EVERYDAY ENGAGEMENT

The Psychological Factors of Technologies that Support Well-being

Inauguraldissertation

zur Erlangung des Doktorgrades der Philosophie

an der Ludwig-Maximilians-Universität München

vorgelegt von

JASMIN NIESS

aus Wien

2019

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Datum der müdlichen Prüfung: 13.02.2019

ABSTRACT

Interactive technologies to improve personal well-being, health and fitness are becoming ubiquitous. There are applications (apps) for healthy eating, fitness apps and trackers, and less obvious helpers such as smart alarm clocks. Other apps promote healthy sleep patterns and still others integrate artificial intelligence to support users to clean their teeth properly. Such technologies can theoretically facilitate self-improvement and enhance well-being, but research to date has shown that psychologically sound, motivational concepts have not yet sufficiently been considered in their design. Users have difficulty with long term engagement when using their well-being technology. Often, they give up before achieving their goal, or have difficulties deriving meaningful insights from the data. To date, it remains unclear which psychological processes lead to such difficulties regarding long-term engagement in the context of technology-supported behaviour change. Applying psychological theories that focus on social interactions or cognitive mechanisms to interactions between humans and technologies could promote a deeper understanding of the psychological mechanisms involved. Furthermore, this can lead to insights regarding potential extensions of psychological theories to the area of technology-supported behaviour change.

The approach how the present thesis aims to address this research gap is twofold: It studies whether psychological concepts and psychological theories used to describe social or cognitive phenomena can be extended to humans interacting with well-being or self-improvement technologies. Secondly, it explores the psychological factors connected to the design of recommendations and goal-oriented feedback of well-being technologies and aims to derive theory-based implications for the design of such technologies.

The present thesis is divided as follows: A general introduction (part one), nine scientific manuscripts in part two (see chapters 5, 6, 7, 8, 9, 10, 11, 12, 13), and a general discussion addressing the described research gap. The rationale behind the structure of the manuscripts is described in detail below:

The first two manuscripts (chapter 5, 6) explore the interaction between humans and well-being and self-improvement technologies using psychological constructs. An essential factor for behavioural change in the therapeutic, academic or counselling context is the dialogue between therapist and client, teacher and student, coach and coachee. Research in human-technology interaction has shown that when people interact with technologies they show social behaviours. The combination of these insights and their continued exploration

has led to the realisation that users perceive the style in which their interactive technology communicates with them and can distinguish between different communication styles (e.g. friendly, critical). These communication styles are accompanied by specific emotional and motivational consequences.

Building on these findings, the second group of manuscripts (chapter 7 - 10) inquires if insights based on psychological theories (e.g., Construal Level Theory) can be extended to human-technology interaction. The level of construal is the extent to which people think about objects or situations in abstract or concrete terms (e.g., going on a vacation versus packing a bathing suit). The level of construal is related to psychological distance. Thus, the closer an object is, the more concrete people would think about it. Further, the psychologically based possibilities to design feedback for interactive technologies to enhance well-being and self-improvement (e.g. 'Level of Construal' manipulation of feedback formulations) are explored in chapter 7. This group of manuscripts also focuses on how the success or failure to achieve a goal can be communicated in the context of behavioural change technologies and which psychological consequences this entails (e.g. rumination).The relationship between hedonic and eudaimonic well-being and self-improvement goals is also considered.

The final papers (chapter 11 - 13) focus on the importance of considering contextual factors when designing for well-being and how the integration of psychological qualities can be used to craft context-sensitive technologies. Two studies that deal with specific contexts of use are presented. This section also reports on the development and design of a tool that can help researchers and designers generate in-depth insights into everyday human-technology interactions.

In sum, this work aims to provide both theoretical and empirical insights into psychological factors of well-being technologies, and highlight practical implications for designing meaningful interactive technologies.

ZUSAMMENFASSUNG

Interaktive Technologien zur Steigerung des Wohlbefindens und zur Selbstverbesserung sind beispielsweise mobile Applikationen (Apps) für eine gesunde Ernährung, Fitness Apps, Fitness Tracker, aber auch weniger offensichtliche technische Helfer wie intelligente Wecker, die gesundes Schlafverhalten fördern sollen oder elektrische Zahnbürsten, die mithilfe von künstlicher Intelligenz dabei unterstützen, richtig Zähne zu putzen. Technologien, die Nutzer dabei unterstützen, an sich selbst zu arbeiten, um gesünder oder fitter zu werden oder ihr Wohlbefinden zu verbessern, sind in unserer heutigen Gesellschaft allgegenwärtig. Solche interaktiven Technologien haben theoretisch

das Potential Selbstverbesserung zu unterstützen und das Wohlbefinden ihrer Nutzer zu stärken. Abhängig von ihrer technologischen Gestaltung können sie ihrem Nutzer Erinnerungen schicken ('Hast du heute schon ausreichend Wasser getrunken? '), Rückmeldung bezüglich zielrelevanten Fortschritts geben ('Du hast dein heutiges Ziel, 8000 Schritte zu machen, erreicht') oder auch, basierend auf von Sensoren erfassten Daten, Informationen bezüglich physiologischer Parameter (z.B. Herzfrequenz während einer Trainingseinheit) aufbereiten.

Bisherige Forschung zeigt allerdings, dass psychologisch fundierte Konzepte in Technologien zur Steigerung des Wohlbefindens und zur Selbstverbesserung noch nicht ausreichend Berücksichtigung finden. Häufig haben Menschen Schwierigkeiten damit, ihre Technologie zur Unterstützung von Fitness und Wohlbefinden langfristig zu nutzen. Oftmalig wird die Anwendung bereits vor der Zielerreichung abgebrochen oder es ergeben sich für die Anwender Schwierigkeiten sinnvolle Einsichten aus den gesammelten Verhaltensdaten abzuleiten. Die Erforschung dieser Thematik ist sowohl für die Psychologie als auch für die Mensch-Technik-Interaktion von Relevanz. Die Mensch-Technik-Interaktion nutzt häufig konzeptbasierte Ansätze und fokussiert oftmals auf die Entwicklung und Evaluation prototypischer Gestaltungslösungen (z.B. eine mobile Applikation, um Mitarbeiter in einem Unternehmen zu motivieren sich häufiger zu bewegen). Dieses Vorgehen führt zu relevanten, aber kontextspezifischen Implikationen. Hierbei ist es unklar, inwieweit sich die abgeleiteten Einsichten auf andere Nutzungskontexte übertragen lassen. Im Gegensatz dazu ist in der Psychologie bereits umfangreiches Wissen bezüglich der Veränderung von Verhalten und der Steigerung des Wohlbefindens vorhanden. Inwiefern psychologische Theorien und Konzepte auf spezifische Nutzungskontexte der technologiegestützten Verhaltensänderung und Steigerung des Wohlbefindens übertragen werden können, ist allerdings noch weitgehend unerforscht.

Das Ziel der vorliegenden Dissertation ist es, diese Forschungslücke mithilfe der Zusammenführung von psychologischem Wissen und Erkenntnissen der Mensch-Technik-Interaktion zu adressieren. Die Kombination von Wissen aus diesen zwei Forschungsgebieten kann dazu genutzt werden, ein tiefergehendes Verständnis für relevante psychologische Mechanismen im Zusammenhang mit interaktiven Technologien für Wohlbefinden und Selbstverbesserung zu generieren. Darüber hinaus hat eine solche wissenschaftliche Arbeit an der Schnittstelle zwischen Psychologie und Mensch-Technik-Interaktion das Potential, praktische Implikationen abzuleiten, die langfristig einen Beitrag zur Gestaltung derartiger Technologien leisten können.

Die vorliegende Dissertation gliedert sich in folgende drei Teile: allgemeine Einleitung, Publikationen und eingereichte Manuskripte, allgemeine Diskussion. Der Fokus der Manuskripte I und II liegt auf der Exploration der Interaktion zwischen Menschen und Technologien

zur Selbstverbesserung anhand psychologischer Konstrukte (z.B. Kommunikationsstil der Selbstverbesserungstechnologie). Ein essentieller Faktor für Verhaltensänderung im therapeutischen oder schulischen Kontext ist der Dialog zwischen Therapeut und Klient, Lehrer und Schüler, Coach und Coachee. Forschung aus dem Bereich Mensch-Technik-Interaktion hat darüber hinaus gezeigt, dass Menschen, wenn sie mit Technologien interagieren, soziale Verhaltensweisen zeigen. Die Verbindung dieser Einsichten und deren weiterführende Exploration hat zu der Erkenntnis geführt, dass Nutzer den Stil, in dem ihre interaktive Technologie mit ihnen kommuniziert ('Kommunikationsstil'), wahrnehmen und dass es ihnen möglich ist, zwischen verschiedenen Kommunikationsstilen (z.B. freundlich, kritisch) zu unterscheiden. Diese Kommunikationsstile gehen mit spezifischen psychologisch relevanten Folgen (z.B. positiver Affekt) einher.

Aufbauend auf diesen Erkenntnissen werden in den Manuskripten III, IV, V, VI psychologisch fundierte Möglichkeiten, Rückmeldungen von interaktiven Technologien zu gestalten, exploriert. In Manuskript III wird beispielsweise, basierend auf der sozialpsychologischen Construal Level Theory, das 'Level of Construal' von Feedbackformulierungen manipuliert und der Effekt dieser Manipulation auf positiven Affekt und Zielcommitment exploriert. 'Mental construal' ist hierbei der Grad mentaler Abstraktion bzw. das Ausmaß, in dem Personen konkret oder abstrakt denken. Die Beziehung zwischen hedonischem Wohlbefinden (Vergnügen, Freude, Genuss) und eudaimonischem Wohlbefinden (Verwirklichung der eigenen Potentiale, Lebenszufriedenheit) im Kontext von Selbstverbesserungstechnologien wird in Manuskript IV exploriert. Manuskript V und VI untersuchen wie Ziele kommuniziert werden können, um, unter anderem Zielcommitment zu gewährleisten und negative, sich wiederholende Gedanken (Rumination) zu vermeiden.

