specifying the Context of Use

As a great number of experienced users participated in the pilot user study's questionnaire, over 85% of the answers originated from FitBark users. Therefore, the first phase of the UCD process, Specifying the Context of Use, could have been biased and impacted by the data collection of only two user groups. Following from this data, requirements were specified through means of persona design as being part of the second UCD phase. There is a chance that the persona design is an incomplete representation of the typical Quantified Pet user and potentially missing out on some characteristics. For future research, it is interesting to examine users from other applications. There are many QP applications that differ in functionalities, attracting users with different purposes. Consequently, this could lead to potentially establishing different personas or verifying the two prominent personas as mentioned in this research.

As the thematical analysis on the questionnaire data has only being performed by one person, misinterpretations could have been made, leading to potentially incorrectly coding the categories and themes. However, for this research it is unlikely to have a visible impact on the thematic analysis as the analysis took over three weeks to be completed and clear, distinctive patterns were visible.

Heuristic Evaluation

Other requirements were established by performing a heuristic evaluation that, even though argued, has only been performed on one application; FitBark. Therefore, there is a chance that some usability problems for QP applications have not been detected and are missed out in the design requirements. The design requirements following from this evaluation seem to be widely applicable to all QP applications and therefore do not indicate any important requirements missing by this narrowed heuristic evaluation. For future research it would be valuable to perform a heuristic evaluation on one or more QP applications to determine if any design requirements can be added to the established ones from this research.

Design Solution

The usability testing provided a lot of feedback on the design and exposed design flaws that should have been detected while still being in the design phase. A limitation is that it would have been of great added value if this phase had contained a small pre-test for verifying the design choices as first round of usability testing. This would have led to an early detection of flaws in graph visualization, color pallets, font and button sizes, and a better implementation of the design requirements. Due to time constraints, this fell out of the scope for this research. Naturally, future work would imply a more iterative approach containing at least one additional usability test to detect early usability problems.

The focus could have been too much on implementing the persona requirements and too little on the design requirements following from the heuristic evaluation. The heuristic evaluation provides material to learn from the successes and failures of FitBark and could well have dismissed current design flaws made in the design phase. The design solution provides limited explanation on important topics that potential users are unfamiliar with, such as *Health Index* and *Sleep quality*. The limitation of only using five screens for this usability test caused the participants, as expressed by themselves, to feel that they missed 'set-up' information. For future work, it would be advised to design a 'installation guide' that users would see when installing the application. This would provide them with information on the features, educating the user, without requiring disturbing the design with permanent explanations in the application.

Two requirements following from the persona design are: providing a tool to compare the data to other dogs and enabling goal achievement. Intentionally, it was decided to implement these two requirements in a subtler manner, as they appeared to be a less dominant characteristic of the chosen persona. However, this turned out to be too subtle. Participants did not get enough satisfaction from the simplicity of this implementation. They prefer to set their own goals, which is not supported in this design. They also prefer to put more emphasis on comparing data to other dogs. All in all, as concluded by the results from the data, the chosen design strategy of a refined goal implementation did not adhere to the listed requirements enough. This research examined if this approach to goals and data comparison could satisfy the user and it appeared to be unsuccessful. Future work can build upon these lessons when examining the design of features for similar purposes.

Usability Testing

Limitations in both the design solution and the evaluation are reflected in the incomplete visualization of the activity timeline that impacts the evaluation of this functionality. In the screen *Today's Activities*, the activity timeline has three bars that show when the dog performed which activity. Unintentionally, the bars only visualize one of each activity per bar, rather than an activity frequently occurring per hour. If the bars would consist of repetitive color blocks, resembling a realistic situation where an activity occurs frequently, interfering with other activities, participants might have understood this by themselves. This has not been tested properly in this usability test. Even though all participants understood the intention after explaining, it is unclear if they could have understood it by themselves from an accurate visualization. Therefore, the usability test cannot determine if this experimental visualization of an activity timeline is successful in its purpose. An improvement on this visualization as suggested is valuable for future work.

Future Work

All sections mentioned above in the *Discussion* provide suggestions for future work that build on methods and design strategies as presented in this research. The proposed design solution is subject of a second iteration in future work, based on the feedback of the participants from the usability test. The feedback consists of two parts; feedback focusing on improving the design and feedback focusing on improving the functionalities of the QP application.

The screens in Appendix H suggest an improved version of the design solution with the design feedback from the participants implemented. This optimization includes improvements such as: improved bar visualizations, increased font size, improved header buttons, and so on. This improved design solution provides a clean base to implement the other functional features as suggested below.

Improvements of functionalities for a QP application as suggested by the participants focusses on features that increase the dynamics of the application. To prevent misunderstanding, participants advise to expose more information on the establishment and retrieval of data for the 'Health index', 'Sleep quality', and 'Exercise' via the implementation of a new screen or lay-over when being pressed. Graphs can be made dynamic by gradually exposing information when opening the screen or made interactive by highlighting bars of the graph that are pressed (and greying out others) for emphasizing particular information. Lastly, interesting and funny informative facts can be added throughout when pressing and examining application features. All abovementioned features can be examined as regards to the extent to which they succeed to increase the

participants' satisfaction of the design. An additional feature proposed by participants is a logging diary that enables the user to choose the purpose of logging. It would be interesting to examine for which purposes they would log, and which design format would support this the most.

For the evaluation, examining the implementation of these features in a fully functional prototype would be of great added value, as it would support exposing the extent to which the application design is adhering to the design and functional requirements as suggested by the potential users. It would be valuable if the participants would not only consist of potential users, but also of existing users. This would involve a user group with experience who can provide input for adding features that are of verified added value to them. This would bring the application design one step closer to a launch of an interface design that caters to the users' needs.

CONCLUSION

With the rising popularity of the Quantified Pet domain, still many aspects remain undiscovered. This study touched upon this by focusing on the design of an application for the Quantified Pet domain, in specific targeting application design for tracking dog's activities.

The research question this study set out to answer was: *'How can an application for the Quantified Pet domain be designed by making use of a User Centered Design approach?'*.

This study examined the human-pet relationship and found that there are three inner drivers that trigger the human-dog interaction: habits, love and guilt. By evaluating 104 users of two Quantified Pet applications, this research examined users in the QP domain and established their motivations for (a sustained) usage of a pet activity tracker. A thematical analysis on this data provided insights on the patterns and themes that characterize QP application users. It appeared that the themes *Activities*, a specific interest in activity data with information on the dog's behavior and *Health*, activity data contributing to improving and ensuring the dog's health for a sustained healthy lifestyle, are the dominating information drivers that trigger and sustain the usage of an activity tracker. When taking a closer look at both themes, it was found that participants that indicated *Health* to be the most important theme throughout, are also interested in or triggered by *Activities* information. *Health* is the main driver, but *Activities* goes hand in hand with it. However, participants interested in *Activities* do not necessarily overlap with *Health* and can form a standalone group with specific interest in activities only. To get a grip on their corresponding requirements, persona design was used as a mediating tool for shaping the requirements and for facilitating in the creative process of design decisions and visualizations. The *Activities* and *Health* theme formed the foundation for establishing two personas, of which the *Health* persona was found to be the primary design target for this research, by being able to satisfy its needs and goals without dissatisfying the *Activities* persona, and by being represented by the 76% of the research community.