Die Relevanz von Kontextfaktoren im Rahmen des Selbstverbesserungsprozesses und wie die Einbettung psychologischer Qualitäten genutzt werden kann, um kontextsensitive Technologien zu gestalten, wird in den Manuskripten VII, VIII und IX erforscht. Es werden zwei Studien vorgestellt, die sich mit spezifischen Nutzungskontexten befasst haben (Manuskript VII, VIII). Außerdem wird über die Entwicklung und Gestaltung eines analogen Designtools berichtet, welches Forscher und Designer dabei unterstützen kann, tiefgehende Einsichten bezüglich alltäglicher Mensch-Technik-Interaktionen zu generieren (Manuskript IX).

Zusammengefasst ist das Ziel der vorliegenden Dissertation, sowohl theoretische und empirische Einsichten bezüglich psychologischer Faktoren von Technologien für Wohlbefinden und Selbstverbesserung zu generieren als auch praktische Implikationen für die Gestaltung bedeutsamer interaktiver Technologien abzuleiten, welche für die

Gestaltung bedeutsamer interaktiver Technologien nutzbar gemacht werden können.

Why do you go away? So that you can come back.
So that you can see the place you came from
with new eyes and extra colors.
And the people there see you differently, too.
Coming back to where you started is not the same as never leaving.

Terry Pratchett, A Hat Full of Sky (2004)

ACKNOWLEDGMENTS

Going through the process of getting a PhD has changed me and I am very grateful that I was surrounded by so many wonderful, extraordinary colleagues, co-authors, friends and relatives throughout this adventure. I experienced delightful moments and intimidating challenges, but being able to share them with people who are near and dear to me is what made this journey truly unique.

First and foremost, I would like to thank my supervisors Sarah Diefenbach, Albrecht Schmidt and Erika Spieß for their kind and valuable advice, their support, their trust and for engaging discussions that fueled my academic interest. I am happy that I had the opportunity to work with and learn from you and I would like to thank you for that.

I would also like to thank all my colleagues, co-authors and friends at LMU Munich, University of Stuttgart, University of Gothenburg and University of Vienna. It was an honour to get to know and work with you. Special thanks go to Ralph Woschee for all his support, to Eleni Georganta for spreading joy and positivity and for being a great and empathetic friend, to Stefan Tretter for being the best office mate ever, for conversations full of self-deprecating humour and for allowing me to vent if needed and to Johannes Arendt for motivating late-night strolls to the vending machine, for always being kind and for inspiring discussions, to Josef Gammel and Tom Schiebler for great nights on the dancefloor.

Further, I would like to thank Kristina Knaving for giving me a million new ideas every time we had a conversation and Jakob Karolus, Sebastian Feger and Matthias Hoppe for awesome evening activities such as Kakerlakensalat and very enthusiastic jam sessions.

I sincerely thank Paweł W. Woźniak for his encouragement and for believing in me when I did not. It is a rare thing to experience conversations about „grey topics“ with someone and suddenly every topic shines in „all the colours“. Thank you!

I would also like to thank my friends: Julia Renner, Manuela Tomitzi, Judith Ölz, Adam Markus, Clemens Manzano, Barbara Pollauf, Christoph Foglar-Deinhardstein, Magdalena Huber, Fabian Huber, Alexander Freund, Daniel Cinkl, Fritz Albrecht, Oguzhan Gökdas, Michaela

Strobl, Max Bartosik, Nina Meidlein, Johannes Bauer, Nora Hofer, Rosmarie Melzer and Robert Melzer. Thank you for filling my life with happiness, thank you for accepting me with all my quirks and insecurities, thank you for showing me that physical distance does not break the connection, thank you for your friendship.

Finally, the biggest thanks goes to my family — Rosemarie Stierle-Niess, Amir Sadeghian, Martin Stierle, Shila Niess, Florian Stierle, Hermann Eggbauer and Erika Niess for making me who I am today, for supporting me in every endeavour and for always being there for me when I needed you. Not a day goes by that I don't miss you. I love you.

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Part I

INTRODUCTION

1 PREFACE

Contemporary technological developments can be utilised to enhance the health and well-being of the global society (Shirky, 2010). For instance, researchers have called for the design of a digital environment that supports psychological well-being and improves wellness on the individual level as well as on a global scale (Calvo & Peters, 2014). In contrast, scholars in psychology and Human-Computer Interaction (HCI) have pointed out the difficulties that society is currently facing due to the ubiquity of new technologies, such as the internet and mobile phones (Salehan & Negahban, 2013; Griffiths, 2000; Porter, n.d.).

Furthermore, researchers have also addressed how technological development has moved society towards a normative ontology to become fitter, healthier and more productive (Spiel et al., 2018) as well as the contemporary belief that every problem that humans face can be solved by computation or, in other words, that there might be an app to solve every problem (Bridle, 2018). Computing should accomplish what it can; however, there seems to be a difference between what is possible and what makes technology meaningful (Calvo & Peters, 2014). Today, technologies can track if I[1] moved enough, they record the locations I have visited and they can sense if I slept well. Hence, people are confronted with a vast amount of data about themselves, but struggle to derive meaning of it (Munson, 2017). Thus, current technological developments need active, engaged and critical users, who are able to reflect on their needs and utilise technology in a way that makes the interaction meaningful for them (Rogers, 2006).

Using the example of chess players, Bridle showcased that meaningful cooperation between humans and computers can be more powerful than the work of the best computer alone (Bridle, 2018). The discourse regarding the chances and challenges of new interactive technologies reflects that humanity seems to be facing a turning point; while technology can distract users, leading to challenges like negligent driving (WHO, 2011), it can also benefit users, leading to solutions like changing the ecology of education (Goundar, 2014). It has been argued that technologies should be utilised to ensure the right of everyone to fulfil their potential (Calvo & Peters, 2014) and to enhance the dignity of humanity (Adorno, 1987).

1 Note: This thesis uses the form 'we' to refer to findings which are results of collaborative research efforts. The form 'I' is used when the opinions and findings of the author developed specifically for this thesis are presented.

Psychology and HCI research was conducted on the use of technological interventions to support mental and physical health and well-being, such as mindfulness interventions, technologies to improve physical fitness and interactive tools for people living with Parkinson's (e.g., Creswell, 2017; Conroy, Yang & Maher, 2014; Nunes & Fitzpatrick, 2018). Researchers found that these interventions, most of which are limited to a specific context of use, can have positive effects on peoples well-being, but scholars and practitioners are still struggling to obtain long-lasting changes (Munson, 2017; Jakicic et al., 2016; Bravata et al., 2007) that improve users' well-being (Diefenbach, 2018; Hollis, Konrad & Whittaker, 2015). Thus, to ensure long-lasting impacts on the individual and societal level, actionable guidelines for designers and practitioners are needed (Munson, 2017).

Over the past three decades, technological devices, such as smartphones or fitness tracker, became ubiquitous (Schmidt, Pfleging, Alt, Sahami & Fitzpatrick, 2012). Due to their pervasiveness, these devices are predisposed to deliver fine-grained, effective interventions. Nevertheless, it remains an open question which technological features can be derived from psychology and implemented in actual technologies to have a long-term effect on users' well-being (Diefenbach, 2018; E. Churchill et al., 2014). Based on the example of persuasive sustainability research, Brynjarsdottir et al. (2012) showcase the difficulties and challenges research and practice are facing in the area of persuasive technology and technology for behavioural change. The authors emphasise the need for making research findings actionable, in order to have more significant societal impact. Since research and practice are struggling to understand (long-term) user behaviour as well as user needs (Yetim, 2013), a systematic need for new ways to think about these chances and challenges arises.

Moreover, technologies are reshaping the global economy. The societal and economic potential of technology has already transformed society (Mokyr, Vickers & Ziebarth, 2015; Brynjolfsson, McAfee & Spence, 2014). These changes are having an impact on social interactions as well as our work and private life (Bostrom, 2008). Current research shows that computerisation is going to change the nature of work across industries and occupations (Colbert, Yee & George, 2016). Hence, the digital revolution will eventually lead to the need to restructure the economic system and to rethink the role of human labour (Brynjolfsson et al., 2014). Technologies are already partly accompanying humans in their work and private lives. This human-technology cooperation may lead to the transformation of the technology into an interactive companion or a digital agent. In order to explore which psychological qualities technologies should embody to become users' companions and to facilitate meaningful interactions, an understanding of the differences and similarities regarding the perception of assistant technologies in work life and private life is

essential. Hence, one of the aims of the present thesis is to examine the psychological qualities of digital assistant technologies.

Technology is changing the world, and some researchers argued that these developments are going to change the world for the better (Shirky, 2010), whereas others pointed to related challenges and dangers (Bridle, 2018; Balestrini, Diez, Marshall, Gluhak & Rogers, 2015). Stanisław Lem pointed out that humans cannot demand contradictory results from technology; that is, humans cannot expect technology to solve every problem and be completely harmless at the same time. He further stated that utilising technology to enable good relies on the actions of society rather than technical possibilities (Lem, 2013).

Due to the societal changes that are resulting from technological developments, researchers and practitioners agree that the global society is facing a challenge and that new research is needed to answer the multitude of open questions that are arising. Horizon 2020, the biggest European Union research and innovation programme, currently invests in multidisciplinary research on societal well-being (Walshe et al., 2013), laying the foundation for the next generation of technologies. This mirrors the interest of researchers and practitioners to explore and shape the digital environment to enable social welfare.

One of the categories of technologies that support well-being that became popular in the last years is technologies for self-improvement and behavioural change. In line with the categorisation of coaching technologies, there are two different types of technology for self-improvement. One category is technologies to support communication between user and coach. The other category includes technologies that can be used for independent self-improvement or self-coaching (Kanatouri & Geißler, 2016). Throughout the self-improvement process, the technology may turn into an interactive coach and advisor, in line with the findings of Nass, Steuer and Tauber (1994). If that is so, designing the interaction between product and user, or in other words, how the self-improvement technology communicates feedback, goal attainment or failure to its user seems to be key for a successful transformation towards enhanced well-being. Since human behaviour is, to some extent, messy and unpredictable, these tools are not yet able to adapt that well (Weir, 2018).

Hence, the aim of the present thesis is twofold. First, the present thesis aims to explore ways to apply psychological concepts to build an in-depth understanding of technology-mediated behavioural change. Second, this thesis aims to inquire how psychological concepts and psychological theory can be applied to formulate feedback of self-improvement technologies and aid users on their path to enhanced well-being.

This thesis is structured as follows: In part one, I set the scene for the presented inquiry. I discuss chances and challenges that arise

due to the technological developments society is facing and why it is important to study these developments. Further, I outline how cross-disciplinary research collaborations between psychology and HCI can be utilised to create high impact research. Part one also discusses the rationale behind the decision for this work to focus on well-being and self-improvement technologies and presents the research questions as well as an overview of the thesis. Part two introduces the studies included in this thesis. The first two papers (paper I, II) mainly focus on the exploration of affective and motivational responses of the communication style of interactive technologies. The following four papers (paper III, IV, V, VI) inquire different ways to apply psychological knowledge in order to craft meaningful feedback content and aid in goal setting. The last three papers (paper VII, VIII, IV) focuse on studies that explore contextual factors of interactive technologies for well-being and investigate possibilities of adapting feedback to a specific context of use. Part three summarises and discusses the results of this thesis with respect to the outlined research questions and presents potential starting points for future research.

2 INTERACTIVE TECHNOLOGIES FOR SELF-IMPROVEMENT

This thesis is motivated by the complex intricacies of designing technologies for well-being and self-improvement. Designing interaction for self-improvement is a challenging task (Calvo, Riva & Lisetti, 2014; D. A. Epstein, Ping, Fogarty & Munson, 2015). Designing functional interactive agents is one important factor for a successful interaction process, but how to design these technologies to foster trust and long-term engagement is still an open question (?, ?).

This is, inter alia, due to the fact that, when it comes to well-being and behaviour change, multiple variables are at play. In a way it is a more complex task for technology to successfully fit into human's everyday life, than to carry out a mission to mars (Weir, 2018).

There are internal factors, such as motivation or physical and mental condition, external factors, such as unpredictable events, as well as characteristics of the technology, such as feedback content. Furthermore, since multiple stakeholders are involved, there is a possibility that the self-improvement technology was designed and utilised with different purposes in mind. Perhaps a researcher designed and explored a system with a behaviour change goal in mind, whereas the company that distributes the system now would like it to be used as long as possible and the end user downloaded the tool to improve his or her well-being.

When it comes to communication technology, one size does not fit all (Shirky, 2010). Designing technology and its content in a way that addresses the needs of the majority of society is a demand of new generations, as they want to actively share, talk about and interact with technology (Shirky, 2010). However, it is not yet possible to personalise the communication of a tool for a user in a way that guarantees success (D. A. Epstein et al., 2015). While user models have been built (Masthoff, Grasso & Ham, 2014) (user modelling is the process of building a conceptual understanding of the user, in order to be able to adapt technology to the user's specific needs) and various facets of the interaction process have been analysed (e.g., message timing, communication style, communication channel), these systems still struggle to offer long-term support that goes beyond their specific context of use. This is partly because humans, as study objects, still remain a mystery. An in-depth understanding of the complex interactions between users and contextual factors and the application of this knowledge are key for designing successful interactive systems that enable self-improvement. However, the exploration of the interplay between individual characteristics and psychological characteristics

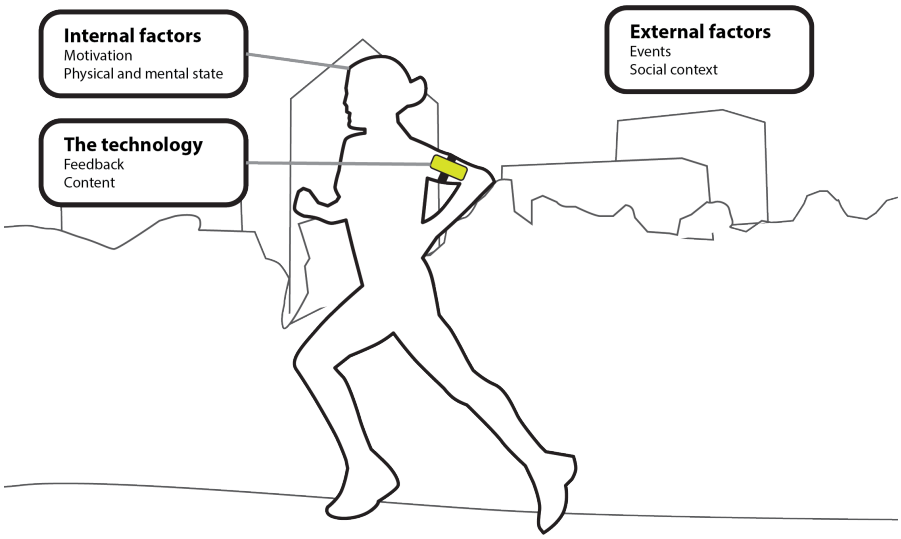


Figure 2.1: Influencing factors for designing self-improvement and well-being technologies

is still a young research area (Rauthmann et al., 2014). Therefore, researchers are not yet able to account for all the unknown variables, such as contextual factors, the effect of the subconscious and various triggers that can lead to unexpected internally perceived or externally visible reactions.

One approach that has the potential to become more than an intermediate solution is to give users options, motivate them to shape their interactions, motivate them to actively engage with tools and critically reflect on it (Rogers, 2006). Mark Weiser emphasised that the computer for the 21st century should be a comfortable and calm technology operating in the background (Weiser & Brown, 1997). But from a technological as well as from a human perspective there seems to be a need to go beyond technology receding to the background of our lives. In line with Shirkys' stance regarding new information and communication technologies, you are not a mere consumer when you download an app. You are participating in how the experience unfolds and users are starting to realise that. On the other hand one can sometimes have the impression that users want everything: participate, create, but a perfect interaction process at the same time (Lem, 2013).

Psychological knowledge and theories focusing on transformative processes are key for the design and the acceptance of interactive technologies for self-improvement. One central aspect of the behaviour change process is motivation (Shah & Gardner, 2008). Another relevant motivational technique to improve performance and support self-regulation is goal setting (Locke & Latham, 2006; Munson & Consolvo, 2012).

Furthermore, in line with classic therapeutic and coaching settings, the dialogue between product and user is essential for a successful process of change (e.g., Priebe & Mccabe, 2008). One would expect that verbal feedback would be comparable to any other extrinsic reward, like money. But when the feedback is given in a genuine way, from someone the recipient respects, it can become an intrinsic reward instead (Shirky, 2010). In contrast to more classic product attributes, such as pragmatic or hedonic characteristics (Diefenbach, Kolb & Hassenzahl, 2014), interactive technologies for self-improvement can potentially address eudaimonic well-being (Mekler & Hornbæk, 2016). This aspect can be relevant for consumer psychology (Diefenbach & Hassenzahl, 2017) as well as in light of user experience research (Müller, Mekler & Opwis, 2015).

Consequently, interactive technologies offer opportunities to support users throughout their change processes and on their way to improved well-being. But, as Conroy and colleagues showcased in a recent review, the application of theoretically founded, motivational approaches in top-ranked mobile apps for physical activity is still sparse (Conroy et al., 2014).

If a tool is useful users will use it (Shirky, 2010). Shirky said this referring to tools that have the potential to satisfy our needs as social beings, but I believe that it can be adapted to a wider range of technologies, such as self-improvement technologies. Thus, through aiming to integrate psychological factors in interactive systems we are investigating how to make these systems useful, and even more importantly, how to make them meaningful.

Hence, the present thesis strives to build an in-depth understanding of the usage of self-improvement technologies. The present inquiry aims to explore the influencing factors for designing self-improvement and well-being technologies with the means of psychological concepts (see figure 2.1).

3 PSYCHOLOGICAL FACTORS IN INTERACTIVE SYSTEMS

This thesis is at an intersection of two research fields — psychology and Human-Computer Interaction (HCI). Psychology emerged as a discipline in the late 19th century and it is the study of human behaviour, their mental processes and the relationship between the two. HCI emerged in the late 20th century and focuses on why and how humans use computers in their everyday life (Preece, Rogers & Sharp, 2015) and how to design for these interactions (Grudin, 2017). This includes building an understanding of (potential) users, crafting interactive artefacts and evaluating how users experience these artefacts (Rogers, 2012).

The overlap between the two disciplines has the potential to enrich the two research fields alike. Psychology endeavours to build an understanding of human behaviour in various contexts, whereas HCI aims to explore human behaviour with and mediated through computers. Technologies became ubiquitous parts of our everyday life, as we were able to observe in the last decades (Schmidt et al., 2012). This development unfolded its potential to become a fascinating and probably one of the most important research endeavours of the late 20th and the 21st century (Shirky, 2010; Bridle, 2018; Calvo & Peters, 2014).

Due to the rapid technological development, this interdisciplinary collaboration is not a potentially fruitful possibility but a necessity. Since the expertise of an HCI researcher or an interaction designer lies in building an understanding of the experience and behaviour of people in a specific context of use, one could say that a good designer can potentially be a good psychologist and the other way around. Both disciplines can learn from each other, if, and only if, they are able to accept their differences and are open-minded enough to perceive these differences as interesting or inspiring instead of as flaws that have to be accepted in sake of the cooperation or adjusted in the long run.

Given the historical development of psychology and HCI, the overlap between these two disciplines is unsurprising, but it does have the potential to enrich both research fields. Before first digital computers entered the consumer market a research discipline emerged that focused on ways how to make the way humans used tools more efficient, namely human factors and industrial psychology (Grudin, 2017). Lillian Gilbreth, a pioneer of the area, extended Taylor's scientific management (Taylor, 1914) with an emphasis on psychological aspects (Gilbreth, 1914). Engineering psychology emerged during

World War II and is today, amongst others, also known as Human Factors (Grudin, 2017).