The persona design established the characteristics and needs of the persona by listing what (s)he is triggered by, what his/her favorite tracking properties are and what his/her goals are. The persona sketched how the *Health Guru* is eager to provide the dog with the correct amount of exercise, to see the dog's activity levels and to reach a healthy weight. From these characteristics followed a set of user requirements that supported these accordingly, such as: providing a tool to log and track weight and providing a tool to compare data to other moments in time (days/weeks/months). To complete the requirements specification, a heuristic evaluation was performed on one of the most notable products in the pet activity tracker industry, FitBark, for setting additional design requirements. The heuristic evaluation judged the (non-)compliance of FitBark's application to five heuristics: visibility of system status; match between system and the real world; consistency and standards; recognition rather than recall; and aesthetic and minimalist design. This led to the establishment of design requirements expressing the importance of color coding, textual explanations, options to minimize complexity and a tool for comparison of data.

These requirements were implemented in a basic application design and proposed as a design solution. For evaluating the design solution, the success of the implementation of the requirements, and the satisfaction towards the design, a usability test was held amongst 10 participants consisting of three elements: a task list, a semi-structured interview, and a questionnaire. Results from the usability test revealed that overall, participants liked the simplicity of the design and experienced the information transferring as pleasant and effective. However, many small design flaws, such as a small font size and small buttons, were also pinpointed out and suggestions for improvement were given. Assessing the satisfaction towards design of the application revealed that, participants saw potential and were on average, moderately to very satisfied with the proposed design.

This research showed possible approaches to the four main activities characterizing the UCD process. There lies great potential in examining this further by exploring the proposed future work. This study contributes to research by examining users in the QP domain and extracting personas with corresponding requirements accordingly, which can be used for further research in this domain.

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APPENDIX A: QUESTIONS USER STUDY 1

General

1. What is your name?
2. What is your age?
3. What is your nationality?
4. Where do you live?
5. How many dogs do you have?
6. What breed of dog(s)?
7. With how many people do take care of your dog(s)?
8. What does the environment around your household look like? Can you describe the infrastructure around your house? E.g. parks, backyard, etc.

Interaction

9. What does your daily interaction with your dog look like? Take me on your daily routine from getting up to going to bed. (what do you do when you get up/get home/before you go to bed/etc.)
10. To sum up: What are the activities you perform with your dog(s)?
11. At what moment of the day do you mainly perform these activities?
12. How much time do you spend on the activities in total?
13. What triggers you to perform these activities?
14. Why do you perform these activities in particular? (are there any other dog activities that you intentionally don't perform?)

Time alone

15. How many hours per day do your dogs spend alone at home?
16. When you're not at home, can you grasp upon what your dog(s) is/are doing? What do you think this is?
17. When you are away from home, do you think about your dog(s)? Why? When?

Needs

On a daily base…

18. Do you think your dog(s) is/are exercising enough? Why?
19. Do you think your dog(s) is/are playing enough? Why?
20. Do you think your dog(s) is/are healthy? Why?
21. Do you think you're delivering to your dog(s)' needs?

Personal

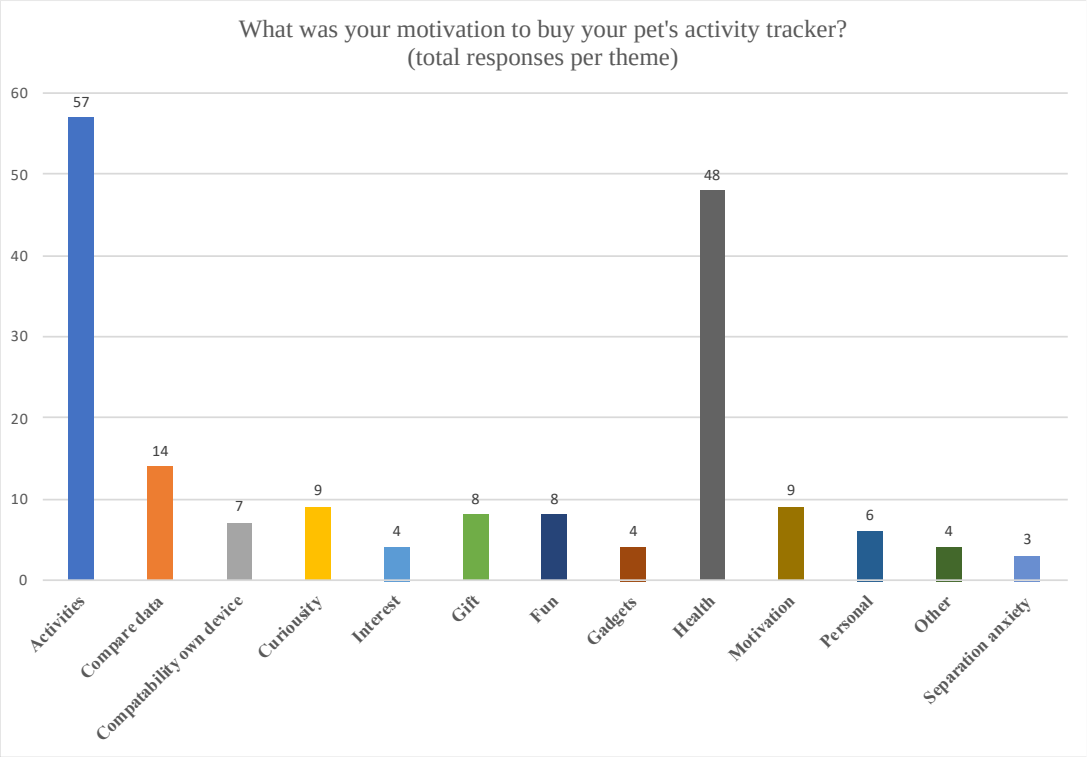
22. What does a healthy dog and happy dog mean to you? How do you perceive this?
23. What do you think your dog(s)' (daily) needs are?
24. Can you pinpoint the pains/struggles you're experiencing concerning having (a) dog(s) and taking care of (a) dog(s)?
25. Do you think you are a good dog owner? Why?
26. Do you think your dog(s) is/are happy? Why?

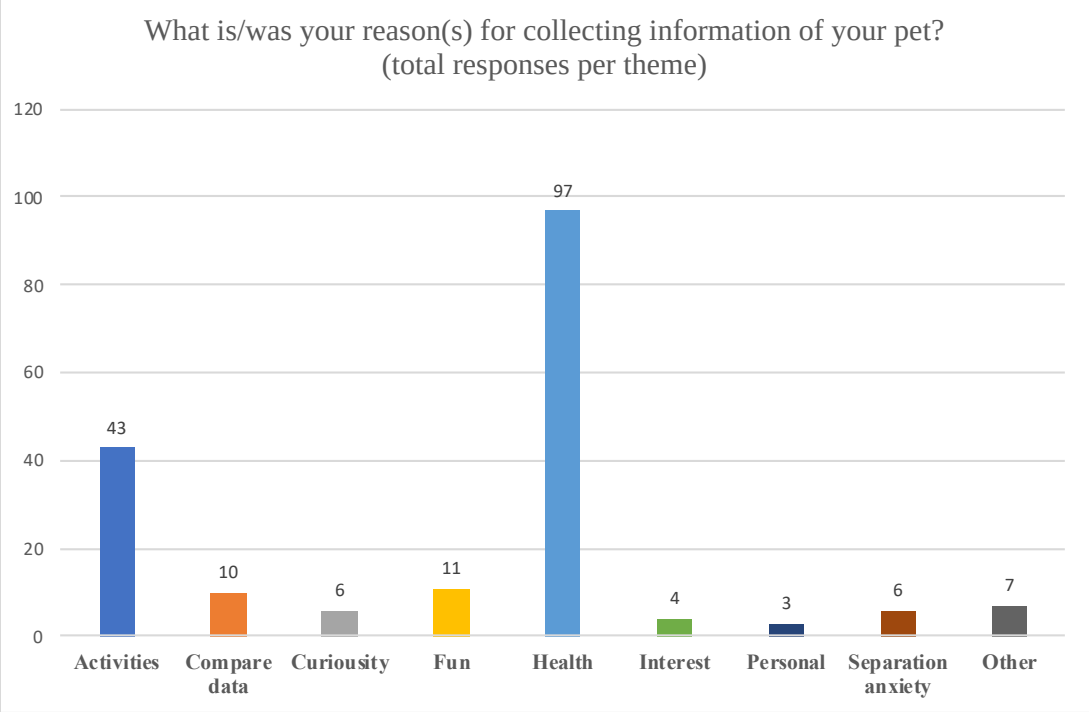
Quantification of your dog

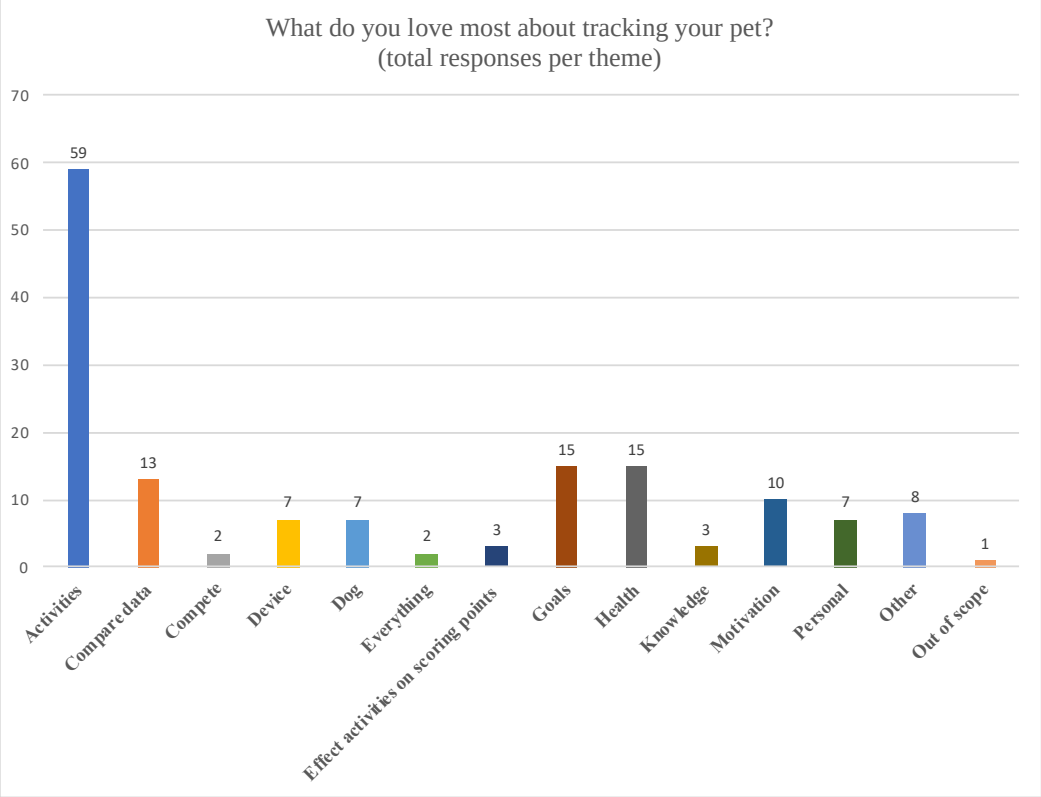
27. What would quantifying your dogs mean to your relationship with your dog(s)?
28. What (behavior) would you be interested in having quantified?
29. What would like you like to know concerning the behavior of your dog(s)?
30. What would you like to know concerning the health of your dog(s)?
31. What would you like to know concerning the emotions of your dog(s)?
32. Do you think your dog(s) would benefit from this quantification? Why?
33. Do you think you would benefit from this quantification? Why?

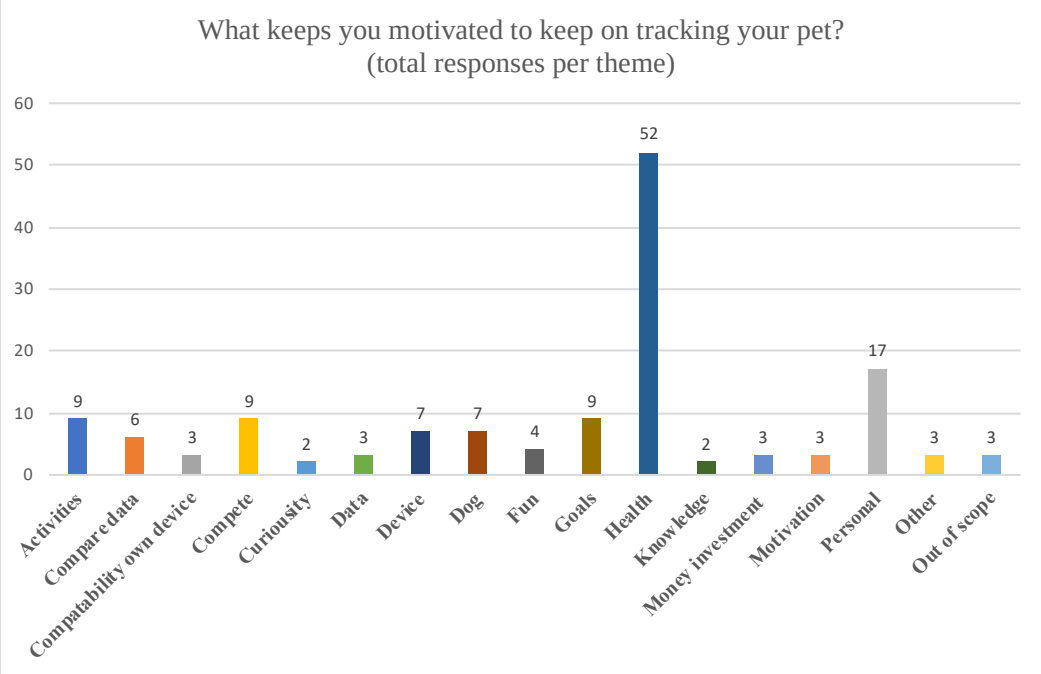
APPENDIX B: ACTIVITY TRACKER USAGE QUESTIONNAIRE RESULTS

The open-ended questions and answers






What do you love most about tracking your pet?
(total responses per theme)
70
60
50
40
30
20
10
0
59
13
2
7
7
2
3
15
15
3
10
7
8
1
Activities
Compare data
Compete
Device
Dog
Everything
Effect activities on scoring points
Goals
Health
Knowledge
Motivation
Personal
Other
Out of scope


What keeps you motivated to keep on tracking your pet?
(total responses per theme)
60
50
40
30
20
10
0
9
6
3
9
2
3
7
7
4
9
52
2
3
3
17
3
3
Activities
Compare data
Compatability own device
Compete
Curiousity
Data
Device
Dog
Fun
Goals
Health
Knowledge
Money investment
Motivation
Personal
Other
Out of scope

Corresponding explanations of the coded themes

Activities: Interest in specifics of the activity data that provides general information of the dog's behavior. Categories in this theme are amongst others: activity levels, details of activities, and activities of the dog when being absent/when taken care of by others.