That a productive cooperation between psychology and HCI is possible is, inter alia, mirrored in the successful adaption of psychological theory for HCI. One example that showcases this cooperation is activity theory. Activity theory has its roots in Soviet psychology and has been successfully adopted from HCI (Preece et al., 2015). Some of activity theories insights stem from Buddhism and the philosophical views of Hegel and Marx, amongst others (Kaptelinin & Nardi, 2012). Activity theory includes two models, the so-called individual model and one that focuses on the mediating role of artefacts (Preece et al., 2015). Activity theory structures activities in a hierarchical way, from operations to actions to activities. Operations are routinised behaviour, actions require more planning and activities provide the minimum meaningful context.

The insights regarding the minimum meaningful context of one or more actions can be utilised to design systems. These levels are not static in their nature, e.g. when an action becomes more automatic it can turn into operations and when the motive changes an activity can turn into an action (Kuutti, 1996).

Activity theory further postulates that the relationship between a subject and an object is mediated through the history of this relationship ('tool'). An additional aspect in the basic structure of an activity is the 'community', those who share the same objects. The relationship between the subject and the community is mediated by 'rule' and the relationship between the object and the community is mediated by the 'division of labour' (Engeström, 2001).

As a data analysis method activity theory can be challenging, since it does not introduce a clear methodological description and is therefore subjective in its application (Rogers, 2012). Nevertheless, if researchers are familiar with the theoretical principles it can be an enriching analytic tool (Preece et al., 2015). In addition to the successful application of activity theory in HCI, acitivity theory has also brought forth the Action Regulation Theory (Hacker, 2003). Action regulation theory aimed for the integration of cognitive concepts as well as concepts of behaviourism and social science. Hacker introduced the proposition to think about work in a holistic way and deems it as essential for personality development (Hacker, 2003).

Naturally, these disciplines evolved over time and today we can look back on a shift from ergonomics to experience, within and between disciplines. Due to the experiential reorientation within human-computer interaction, aspects beyond usability came into focus (Hassenzahl & Tractinsky, 2006). The differentiation between hedonic and pragmatic aspects of technologies originates from work in consumer research (Hirschman & Holbrook, 1982). The fields evolved from a cognitive, pragmatic or an usability focus, towards an affective, ex-

periential perspective, focusing on hedonic and recently eudaimonic aspects (Mekler & Hornbæk, 2016; Müller et al., 2015). Thus, a development process from usability, to positive user experience with more of a short-term nature, towards a focus on long-lasting positive user experience emerged.

Hedonic and pragmatic characteristics are not opposite poles but independent concepts (Ahtola, 1985). In their work Nisbett and Wilson explored how participants rated an instructor who gave a talk. They found that a halo effect can occur. Thus, if the evaluation regarding hedonic qualities was high, this lead to a higher evaluation regarding pragmatic qualities and vice versa (Nisbett & Wilson, 1977). This in turn does not mean however, that usability is more important than user experience, but instead showcases the relevance to take the multifaceted nature of experiences into account.

Experiential qualities can foster a positive product relationship and long-lasting pleasure (Mugge, Schoormans & Schifferstein, 2005). One way to design for positive experiences with interactive products is to take psychological need fulfilment into account (Hassenzahl, Diefenbach & Göritz, 2010).

Multiple psychologists have explored basic human needs. One of the best known is Maslow's Theory of Human Motivation. In his work he discussed five categories of basic human needs, namely physiological needs, safety needs, love and belonging, esteem and self-actualisation (Maslow, 1943). Another, more recent theory studying human needs is the Self-Determination Theory by Ryan and Deci (Ryan & Deci, 2000). In their work, the authors focused on three needs, namely autonomy, relatedness and competence. The theory engages with the question how to support intrinsic tendencies of humans to behave in healthy and effective ways (Ryan & Deci, 2000). In the context of interactive technologies, the theory of Sheldon and colleagues is of particular interest (Sheldon, Elliot, Kim & Kasser, 2001). The authors introduced ten psychological needs, self-esteem, relatedness, autonomy, competence, pleasure and stimulation, physical thriving, self-actualisation and meaning, security, popularity and influence, money and luxury. Based on their work, Hassenzahl and colleagues extracted seven needs and explored them as a source of positive experience with interactive products. The authors found a relationship between need fulfilment and positive experience and a link between need fulfilment and hedonic quality perception and pointed out that experiential qualities can be linked to other theories, such as flow theory (Hassenzahl et al., 2010).

We can observe that research and practice has moved on from viewing technologies as machines designed to do the users bidding and meant to be handled by experts, to ubiquitous technology that is meant to be operated by everyone and embedded in everyday routines (Calvo & Peters, 2014). Nowadays, concepts like well-being are taking the

stage and interdisciplinary research is crucial to designing technology that supports human flourishing on an individual level as well as on a global scale (Shneiderman, 2016).

Psychology can have a positive effect on the digital society through translating psychological theory to design (Calvo & Peters, 2014). The artefact-centred nature of HCI can be augmented to the more theory based psychological approach. Psychology can enhance the outreach of the discipline psychology and possibly produce more tangible results through adapting approaches from HCI. In the past, science, and here psychology is included, was considered research-oriented, whereas design and engineering were associated with practice. Today however, these borders are shifting (Shneiderman, 2016). In line with Ben Shneiderman I am convinced that a new generation of researchers is needed, one that is as committed to research excellence as much as they are committed to societal improvement (Shneiderman, 2016).

One challenge for both disciplines is to fit their research and design process into accepted methodological frameworks. Some research projects however do not fit into the predefined path from the subjective experience, to the striving for objective experience evaluation, back to the subjective experience at the end of this process, namely the interaction with the product. Design researchers in the HCI community are confronted with the challenge that new products are often not considered enough a contribution to count as research (B. Gaver & Bowers, 2012).

Whereas approaches of psychologists in HCI can be critically questioned regarding ideas how to make their findings actionable, how the knowledge can be applied in order to design better systems. Nevertheless, design research can lead to theory construction (Forlizzi, Zimmerman & Stolterman, 2009) and psychological knowledge can be applied in HCI in meaningful ways (Hekler, Klasnja, Froehlich & Buman, 2013). As a result, I argue for combining basic and applied research in order to produce research with high impact for academia and the society (Shneiderman, 2016). Technologies provide new research challenges, new means to study these developments, as well as new opportunities for researchers to collaborate (Shneiderman, 2016).

Reflecting about the design of new interactive technologies, Rogers emphasises that people should be in control of their activities, their interactions with the world, thus moving from reactive to proactive users (Rogers, 2006). This leads to the question if being engaged is connected to being in control. Do we have to be in control to be engaged, in line with the concept of flow (Csikszentmihalyi & Larson, 2014) or can we also be engaged when we are not in control? Since we are heading towards a time where we will not directly design the interaction but instead crafting the meta system that designs the interaction between product and user, this question becomes ever more relevant (Martelaro & Ju, 2018).

As Rogers pointed out we are confronted with a vast variability of human behaviour, their motives regarding their behaviour, how they take action and when (Rogers, 2006). Furthermore, scholars in psychology and HCI have recognised that the context of everyday life has an additional complex, fluid influence on behaviour (Rauthmann et al., 2014; Salvador & Anderson, 2003). Therefore, it remains a challenge to design truly smart systems that can accurately model and adequately react to people's needs in a given situation (Rogers, 2006).

In line with the definition of the WHO we moved towards an understanding of health not being the absence of diseases but instead the experience of physical and mental well-being [1]. HCI scholars call this phenomena wellth creation (E. Churchill et al., 2014). Interactive technologies have the potential to support this endeavour but are yet failing to do so in the long run (Jakicic et al., 2016; Diefenbach, 2018). One of many contemporary research questions is how human behaviour can be changed to increase wellness (Shneiderman, 2016). The question remains how this philosophy can be applied in the present thesis, how the striving for such a high goal can be realised in a meaningful way. Rogers suggested the approach to pursue less ambitious challenges and more practical goals in order to make the acquired knowledge actionable (Rogers, 2006). This work adapts her approach and aims to take small steps to move towards a fine-grained understanding of psychological factors in technologies that support well-being and everyday engagement.

The experiential turn within HCI was followed by a turn towards engagement (Bardzell, Bardzell, Pace & Karnell, 2008). But, based on a recent literature review, more than half of the recent works in HCI focusing on engagement are not providing a definition, partly due to the fuzziness of the concept (Doherty & Doherty, 2018). On the other hand, interaction designers and HCI scholars alike have applied and studied strategies to design for engagement, such as immersion, enabling exploration, supporting social connectedness and feedback modalities, amongst others (Doherty & Doherty, 2018).

3.1 FOSTERING ENGAGEMENT

To engage participants in activities and to explore the mechanisms behind engagement is an ongoing venture in psychology (e.g., Csikszentmihalyi & Larson, 2014) as well as in HCI research (e.g., Doherty & Doherty, 2018). Various psychological theories focus on engagement and have been successfully applied in HCI, such as flow theory (Csikszentmihalyi & Larson, 2014; Cowley, Charles, Black & Hickey, 2008) or self-determination theory (Ryan & Deci, 2000; Wiebe, Lamb, Hardy & Sharek, 2014).

1 https://www.who.int/about/mission/en/

When ongoing engagement is disrupted, self-determination theory states that coping mechanisms, such as effort or ego resources are required to regulate actions (E. Skinner & Edge, 2002). Here, a link between self-determination theory and flow theory can be established. Flow is defined as the experience of optimal fulfilment and engagement, a person in flow is in control of his actions. But, in contrast to how the needs competence and autonomy are described in self-determination theory, flow is not a direct awareness of mastery but can be described by not being concerned about a potential lack of control (Csikszentmihalyi & Larson, 2014). Flow is enabled through a perfect balance between the requirements of an activity and the (self-perceived) ability to perform this activity. The activity should be challenging enough but not too difficult. In order to stay in flow the focus has to be on a rather narrow stimulus field. When someone is bored, their attention would drift away. When experiencing anxiety one is likely to focus on the self, on insecurities or shortcomings, therefore the focus would shift, hindering engagement.

Yvonne Rogers is calling to move from Weiser's vision of calm computing towards engaging UbiComp experiences. She emphasises the need to reflect about our interactions with technology, to design them in exciting or even provocative ways to stimulate learning and critical thinking (Rogers, 2006). Her approach has the potential to offer a vision about how to deal with technology today, to move technology from the background to the foreground, to design them in stimulating or even provoking ways in order to foster reflection (Rogers, 2006).