Compare data: The ability of the activity tracker to compare data. Categories in this theme are: comparing data tracker to other dogs, to the dog's own data of other moments in time, and even to the owner's data that has a compatible tracking device.

Compatibility own device: The ability of the activity tracker to connect the activity tracker of the owner to the tracker of the pet. This theme has no categories.

Compete: Using the tracked activity data and information that's translated into 'activity points' as means for competing with others connected partaking in the social network of the activity tracker. Categories in this theme are: scoring points, beating others and showcasing on the leaderboard.

Curiosity: Curiosity towards the dog's health, activity levels and behavioral patterns. This theme has no categories.

Data: Seeing interesting and related results that ensure the owner of information on the activities that have been performed. The data functions as an assistive tool for reminding, for example, how often and how far the dog's walks have been. Categories in this theme are: data ensuring and results.

Device: The characteristics and features of the activity tracker. Categories in this theme are amongst others: battery life, ease of use, waterproof, and the in-app community.

Dog: The emotions behavior of the dog. Categories in this theme are: having fun, seeing the dog happy, and seeing the dog tired.

Effect activities on scoring points: Seeing how the activities of the dog affect the points that are scored. This theme has no categories.

Everything: All aspects of the activity tracker and the corresponding effects on the dog's and owner's personal behavior. This theme has no categories.

Fun: The fun participants experience when using the activity tracker. This theme has no categories.

Gadgets: The interest in and love of the owner for using gadgets in daily life. This theme has no categories.

Gift: Receiving the activity tracker as a gift by a third party. Categories in this theme are: present and free trial.

Goals: The ability of the application to show the activity data in the form of goals and has subsequent categories as goal (non)achieving, breaking and obtaining streaks with the activity data.

Health: Using the activity tracker to improve and ensure the dog's health for sustaining a healthy lifestyle and expresses an interest in all related activity data. Categories in this theme are amongst others: providing the correct amount of exercise, monitoring health, weight, and calorie burn.

Interest: General interest in the activity tracker and interest in getting to know more about the dog's health/behavior/activities. This theme has no categories.

Knowledge: The satisfaction coming from gaining verified knowledge on (fulfilling) the dog's needs. This theme has no categories.

Money investment: Having invested money in (buying) the activity tracker. This theme has no categories.

Motivation: The ability of the tracker to motivate the owner to become more active, to perform more activities with the dog and to sustain this behavior. This theme has no categories.

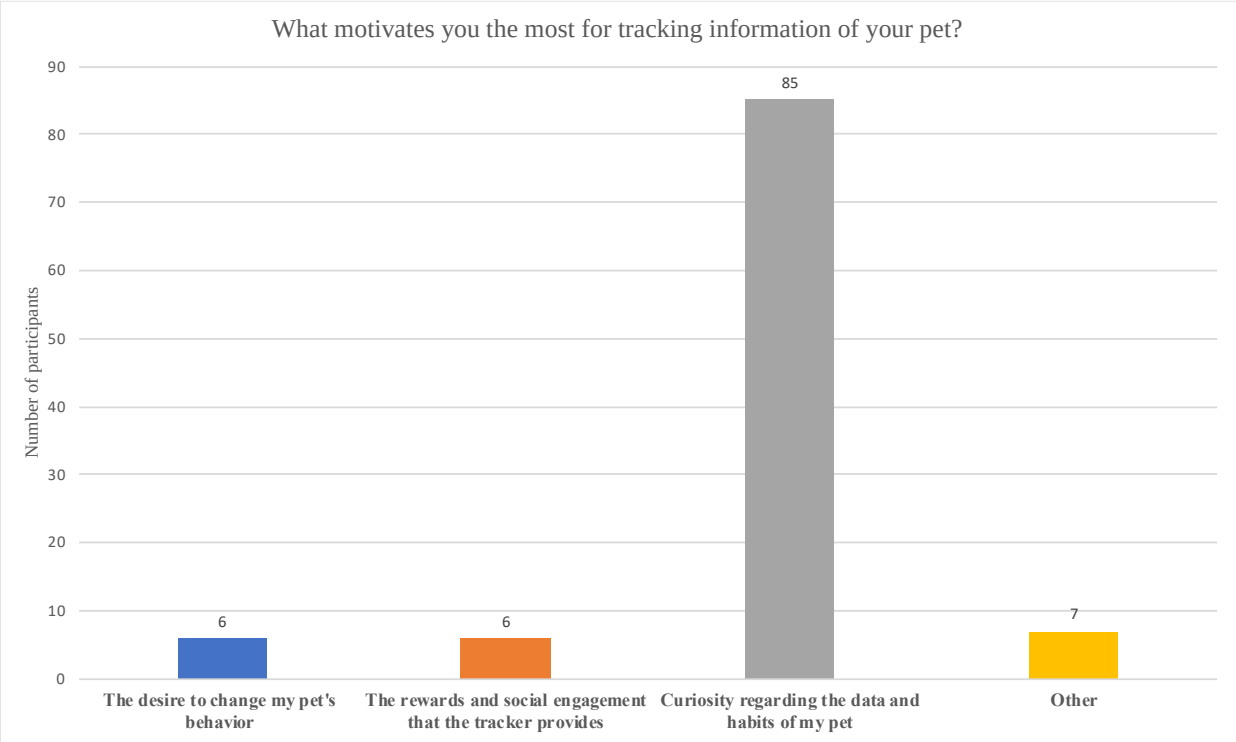
Other: All thematically coded answers that were only given once (per question) are listed under the header 'Other'. Examples are: routine, reminder, stimulated by others, learning about the dog's health, and business marketing.

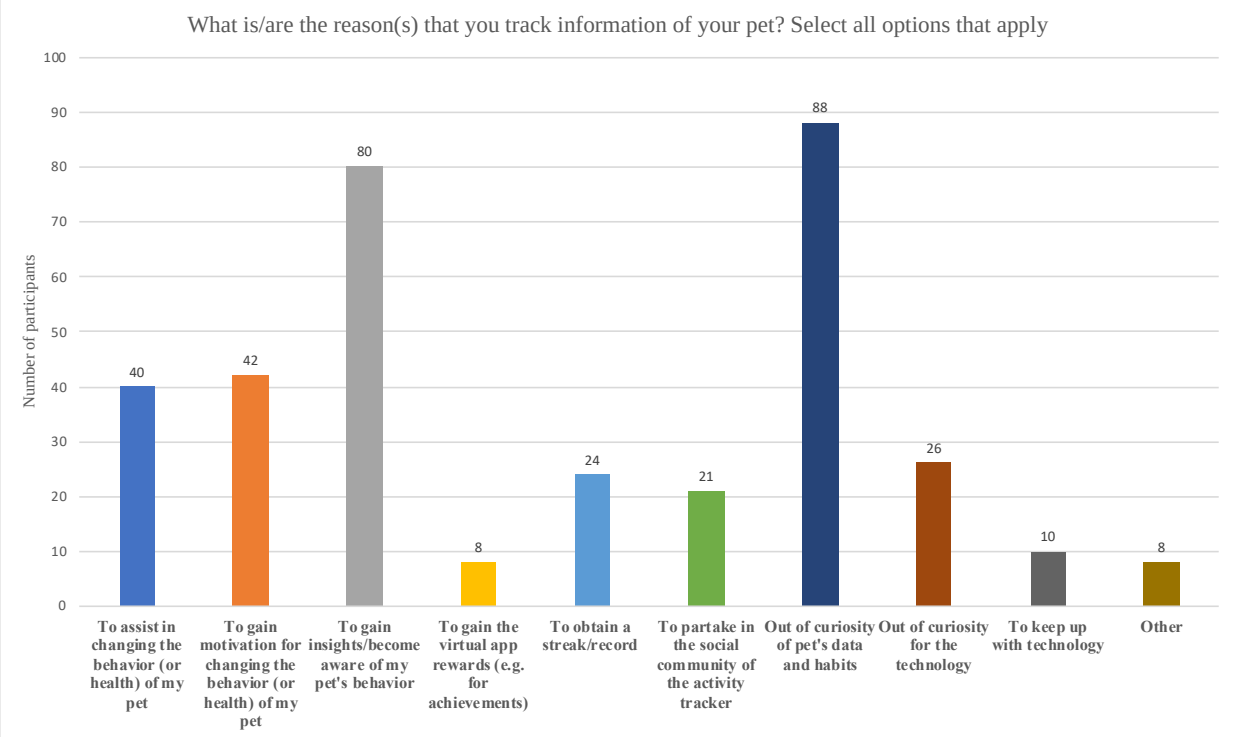
Out of scope: People that have indicated they have stopped using the activity tracker. This theme has no categories.

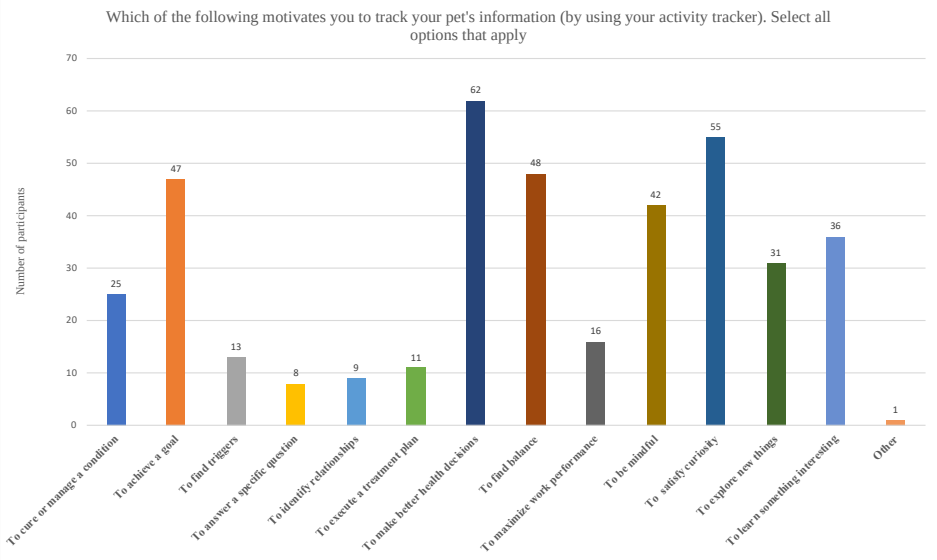
Personal: Reasoning that directly relates to and reflects on the owner and its responsibilities, with categories such as: keeping accountable for the dog's needs, maintaining a personal healthy lifestyle, and love for the dog.

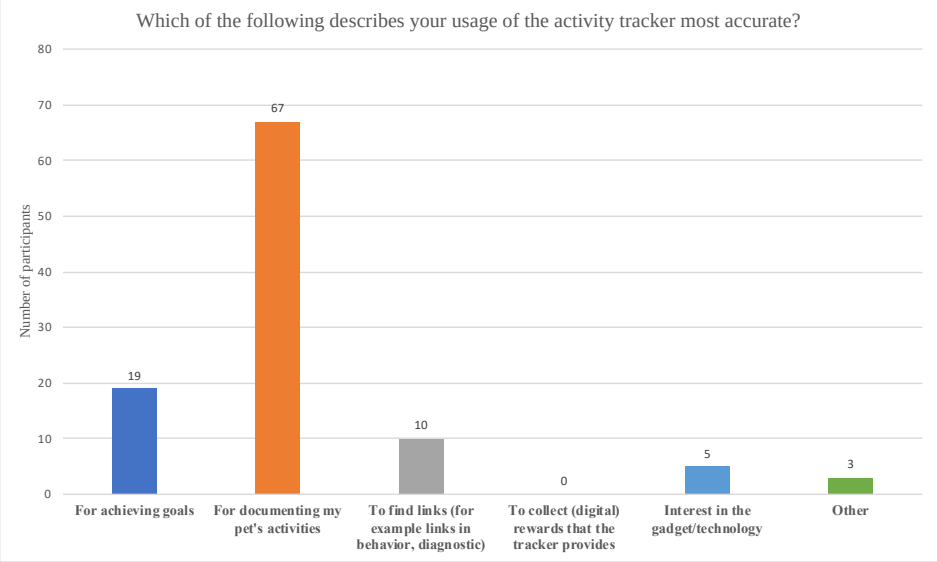
Separation anxiety: Using the activity tracker for detecting any signs of separation anxiety. This theme has no categories.

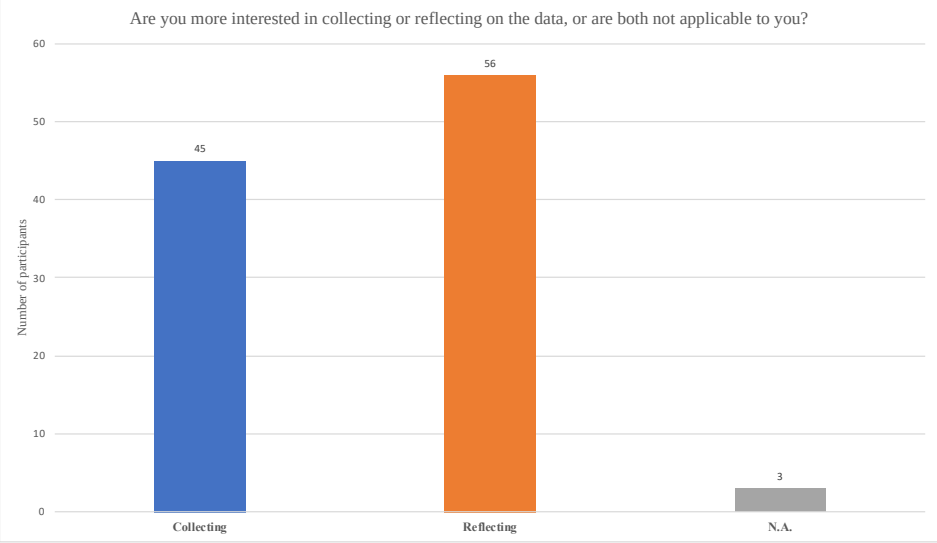
The multiple-choice questions and answers






Which of the following motivates you to track your pet's information (by using your activity tracker). Select all options that apply
Number of participants
70
60
50
40
30
20
10
0
25
47
13
8
9
11
62
48
16
42
55
31
36
1
To cure or manage a condition
To achieve a goal
To find triggers
To answer a specific question
To identify relationships
To execute a treatment plan
To make better health decisions
To find balance
To maximize work performance
To be mindful
To satisfy curiosity
To explore new things
To learn something interesting
Other


Which of the following describes your usage of the activity tracker most accurate?
Number of participants
80
70
60
50
40
30
20
10
0
19
67
10
0
5
3
For achieving goals
For documenting my pet's activities
To find links (for example links in behavior, diagnostic)
To collect (digital) rewards that the tracker provides
Interest in the gadget/technology
Other


Are you more interested in collecting or reflecting on the data, or are both not applicable to you?
Number of participants
60
50
40
30
20
10
0
45
56
3
Collecting
Reflecting
N.A.