Engagement occurs when the psychological needs, namely self-determination, competence and relatedness are met (E. A. Skinner & Belmont, 1993). In educational settings, engagement was described as the combination of high effort and a positive emotional tone during an activity (Reeve, 2002). Reeves states that, since the motivations underlying engagement cannot be directly observed (e.g., intrinsic motivation), engagement provides a useful manifestation (Reeve, 2002). This tangible benefit of the concept may also be one explanation for the interest in engagement in HCI. However, within HCI, engagement, a concept seemingly so closely but yet so intangibly linked to experience proves to be difficult to define (Doherty & Doherty, 2018) and similarly challenging to measure (O'Brien & Toms, 2013).

From a methodological point of view, studying engagement poses similar challenges as studying user experience. Firstly, we either measure engagement through some sort of proxy (O'Brien & Toms, 2013), or we measure engagement after we have asked participants to engage with the tool of interest (Bohus & Horvitz, 2009). Furthermore, the majority of the studies focused on engagement to date are brief experiments instead of longitudinal studies (Doherty & Doherty, 2018). However, previous research investigating engagement in long-term interventions found a significant decrease in engage-

ment over time (Bickmore, Schulman & Yin, 2010). This, in turn, can lead to an artificial, somewhat limited understanding of engagement. There are various conceptualisations of engagement and no consensus has been reached if engagement should be positioned as a cognitive, behavioural or emotional process (Doherty & Doherty, 2018).

Data representation can be a catalyst to foster engagement. Houben et al. make a case for vagueness and ambiguity to incentivise data exploration (Houben et al., 2016). One can draw a connection between ambiguity for reflection and ludic design. Gaver and colleagues emphasised that objects should be ambiguous and open-ended, offering different ways to interpret and make sense of them. In order to support people in finding their own meaning in activities, things should be designed in ways that avoid presenting users with clear meanings. The focus lies on the aesthetic experience and the sense making process. This, in turn, can lead to exploration and may support reflection (W. W. Gaver, Beaver & Benford, 2003). Since technologies for well-being mostly have a very clear purpose, integrating ambiguous elements into their design and staying open to various interpretations of how the artefact should be used (Sengers & Gaver, 2006) may proove to be challenging. I would argue, however, that it is not impossible. For example, if we think about activities that improve our well-being, this might can be achieved through going for a run, talking a relaxing bath, watching a movie or cooking a nice dinner. Thus, technology could support users making sense of themselves and what they need at a present moment, through supporting their reflection process, instead of pushing them to do one specific activity. But, this does not imply that ambiguous systems should confuse their users. Instead, ambiguity can be utilised when designing interactive systems to make the interaction with them thought-provoking and engaging (W. W. Gaver et al., 2003).

One potential way to combine these findings with psychological theory and implement them into interactive technologies for well-being and self-improvement is with the means of construal level theory (CLT) (Trope & Liberman, 2010). CLT assumes that construal levels are related to psychological distance, the distance of a stimulus from the perceiver's direct experience. The four dimensions of psychological distance are: spatial –– how distal in space the stimulus is from the perceiver, temporal –– how much time (past or future) separates the perceiver's present time and the target event, social –– how distinct a social object is from the perceiver's self (e.g., self vs. others, friend vs. stranger), hypotheticality –– how likely the target event is to happen (or an object to exist), or how close it is to the perceiver's reality (Trope & Liberman, 2010). In CLT, high level construals are viewed as relatively abstract. In comparison, low-level construals are relatively concrete. If an object is represented in a more abstract way certain features of it are omitted (Trope & Liberman, 2010). Fujita and Roberts (2010)

found a connection between the level of construal and self-control and S. J. Katz and Byrne (2013) point towards the potential of CLT for persuasion. Exploring ways to present information and feedback in different construal levels might lead to new findings of how to design for engagement and sense-making.

Another way to foster engagement is exploring ways for technologies to communicate purposeful feedback and support goal-setting in meaningful ways. This endeavour can be connected with flow theory, the highest goal regarding engagement. In order to experience flow the present activity should not be too difficult nor too easy; furthermore clear, reachable goals and meaningful feedback is needed (Nakamura & Csikszentmihalyi, 2009).

As mentioned above, investigating engagement is challenging and it becomes even more difficult when we are aiming to explore long-term engagement. Since conducting long-term studies in the context of behaviour change is challenging (Rogers, 2006), it is our goal to approach the diverse topic of technologies for well-being and self-improvement in versatile ways (regarding our research questions as well as our methodological approaches), in order to do the multifaceted topic justice.

3.2 PSYCHOLOGICAL CONCEPTS AND THEORIES USED IN THIS THESIS

I assume that, in order to design technologies that support users on their way to well-being and offer opportunities for long-term engagement, an in-depth understanding of psychological processes (e.g., well-being, trust in the technology, reflection), as well as sensible theory based decisions (communication style, construal level theory) are needed. The present thesis applies multiple psychological concepts and theories in the presented research. The following sections provide an overview of the utilised concepts.

3.2.1 Communication Style

Interpersonal communication plays an important role in the pursuit of change and improvement, be it in the classical therapeutic setting (Friedman, 1987), in counselling (Bamberger, 2011), or in leadership (Howard & Bray, 1990). This leads to the assumption that communication might also be of relevance in a technology-mediated process of behavioural change. When it comes to the interaction between humans and technologies, the reaction that users show towards technology are often similar to interpersonal behaviour (Nass et al., 1994; Fogg, 2002). In other words, humans interact socially with technical products (Nass et al., 1994), even when interacting with written

language, such as text on a computer screen (Nass, Moon, Fogg, Reeves & Dryer, 1995). Consequently, the similarities regarding the communication behaviour in human-human and human-technology interaction might can be applied to the field of self-improvement technologies and technology-mediated behavioural change. In this thesis I differentiate between content of a message and the communication style in which the message communicates the content, since both are crucial for the resulting perceptions and actions of the communication partners (Schulz von Thun, 1989).

Based on the importance of communication in therapeutic processes, a good relationship and fruitful communication between the self-improvement product and the user appears to be an important aspect of a successful change process. Thus, I assume that not only the content, but also the style of communication is crucial for the resulting perceptions and actions of the communication partners.

To operationalise communication style of interactive technologies for self-improvement, the present thesis builds on a model and a taxonomy from communication psychology from Schulz von Thun and Hofmann (Hofmann, 2011; Schulz von Thun, 1989).

Schulz von Thun (Schulz von Thun, 1989) introduces eight different communication styles, namely the needy-dependent communication style, the helpful communication style, the selfless communication style, the aggressive-demeaning communication style, the self-praising communication style, the determining-controlling communication style, the self-distancing communication style, and the communicative-dramatising communication style (see chapter 5 for a more detailed description).

The taxonomy introduced by Hofmann (2011) is based on the model from Schulz von Thun (1989). Hofmann narrowed the taxonomy down to seven different communication styles, namely self-centred communication, the dramatising communication style, the cooperative style of communication, the diligent communication style, the critical style of communication, the cooperative communication style, the rational-distanced communication style, the sensitive-avoiding communication style (see chapter 5 for a more detailed description).

Note, that these communication styles do not form distinct categories but instead most people combine tendencies of different styles.

In order to provide a compact taxonomy for the studies within this thesis six communication styles have been derived from the work of Hofmann and Schulz von Thun (Hofmann, 2011; Schulz von Thun, 1989). The derived communication styles of interactive technologies for self-improvement are the helpful-cooperative style, which is mainly about being helpful and caring; the diligent-determining-controlling style, which focuses on guiding and controlling its environment; the rational-distanced style, that aims to stay objective and rational; the critical-aggressive-demeaning style, which focuses on imperfections

Table 3.1: Psychological concepts and theories used in the papers included in this thesis.

Psychological Concept	Paper
Communication Style	I, II, III
Construal Level Theory	III
Trust in Technology	IV, VI
Positive & Negative Affect	I, II, III, IX
Hedonic & Eudaimonic Well-being	IV
Goal Commitment	II, III, V, VI
Reflection & Rumination	IV, V, VI, VII
Psychological Needs	VIII, IX
Temporality	IX

and weaknesses of others; the self-praising-dramatising style, which is impulsive and attention seeking; and the selfless-sensitive-avoiding style, which is kind and cautious. Since the communication style can be differentiated of the content of a message, feedback with the same content would be formulated differently dependent of the communication style that has been applied.

3.2.2 Feedback

Feedback is essential to help people strive for goals. For example, a doctor's feedback may influence whether or not health-related goals are pursued; a professor awards grades, which in turn help students decide how much effort the invest on studying for a test. Positive feedback focuses on achievements and strengths. Negative feedback focuses on weaknesses and lack of success. No consensus has yet been reached on whether positive or negative feedback has more benefits (Fishbach & Finkelstein, 2012).

For instance, negative feedback can increase the compensatory effort to achieve a goal. But, if negative feedback subsequently causes negative affect, this can lead to procrastination (Fishbach & Finkelstein, 2012) and to the prioritisation of immediate enjoyment, even if it counteracts the (long-term) goal (Sheeran & Webb, 2012).

Positive feedback can increase motivation by increasing goal attainment and perceiving the value of the target (Fishbach & Finkelstein, 2012). Positive feedback can also increase perceived self-efficacy, whereas negative feedback can reduce it (Fishbach & Finkelstein, 2012). In contrast, negative feedback can be seen as a signal of too little progress, which in turn can lead to more effort (Fishbach & Finkelstein, 2012).

To summarise, communication style and feedback can be differentiated. The communication style shapes the tone in which a message is given (e.g., friendly/cooperative style - 'Time to work out.' vs. critical/dominant style - 'You have to work out now!') and the focus of feedback research is on the content of a message (e.g., positive feedback - 'You did it once. If you continue practising you can do it twice.' Negative feedback - 'You are continually failing. You have to practise more, otherwise you don't stand a chance.'). Consequently a message given in a friendly communication style can still convey negative content and the other way around. This differentiation is a key aspect that differentiates my work from past efforts which mainly focused on different forms of feedback (Fishbach & Finkelstein, 2012).