APPENDIX C: HEURISTIC EVALUATION

The following heuristics are used for judging the compliance with FitBark's application: visibility of system status (informing the user about progress and process of action); match between system and the real world (design systems based on familiar ideas and concepts); consistency and standards (keep consistency within the system); recognition rather than recall (make objects, actions, and options visible); and aesthetic and minimalist design (balance between good looks and good functionality). The findings are summarized and listed per heuristic.

Visibility of system status

FitBark excels in informing the user about the progress/process of the tracked activities and the status of the measured data. However, they slip when the data is visualized in graphs. This is strongly cohesive with the chosen color coding. When the color coding follows clearly from related information on the screen, there is no room left for misinterpreting the data. If not, the graphs become confusing and difficult to understand, which unfortunately is the case for some of their visualizations. In almost all cases, visualizations are supported by color coding or textual explanations, that (usually) support in correctly transferring the data to the user. For all their graph visualizations, they always provide information or an assistive visualization (such as a line) to inform the user on the average of this data.

Match between system and the real world

The application uses a visualization type (clock representation) for a different visualization metric. In this application, the clock represents 24 hours, which could conflict with the regular 12-hour representation of the clock that the user is familiar with. This is not directly a problem but requires users to adapt and could cause so distortion. Also, the application uses two plots of information with different metrics in one graph. This requires very good color coding or textual support to be interpreted well, which is unfortunately not always the case as shown in the previous heuristic principle.

Consistency and standards

Most consistency flaws are made in the color coding of the visualizations, such as conflicting colors and inaccurate referencing to screen information. This leads to difficulties in understanding the information and non-compliance with 'visibility of system status'.

Recognition rather than recall

FitBark is very supportive in offering options, especially for visualizing health and activity information. They provide options to display the information for the desired time period (day/week/month/year) and enable the user to select their own desired visualized activity/health metrics.

Aesthetic and minimalist design

The overall design of FitBark is quite disordered and expresses aesthetics that can be experienced as old-fashioned and outdated. Their design identity consists of large fonts and objects that can cause overstimulation. However, keeping this deliberately chosen corporate identity in mind, they provide consistent aesthetics and minimalistic design. There is much information to present and they concise the information to a detailed manner with added value.

The heuristic evaluation exposes that FitBark has a clear division in the functionalities that their screens serve. They provide screens that convey and visualize tracker information and screens that enable social connectivity, such as providing options for seeing other dog's profiles, following them, and a leaderboard for competition. The usability problems centered around the informative screens, whereas the social connectivity screens were insensitive to any usability problems.

APPENDIX D: DESIGN SOLUTION

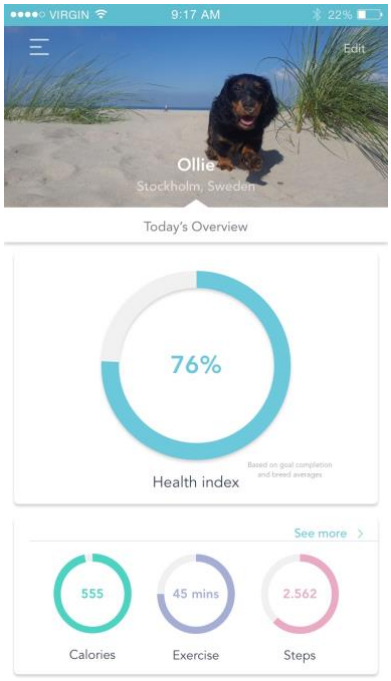


Figure 1 Home Screen

Figure 2 Today's Activities

Figure 3 This Week's Activities

Figure 4 Today's Health

Figure 5 This Month's Health

The design choices and requirements implementation

Resulting from the functional and design requirements, an application is designed using Sketch. For the simplicity of this application design, it has been chosen to narrow the number of screens down to the minimum number of screens that still support all requirements and that provide enough context to evaluate the success of this implementation. The functional requirements express the need for at least three screens: a home/overview screen, an activity information screen, and a health information screen. To support navigating through the application to other moments in time and to provide more context on how activity/health information is displayed, the number of screens is expanded to 5 screens: two for both activity and health information.

For all four health and activity information screens, there is a tool to compare data to other moments in time and to the data of 'the average dog'. The comparison of 'average dog data' is supported by providing each graph visualization with an 'average line' and informative text. A navigation bar in the header enables jumping to different moments in time (week/month/year) and supports viewing and comparing data to other timeframes. Additionally, the *Today's Activities* screen consists of a graph that shows an activity timeline.

As weight can be seen as an indicator of health, both health information screens provide a tool to track weight data. Logging weight is enabled by an 'Edit Entry' button next to the 'Weight' information in *Today's Health*.

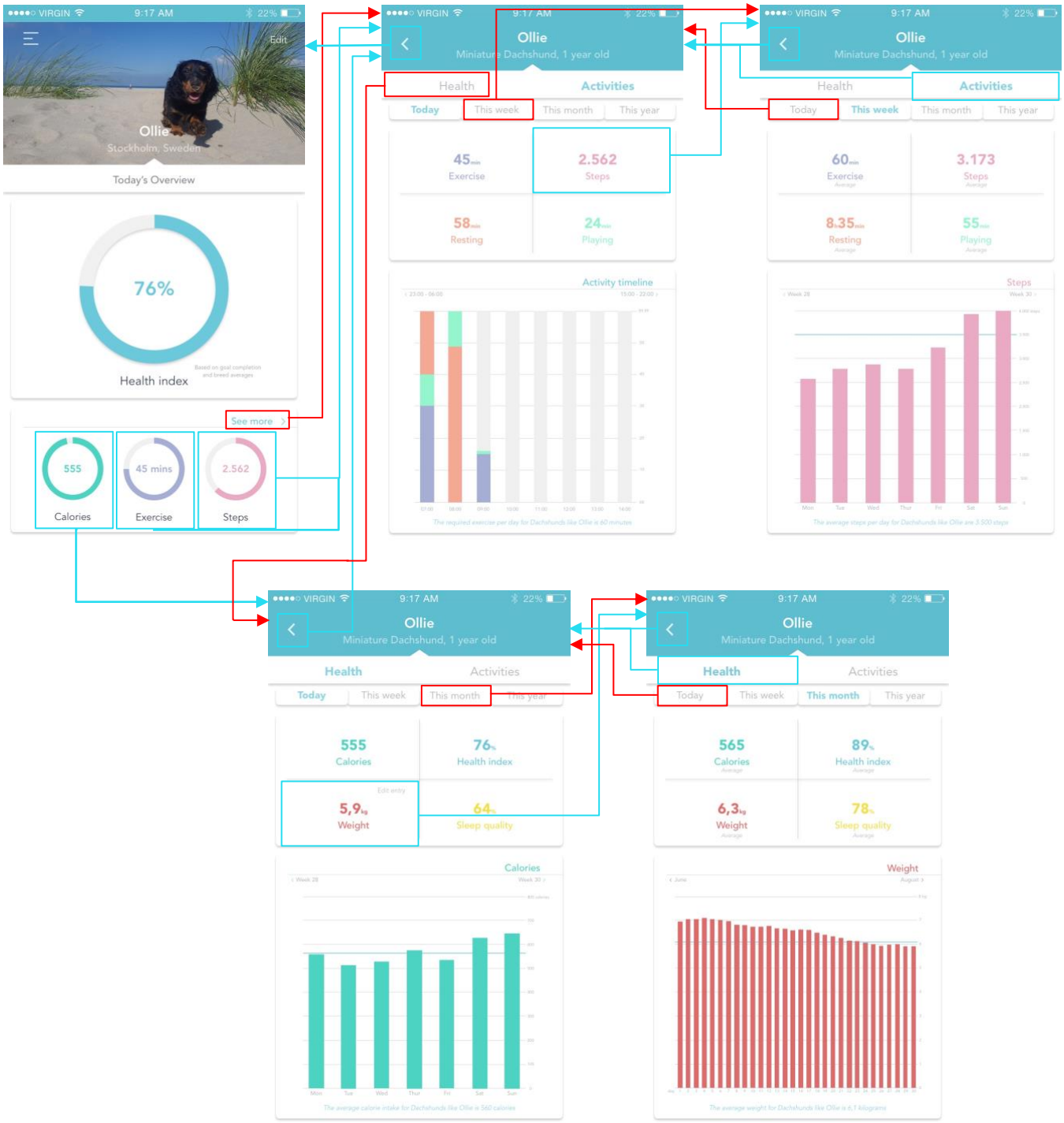
To support quick information transfer, a *Home Page* that updates the user on the dog's (most relevant) health and activity information. To summarize the status of the dog's health, a health index of the dog is shown, based on his goal completion and his data compared to breed averages. This enables a quick update on how well the health goals for the dog are being met. The *Home Screen* also provides information on specific goals related to activities and health: the burned calories (health), the minutes of exercise (activities) and the number of steps taken (activities).

As mentioned, the data is also portraited relative to goals, supporting goal achievement. However, from the persona design followed that this requirement appeared not to be a dominant *Health Guru* characteristic. Therefore, it is chosen to support goal achievement in a subtle manner. The *Home Screen* visualizes the information by typical 'goal' completion circles. More indirectly, all graph visualizations are provided with a line that resembles the data of 'the average dog'. This line is an expression of the goal that should be met for a healthy dog and informs the user on how well the activities and health are meeting this line.

The design requirements from the heuristic evaluation function as design guidelines. All information and correlating visualizations are supported by consistent matching color coding and textual explanations. Comparison of data is supported by an 'average line' and informative text in each graph visualization, matched to each other via color coding. Options for details on activity/health information and for navigating through time are directly displayed to the user.

APPENDIX E: WIREFRAMES APPLICATION DESIGN

The screens are designed with the intention for the user to navigate by using the buttons in the top headers. This intentional route is visualized by the red arrows and boxes in the wireframes. The blue arrows and boxes represent the alternative navigational routes as been used by the participants while performing tasks from the task list as part of the usability testing.



APPENDIX F: USABILITY TESTING SEMI STRUCTURED INTERVIEW RESULTS

The feedback of the semi-structured interview is gathered, summarized and listed per screen. For the *Home Screen*, the interview focusses on the interpretation of the Health index and on the information visualized in and by the circles. The focus for the Activity and Health pages is on the clarity of the information in the boxes and the interpretation of the graphs.

Home Screen

The header with the dog's profile is experienced as pleasant and welcoming. The Health index raises questions by the participants. Even though there is a short explanation on the side, many express that it feels like they have missed out on an explanation that they would expect when first installing the application. This item requires context for a successful interpretation. The information visualized in the circles is interpreted correctly and seen as daily goals to be achieved. Even though only mentioned by one participant, the calories lack context on targeting calorie-burn or calorie-intake and should be added to it.

Today's Activities

The information in the boxes is clear. A few participants have confusion on the distinction between exercise and playing and see an overlap. They would prefer context on the division. Also, a few participants wonder to which extent and intensity resting is monitored. The graph is interpreted by all participants as being a visualization of the stacked activity minutes per hour. After it was pointed out by the experimenter that it is an activity timeline that shows on which parts of the hour an activity took place (rather than the total minutes of each activity per hour), almost all participants understood this and could decode it well.

This Week's Activities

In addition to the previously mentioned comments on the information in the boxes, some participants mentioned that the text 'Average' could increase in font size. The graph is clear, all participants interpreted and read the graph correctly without any comments on the design. When asked if the participants could derive the average steps for similar dogs, half of them directly pointed out the 'average' line and interpreted this as intended. After pointing out the presence of the line to the other participants, they understood it without additional explanation. Hardly any of the participants noticed and read the text below and suggest adjusting the color of both this text and the line.

Today's Health

The confusion on the 'Health index' from the *Home screen* is still present and many participants do not know how to interpret this here. They would prefer an explanation to be revealed when pressing 'Health index', so that they gain context and understanding. Half of the participants also have trouble interpreting 'Sleep quality' and would prefer a similar approach. One participant pointed out that it would make more sense to show the calorie-burn, rather than the calorie-intake, since this would require manual food logging. However, none of the other participants mentioned, or noticed, this. The graph, as being similar to the graph in *This Week's Activities* is clear to all participants and interpreted correctly, with the only remark being that the bar chart could also be visualized as a line graph, for simplicity and aesthetics.

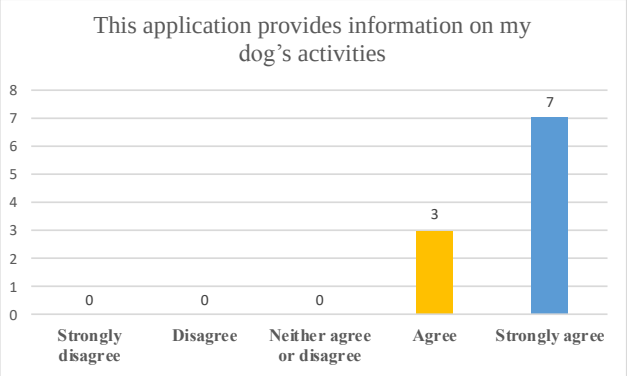
This Month's Health

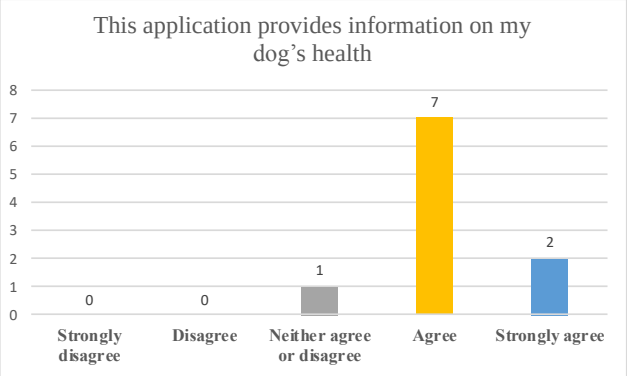
Additional to the comments mentioned before, few participants mention that the positioning of the information in the boxes could be improved upon and take advantage of the offered space in the boxes by increasing the font size. More than half of the participants mention that the graph is too much and difficult to extract data from. It is suggested to change the bar chart to a line graph and to only zoom in on the information part that is subjective to change, making kilo's 0 to 5 irrelevant for display. It is also suggested to show the data per week, rather than per day, for simplification purposes.