3.2.3 Construal Level Theory

People can only directly experience what is happening in the present moment directly to themselves. Nevertheless, people are able to comprehend how someone else (e.g., a friend) is perceiving a situation and to be empathetic about it. Moreover, people are able to think about the past and plan for the future and these memories and plans guide my decisions and actions. Construal Level Theory (CLT, (Trope & Liberman, 2010, 2003)) postulates that we are able to understand the point of view of someone else and think about experiences that we are not experiencing directly in the present moment through forming abstract mental construals of distant objects (Trope & Liberman, 2010).

Abstract or so-called high-level construals are relatively abstract and superordinate mental representations compared with concrete, low-level construals, which involves focusing on central features and omitting more conrete features (Trope & Liberman, 2003). For example, a specific activity might is represented as 'taking some time to take a bath'(which is, in this case, a low-level construal) or as 'taking some time to relax', which is, in this case, a high-level construal, hence we omit the bath. For instance, when someone attempts to comprehend how a friend experienced a situation, this person is forming a mental construal of this psychologically distant situation (Trope & Liberman, 2010).

Psychological distance is subjective and has the self, in the present moment as its anchor. There are four different dimensions of psychological distance, namely time, space, social distance and hypotheticality. Thus, when a person is thinking about handing in their thesis today, compared to handing it in in two months the psychological distance increases, hence the mental construal regarding handing in the thesis would become more abstract. Psychological distance affects and is simultaneously affected by level of construal (Trope & Liberman, 2010).

More abstract construals often include information regarding the value of a situation or an object. Thus, it contains important information and is not simply more vague than concrete construal (Trope, Liberman & Wakslak, 2007). A vast body of research has empirically supported the reciprocal connection between psychological distance and construal level. These findings have been applied in various areas such as consumer behaviour (Trope et al., 2007), auditory perception (Hansen & Melzner, 2014) and self-control (Fujita & Roberts, 2010). Furthermore, the generative power of construal level theory has led to further theoretical developments such as the Construal Level Theory of Mobile Persuasion (S. J. Katz & Byrne, 2013).

3.2.4 Trust in Technology

Trust is an essential aspect of our everyday, which is reflected by the research interest in trust in various domains. Trust is composed of different facets, which can aid in building a better understanding of the concept (Lewis & Weigert, 1985). For instance, Castelfranchi and Falcone differentiate between rational and implicit trust (Castelfranchi & Falcone, 2010). A similar differentiation was also chosen by other researchers. Lewis and Weigert distinguish cognitive and affective trust (Lewis & Weigert, 1985), similar to McAllisters' differentiation between affect-based and cognition-based trust (McAllister, 1995). Cognition-based trust is based on cognition, in the sense that we consciously decide who we trust under specific circumstances. This decision is based on the assessment of the trustworthiness of the person (Lewis & Weigert, 1985), which in turn is based on past interactions with the person or social similarities (Zucker, 1986). In contrast, affect-based trust is based on attributions regarding the motives of people to behave in a specific way (McAllister, 1995). Previous research indicates that affect-based and cognition-based trust are causally related, but function in a unique way (McAllister, 1995)

When looking at trust in technology, similarities to the conceptualisation of interpersonal trust can be found. For instance, McKnight and colleagues differentiate between knowledge-based trust in technology and initial trust in technology (Mcknight, Carter, Thatcher & Clay, 2011). Initial trust in technology is build on assumptions regarding a specific technology, without having any experience with this particular technology (e.g., a person downloads a meditation app that guides him or her through meditation exercises and trusts that the advice from the app is meaningful and should be followed). In contrast, knowledge-based trust is based on experiences an individual already made with a specific technology (e.g., someone used a meditation app for two months and, with the support of the meditation app, developed the ability to reach a meditative state. Consequently, the person

trusts the app based on the positive experience he or she already made while using the technology) (Mcknight et al., 2011).

3.2.5 Well-being and Positive Affect

Subjective well-being consists of multiple components, namely life satisfaction, domain-specific satisfaction (e.g., work satisfaction), positive affect (often experiencing pleasant emotions and positive moods) and low levels of negative affect (Diener, 2000). Positive and negative affect are distinct factors (Diener, 1984) that contribute to well-being separately and should therefore be assessed separately. There are multiple methods to assess subjective well-being ranging from single item measures to multiple item measures such as the PANAS (Watson, Clark & Tellegen, 1988), to experience sampling methods (Stone, Schiffman, DeVries & Frijters, 1999) and physiological measures. Well-being or happiness is often defined as predominantly experiencing positive affect instead of negative affect (Bradburn, 1969). The state of feeling good or bad is called core affect. Subjective well-being is often defined as the predominant experience of positive affect and well-being is often defined as hedonic well-being these concepts are connected. Hence, they can be separated conceptually, but their connection should be kept in mind, when conducting research and interpreting results with a focus on well-being or positive affect.

Psychological research differentiates between two conceptualisations of well-being, hedonic and eudaimonic well-being (Waterman, 1993; Ryan & Deci, 2001). Hedonic well-being can be described as pleasure, enjoyment, presence of positive affect, absence of negative affect, and short moments of pleasure (Ryan & Deci, 2001). Eudaimonic well-being includes aspects such as personal growth, self-fulfilment, and (long-term) life satisfaction (Ryan & Deci, 2001). Hedonic and eudaimonic well-being are complementary psychological functions and not mutually exclusive (Huta, 2015).

Unlike many other products, self-improvement technologies have the potential to address eudamonic well-being. The reasons to use a technology for self-improvement and well-being may goes beyond the momentary pleasure of using it. Instead, using the technology can potentially lead to deep fulfilment and life satisfaction. On the other hand, using the technology can also come at a certain cost (e.g., going for a run on a cold, dark winter morning, because the fitness app pushed you to do so) but can lead to improved eudaimonic well-being (e.g., succeeding to follow your training plan and running a marathon). In other words, what the user wants to achieve by using the self-improvement product can go beyond the momentary experience of using of the product. Furthermore, Fowers and colleagues found that hedonic and eudaimonic well-being are directly related to goal orientation (Fowers, Mollica & Procacci, 2010). Hence, both well-being

concepts seem to be of interest when studying technology-supported self-improvement and will therefore be explored in this thesis.

3.2.6 Goal Commitment

Goal-setting theory postulates that the goal difficulty and the specificity of a goal influence performance (Locke & Latham, 1990). Goal difficulty is the knowledge and skill that is needed to be able to achieve a goal. Since people are in possession of different skill sets the same goal can be easy for one person and difficult for another (Latham & Locke, 1991). The more specific a goal is the more effective it is (Locke & Latham, 1990). Goals can affect performance through four mechanisms: directing the attention to goal-relevant activities, having an energising effect (e.g., pursuing high goals with more effort than low goals), affecting persistence and affecting action indirectly (e.g., using strategies relevant to achieve the goal) (Locke & Latham, 2002). Interestingly, goals are something we strive to attain and at the same time they can be used as a means to assess satisfaction. More precisely, if a person is trying to reach a specific goal, the same person will not be fully satisfied until he or she has reached this particular goal (Locke & Latham, 2002).

Goal commitment is a central aspect of goal-setting theory (Locke, Latham & Erez, 1988) and the relationship between performance and a goal is strongest when people are commited to their goal (Locke & Latham, 2002). Goal commitment is the determination to pursue and reach a goal (Locke et al., 1988). However, if there is no goal commitment, setting goals will not work (Locke & Latham, 2006). There are three main determinants of goal commitment: external factors (such as authority, external rewards), interactive factors (such as participation and competition), and internal factors (such as expectation, internal rewards) (Locke et al., 1988). These factors determine goal commitment, which in turn affects performance (Locke et al., 1988). Goal commitment can be enhanced through self-efficacy (believing in one's ability to achieve a specific goal) and through increasing the importance of the goal (Locke & Latham, 2002). Furthermore, goal-setting theory postulates that goal commitment decreases if a goal becomes too difficult or if the self-efficacy of a person decreases (Locke et al., 1988). In addition, feedback is needed in order for a goal to be effective.

3.2.7 Reflection & Rumination

Repetitive, recurrent thoughts circling about oneself can have positive consequences, such as developing health-promoting behaviour and negative consequences, such as anxiety (Watkins, 2008). Repetitive thought, focusing on oneself inter alia includes the constructs reflection

and rumination (Watkins, 2008). Reflection and rumination are distinct concepts (Trapnell & Campbell, 1999). Paying attention to oneself, can either be motivated by perceived threats, losses or injustice concerning the self (rumination) or motivated by curiosity or interest in oneself (reflection) (Trapnell & Campbell, 1999). Rumination can be defined as a from of self-focus and has a negative effect on problem-focused coping (Mor & Winquist, 2002).

Mindfulness, which can be defined as present moment awareness and a non-judgmental, accepting attitude (Kabat-Zinn & Hanh, 2009) was found to be negatively related to repetitive thought such as rumination (Evans & Segerstrom, 2011; Brown & Ryan, 2003). To date, ongoing efforts in Psychology explore when positively connoted self-reflection turns into rumination (Nolen-Hoeksema, Wisco & Lyubomirsky, 2008)

3.2.8 Psychological needs

Basic psychological needs are essential aspects of human functioning (Ryan & Deci, 2000). The satisfaction of psychological needs is related to motivation, well-being and a general healthy development (Gagné et al., 2015). Multiple theories focus on basic psychological needs (e.g. Maslow, 1943; Ryan & Deci, 2000). For instance, Maslow differentiates between psychological needs, safety, love, esteem and self-actualisation in his original theory of human motivation. In contrast, Basic Psychological Needs Theory, a sub-theory of Self-Determination Theory, postulates three basic psychological needs, namely autonomy, competence and relatedness (Ryan & Deci, 2000). Sheldon and colleagues explored ten psychological needs and found that autonomy, competence, relatedness, and self-esteem seem to be most important and satisfying. The authors also found that security seems to be of importance in times of privation. Pleasure-stimulation, self-actualisation-meaning, popularity-influence, and physical thriving and money-luxury were found to be of less importance.