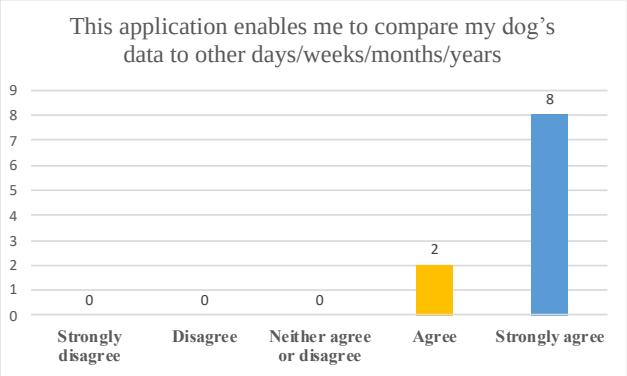
General

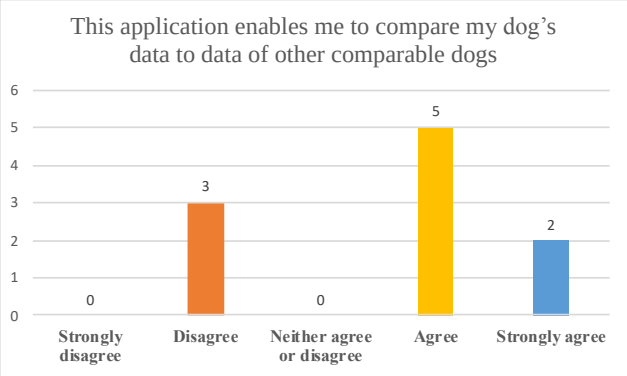
Almost all participants mentioned that the font size is too small for easy and comfortable reading of the information. Additionally, testing with male participants pointed out that the button sizes for the headers (this week, etc.) are too small and difficult to press when having large hands and fingers. Many participants are enthusiastic about the colors used in all screens except the 'Health' screen. Here, some experience discomfort with the coloring of 'Sleep quality' and think it should be adjusted to a more comforting and color-scheme fitting color.

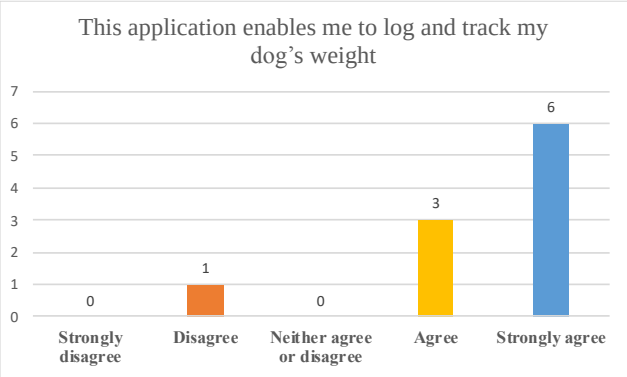
APPENDIX G: USABILITY TESTING QUESTIONNAIRE RESULTS

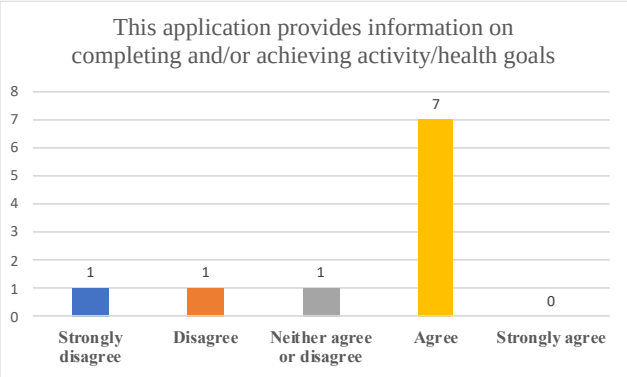


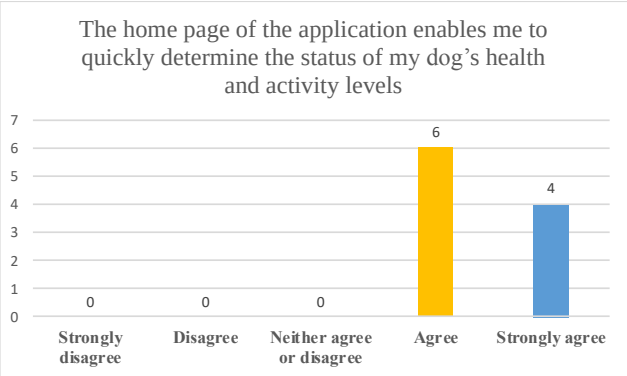


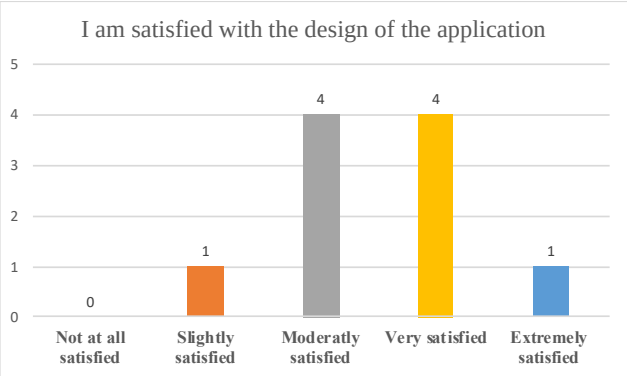












APPENDIX H: IMPROVED DESIGN SOLUTION FOR FUTURE WORK

The following screens suggest an improved version of the design solution with the design feedback from the participants implemented. This optimization includes: improved weight graph visualization, increased font size, optimized text-space ratio in information boxes, improved color scheme, improved header buttons, adjusted average line text in color and size, improved Activity timeline graph visualization, information icon next to *Health index* and *Sleep* quality, and added context to calories on *Home screen.* This improved design solution provides a clean base to implement the other functional features as suggested below.

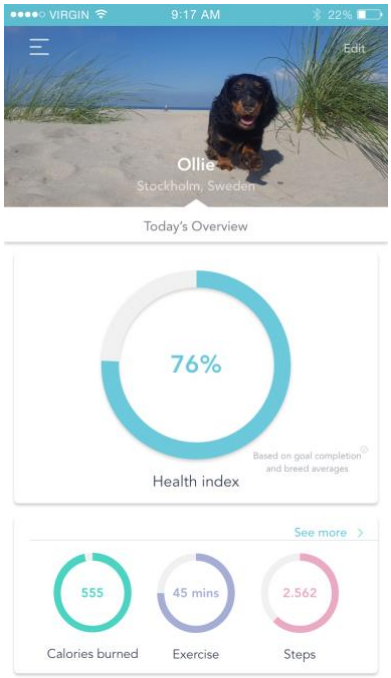


Figure 6 Improved Home Screen

Figure 7 Improved Today's Activities

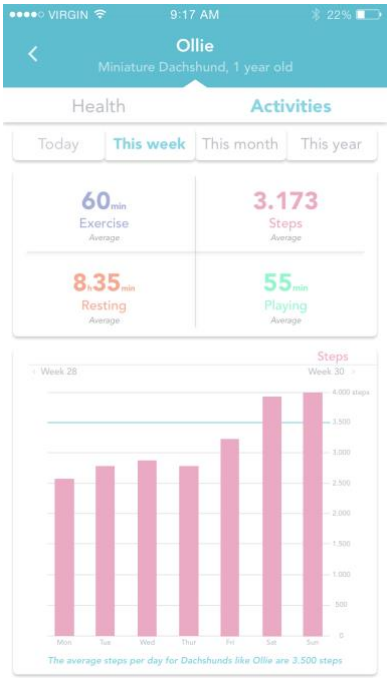


Figure 8 Improved This Week's Activities

Figure 9 Improved Today's Health

Figure 10 Improved This Month's Health