In this thesis the differentiation of basic psychological needs in the context of interactive technology introduced by Hassenzahl et al. (2010) will be applied. Their conceptualisation is based on the work from Sheldon et al. (2001).The authors Hasenzahl, Diefenbach and Goeritz introduced seven psychological needs: competence, relatedness, popularity, stimulation, meaning, security and autonomy. These needs are relevant in the context of interactive technologies. The fulfilment of these needs in the context of interactive technology can lead to a more positive experience, which can be connected to positive engagement (Hassenzahl et al., 2010).

3.2.9 Time

Implicitly our research also touches on the psychological intricacies of time. Due to its fleeting nature time cannot be possessed like other things such as cars or books. This in turn makes it more valuable than other possessions, more valuable than money and highly relevant for interaction design. Since time passes independent of what we do with it, one might assume that people would be very careful how they spend their time, but often that does not seem to be the case (Boyd & Zimbardo, 2012). How people experience time is subjective and, inter alia, influenced by emotional state and social context. An admittedly simplified, but illustrative example for the subjectivity of time is the example of two friends. Two friends agree to meet at 2:00 pm. One of the two friends arrives at 2:00 pm, whereas the other friend arrives at 2:20 pm. Objectively there is no difference regarding the valence of 2:00 pm compared to 2:20 pm. However, since time is subjectively construed in regards to the social norms in which the two friends are living, the valence of arriving at 2:20 pm is negative. In order to add some structure and meaning to the continuous flow of time, people use frames, such as seasons, birthdays or singular events (e.g., handing in a thesis). Boyd and Zimbardo call this process Time Perspective (TP) (Boyd & Zimbardo, 2012). Maintaining a balanced time-perspective can be defined as the ability to switch among times frames (i,e., past, present, future) to adapt to the demands of the current situation (Boniwell & Zimbardo, 2004). Zimbardo and Boyd postulate that TP is a means to perceive and negotiate our social world and can support the maintenance of a healthy social network (Boyd & Zimbardo, 2012).

The authors postulate to stop for experiences and interactions that make us happy. They found that when people feel stressed or busy they limit time for their sleep, hobbies, friends, families and themselves. Building an understanding of users and eventually finding moments for them to pause for meaningful interaction will be addressed in chapter 13

4 RESEARCH QUESTIONS AND OVERVIEW OF THE THESIS

The present thesis attempts to unpack psychological factors of technologies that support well-being. More specifically, this means that I am investigating how psychological knowledge can be utilised to build an in-depth understanding of user behaviour and user needs. Furthermore, I am exploring ways how interactive technologies that support well-being can communicate feedback and aid its users throughout the goal setting process. In addition, I engage with different contextual factors, such as diverse user groups and understanding temporality of interactive technology usage. These inquiries can be understood as puzzle pieces meant to be combined to enrich the current understanding of technologies for well-being and to support the design of engaging interactive technologies.

In order to design for everyday engagement it is not necessarily needed to make users forget that they are interacting with a tool. Instead, they should be supported to be able to choose in what way they want to interact with their product and how the dialogue between their product and them should be designed. Previous research already extensively engaged with the effects of interpersonal feedback (Fishbach & Finkelstein, 2012). Furthermore, past work showed that humans show social behaviour when interacting with technologies (Nass et al., 1994). If we assume that humans perceive technologies in a social way, the one possible consequence would be that technologies for well-being and self-improvement may turn into an interactive coach or advisor. Thus, in line with the body of knowledge from therapy and coaching (Gerrig, Zimbardo, Zimbardo, Psychologue & Zimbardo, 2010), the dialogue between the product and its user seems to be a key factor in designing systems for well-being and to support human potential. Hence, this work explores the following research questions (see chapters 5,6):

- **RQ1**: Do users perceive the interaction with technology as a form of communication?
- **RQ2**: Are users able to perceive different communication styles when interacting with their well-being or self-improvement technologies?

  If that is so, the subsequent research question is;
- **RQ3**: What are the emotional and motivational consequences of different styles of communication for the user?

Goals, derived and formulated in a sensible way are essential for a meaningful and successful process of change (Locke & Latham, 2006) and therefore essential for designing engaging self-improvement technologies. Based on past research I hypothesise that the construal level of goal formulations affects the perception and effectiveness of goals. Furthermore, understanding how technologies can suggest self-improvement and well-being goals and how to communicate unmet goals can lead to building improved systems that support engagement (Agapie, Avrahami & Marlow, 2016). Moreover, to date, research identified a need to further understand how goals evolve over time (D. A. Epstein et al., 2015). These insights lead to the following research questions (see chapters 7,8, 9,10):

- **RQ4**: How does Level of Construal of feedback formulation affect psychological outcomes (e.g., goal commitment)?
- **RQ5**: How does goal attainment and failure affect psychological outcomes (e.g., goal commitment)?
- **RQ6**: How can a self-improvement technology communicate met and unmet goals in a meaningful way?
- **RQ7**: How are self-improvement goals connected to hedonic and eudaimonic well-being?

Humans are constantly connected to technology and engage in an increasing number of offline and online activities in everyday life. In order to build interactive artefacts that fit into users' everyday, an in-depth understanding of contextual and temporal dimensions of users daily lives is needed. We investigate these dimensions by means of the following research questions (see chapters 11,12,13):

- **RQ8**: How can an in-depth understanding of temporal and contextual factors of the usage of technologies for well-being and self-improvement be build?
- **RQ9**: How can psychological qualities utilised in the design of interactive technologies for well-being and self-improvement be designed for diverse user groups and varying contexts of use?

4.1 DISCLAIMER REGARDING THE METHODICAL APPROACH

Behavioural change and the adoption of well-being and self-improvement technologies is a long-term process. Hence, my inquiry is prone to some limitations. Due to the novelty effect in shorter studies that explore systems and due to the inherent challenges of conducting

long-term studies in the wild, my insights have to be interpreted with caution. The studies included in this thesis aim for an exploration on the intersection of psychology and HCI. Note however, that further studies are needed to inquire the generalisability of these findings. I applied a mixed-method approach, aiming to acquire rich insights. Through utilising a variety of methods (quantitative and qualitative), I was aiming to challenge my own results within studies and between the studies I conducted. Even though it is important for me to stress that my results represent an exploration and the interpretation of the results beyond the specific papers should be done with caution, I hope that my insights have the potential to spark new ideas that may lead to future research and potentially inspire the design of improved well-being and self-improvement systems.

4.2 A NOTE ABOUT TERMINOLOGY AND CONCEPTS

This research is crossing disciplinary borders. Since every research field uses its own terms, concepts and notions there is a need to clarify that, when I am referring to interactive technologies for well-being and self-improvement, this can include every system that can have a positive impact on the users mental or physical health. Thus, in line with the definition of the World Health Organisation, I am referring to 'a state of complete physical, mental,and social well-being, and not merely the absence of disease or infirmity.' Hence, the terminology used may refers to areas such as self-improvement technologies, positive computing, quantified self, persuasive technologies, behaviour change technology, personal informatics, self tracking, self surveillance, personal analytics, amongst others and in no particular order.

4.3 ETHICS STATEMENT

The research studies presented in this thesis followed the 'Ethical Principles of Psychologists and Code of Conduct' of the American Psychological Association. Participants were free to terminate participation at any time. Furthermore, all studies were designed in accordance with the Declaration of Helsinki (Association et al., 2013).

Part II

PUBLICATIONS

PAPER OVERVIEW

Table 4.1: The distribution of work in the papers included in this thesis.

Paper	Distribution of Work
I	Jasmin Niess carried out the interviews, performed the data analysis and drafted the manuscript. Sarah Diefenbach participated in the design of the study, helped to interpret the results and revised the manuscript for content and clarity.
II	This work is based on a student project from Vanessa Allwardt, Anna Fuhrmann, Natalie Hartung, Katharina Pfaffinger and Franziska Wittmann, supervised by Jasmin Niess and Sarah Diefenbach. Jasmin Niess supervised the conceptualisation of the mobile application, supervised the development of the study design and the data collection, performed the data analysis and drafted the manuscript. Sven Mayer developed the mobile application. Sarah Diefenbach supervised the development of the study design and edited the paper for content and clarity.
III	Jasmin Niess developed the study design, carried out the data collection, analysed the data and drafted the manuscript. Sarah Diefenbach contributed to the development of the study design and revised the manuscript for content and clarity.
IV	Jasmin Niess and Paweł W. Woźniak are joint first authors of this paper. They jointly conceptualised the work and conducted the various data gathering activities required for the work. They also performed quantitative and qualitative analysis for the purposes of the publication and drafted the manuscript.
V	Jasmin Niess developed the study design and conducted the data collection. Paweł W. Woźniak performed the data analysis. Jasmin Niess drafted the manuscript. Przemysław Piotr Kucharski developed the web-based data collection and survey tool.
VI	Jasmin Niess developed the study design. Kristina Knaving developed the visualisation prototypes. Paweł W. Woźniak conducted the data collection. Jasmin Niess performed the data analysis. Jasmin Niess drafted the manuscript with support from Paweł W. Woźniak and Kristina Knaving.
VII	Jasmin Niess developed the study design together with Paweł W. Woźniak Yomna Abdelrahman, Passant ElAgroudy and Sarah Diefenbach. Jasmin Niess conducted the data analysis and drafted the manuscript, together with Paweł W. Woźniak. Yomna Abdelrahman, Passant ElAgroudy and Yasmeen Abdrabou collected the data. Caroline Eckerth supported the data analysis. Kristina Knaving provided critical feedback on the manuscript.
VIII	Jasmin Niess and Sarah Diefenbach developed the study design and collected the data, supported by Kim Borrmann and Marietta Herzog. Jasmin Niess analysed the data, supported by Sarah Diefenbach and drafted the manuscript. Axel Platz provided critical feedback on the manuscript.
IX	Jasmin Niess and Paweł W. Woźniak developed the prototype, drafted the study design, collected the data, analysed it and drafted the manuscript.

Table 4.2: The research questions and contributions in the included papers.

RQs	Paper	Main Contribution
RQ 1 RQ 2 RQ 3	I	Qualitative study that explored communication style of self-improvement technologies. Interaction of technology perceived as communication (style), different communication styles have been perceived and connected to psychological consequences (e.g., positive affect).
RQ 1 RQ 2 RQ 3	II	Longitudinal field study (five weeks) evaluating a self-developed mobile fitness app that communicated fitness feedback in different communication styles. We found that different communication styles can be differentiated by the users. Friendly and dominant communication style had an effect on well-being and reported training sessions.
RQ 3 RQ 4 RQ 5 RQ 6	III	Quantitative online study that study found that a more abstract construal level lead to significantly higher goal commitment and positive affect compared to a more concrete level of construal, given the participants achieved their goal. Further, the results showed that friendly communication style resulted in significantly more goal commitment and positive affect than dominant communication style. In the negative situation the concrete construal level lead to a more positive affective response and no effect for communication style on goal commitment was found.
RQ 7	IV	Development of the Tracker Goal Evolution Model, which describes user practices around fitness tracker goals on three levels: Hedonic and eudaimonic needs, Qualitative goals and Quantitative goals. These three levels are connected with two transitions: manifestation and translation. The model can be used as a complement to models of personal informatics as it offers a new perspective on how a user's goals evolve through the journey through personal tracking.
RQ 5 RQ 6	V	Disclosing how a suggested tracker goal was computed resulted in significantly increased goal commitment and perceived transparency of the system. The study also found limited evidence that a transparent step goal also fostered trust in the system. The results show that there are complex trust dynamics involved in users contextualising and committing to a suggested step goal.
RQ 5 RQ 6	VI	Bar graphs offered a significantly better potential for reflection and interpretative charts triggered significantly more rumination. This implies that future trackers should use objective visualisation as the default data view. Ways how the design of future fitness trackers could account for occasionally unmet fitness tracker goals and create a meaningful long-term experience have been outlined.
RQ 8	VII	Users in the two groups differed in their desired level of independence, preference for social interactions around tracking and how they related to goal and metrics. Furthermore, the results highlighted a need for future trackers to offer more customisable experiences that take the diversity of users into account. To aid in that process, four design dimensions for fitness trackers that stem from our analysis have been proposed: Personal — Social, Tracker — User, Goal — Metric and Coach — Companion.
RQ 8	IX	Development and Evaluation of the Wheel of Everyday Interactions; a design tool that supports engaging with users' everyday interactions. The wheel supports engagement with the temporality of everyday interactions and is designed as a method for synthesizing user research during design sprints. It can also be used as a temporal companion to a persona.
RQ 9	VIII	Exploration of differences in perceptions of assistant technologies in work and private contexts and psychological factors for designing digital companions. Companions can assume different roles and the preferred role may depend on the context of use. There were two types of companions (active and passive), which are a continuum rather than a dichotomous variable.

5 PAPER I: COMMUNICATION STYLES OF INTERACTIVE TOOLS

This chapter is based on:
Niess, J., and Diefenbach, S. (2016). Communication styles of interactive tools for self-improvement. Psychology of Well-being, 6(1), 3.

Background: Interactive products for self-improvement (e.g., online trainings to reduce stress, fitness gadgets) have become increasingly popular among consumers and healthcare providers. In line with the idea of positive computing, these tools aim to support their users on their way to improved well-being and human flourishing. As an interdisciplinary domain, the design of self-improvement technologies requires psychological, technological, and design expertise. One needs to know how to support people in behavior change, and one needs to find ways to do this through technology design. However, as recent reviews show, the interlocking relationship between these disciplines is still improvable. Many existing technologies for self-improvement neglect psychological theory on behavior change, especially motivational factors are not sufficiently considered. To counteract this, we suggest a focus on the dialog and emerging communication between product and user, considering the self-improvement tool as an interactive coach and advisor.

Methods: The present qualitative interview study ($N = 18$) explored the user experience of self-improvement technologies. A special focus was on the perceived dialog between tool and user, which we analyzed in terms of models from communication psychology.

Results: Our findings show that users are sensible to the way the product 'speaks to them' and consider this as essential for their experience and successful change. Analysis revealed different communication styles of self-improvement tools (e.g., helpful- cooperative, rational-distanced, critical-aggressive), each linked to specific emotional consequences.

Conclusions: These findings form one starting point for a more psychologically founded design of self-improvement technology. On a more general level, our approach aims to contribute to a better integration of psychological and technological knowledge, and in consequence, supporting users on their way to enhanced well-being.

Keywords: Positive computing, Self-improvement technologies, Communication styles, Change success

5.1 BACKGROUND

Technologies for self-improvement have become an increasingly popular consumer product and tool of healthcare providers (e.g., Diefenbach, Niess & Mehner, 2016). In line with the general scope of positive computing and technology for well-being and human potential (e.g., Calvo & Peters, 2013; Sander, 2011), such products want to support their users in reaching personal goals like living more healthy, doing more sports, or taking the appropriate time for reflection and thankfulness during the day. SIMA, for example, is a mobile app which supports the user in integrating mindfulness into everyday life. Other forms of self-improvement tools are internet-based interventions in the context of occupational healthcare. For example, an online training for teachers enabled a significant reduction of sleep problems as well as an increase in recreational behavior and mental detachment from work (Thiart, Lehr, Ebert, Berking & Riper, 2015). Such examples reflect the high potential of technology to support human well-being and make it appear as a promising complement to more traditional forms of physical and mental healthcare provision (Monkaresi et al., 2013; Wiencke et al., 2014). Apart from these promises, the product category of self-improvement tools also com- prises some tricky challenges, especially when it comes to questions about concrete interaction design. This could be, for example, the manner of feedback which should be given to the user, the visualization of progress (or relapse) to create long term motivation, or the proper timing of feedback (IJsselsteijn, De Kort, Midden, Eggen & Van Den Hoven, 2006). As Kanis and Brinkman e.g., Kanis and Brinkman (2008) phrased it: 'There is clearly an opportunity to employ technology for positive change, but how this can be achieved is more difficult to determine'. As focusing on the complex and sensible issue of human behavior, the design of self-improvement technologies requires an interdisciplinary perspective and knowledge from different fields (e.g., psychology, design, human-computer interaction) must be integrated for the best solution possible (Calvo et al., 2014). In order to support positive change, not only technical solutions are needed to initiate positive behavior (e.g., reminders, feedback), but also a psychologically founded and motivating conceptualization of communication from product to user, and an adequate representation through design.

However, current reviews show that this is often not the case. For example, a review on physical activity apps showed a limited number of utilized behavior change techniques and a relative disregard of motivational compared to educational factors (Conroy et al., 2014).

Self-improvement technologies such as Sleepcare (Beun et al., 2016; Beun, 2012), explicitly built on theoretical knowledge from psychology and coaching, are rather exceptions. Sleepcare, for example, negotiates with users about an adequate amount of sleeping hours in parallel to a coaching process, copying the phases of alignment, plan and commit, and task execution. The moment a person chooses to improve their self and enhance their well-being with the help of an interactive product, the self-improvement tool transforms to an interactive coach and advisor with a responsible role. As one participant in the study by Beun et al. Beun et al. (2016) put it: 'It sounds kind of funny, but I had the feeling of a 'bond' with my coach, although I am very much aware that it's just an algorithm'. We believe that an explicit understanding of the interaction between tool and user as an 'act of communication' appears of vital importance for a sensible design of self-improvement technologies. Considering that, the interaction between tool and user actually represents a form of 'therapeutic intervention', i.e., a purposeful and systematic support of positive change, the product-user-relationship seems to be an important basis for this. Like in traditional face-to-face settings for coaching and therapy, where the emerging dialog between coach and client is acknowledged as an essential factor for the success of change (e.g., Lutz, 2010), this idea may be transferred to the dialog between self-improvement technologies and their users as well.

In the present paper, we explore the relevance and potential of communication between self-improvement tools and their users with the help of models from communication psychology. A first question is whether different self-improvement technologies use different styles of communication, and whether users perceive and discuss these. Furthermore, we elaborate on the emotional consequences of different styles of communication on the user's side and possible relations to specific purposes or needs. The following section summarizes relevant background theory on the relevance of dialog in human-computer interaction (HCI) as well as therapeutic settings and presents relevant models from communication psychology. Afterwards we present an interview study with 18 users of self-improvement tools, reporting on their experience and the perceived communication of the used technology. Finally, we discuss the present study's limitations and important issues for future research.

5.2 THEORETICAL BACKGROUND

5.2.1 The Relevance of Dialog and Interaction in HCI and Therapy

When interacting with technology, people often show reactions that correspond to behavior towards living beings (Fogg, 2002; Nass et

al., 1994). In other words, people interact with technology in a social way (Nass et al., 1994). For example, human-robot-interaction can trigger similar emotional and psychological reactions as human-human-interaction (Jung, Martelaro & Hinds, 2015). People are able to differentiate different communication styles used by robots, whereby user preferences for communication styles depend on the user's cultural background (P. P. Rau, Li & Li, 2009). For example, Chinese participants rated robots as more likeable and trustworthy when they used an implicit communication style-a finding that might also apply to human-human-communication (P. P. Rau et al., 2009). In an experiment of Nass et al. Nass et al. (1994) participants reacted to different computer voices as though they were different social actors, regardless if they were on the same or different computers.

The form of communication thus appears as a central aspect for the overall experience in human-computer interaction. Note, however, that verbal dialog is only one aspect that may affect the perceived communication or character of a product. For example, also written language (displayed on a computer screen) can evoke a more dominant or submissive impression of a computer's personality (Nass et al., 1995). And also different forms of physical interaction and related interaction attributes (e.g., slow vs. fast, gentle vs. powerful) come with particular experiential qualities (Lenz, Diefenbach & Hassenzahl, 2013), and may result in attributions of character such as attributions of interaction character like stubborn (Djajadiningrat, Matthews & Stienstra, 2007), more dominant or more elegant (Desmet, Nicolás & Schoormans, 2008).

In sum, there are many parallels in the perception of technology 'speaking' to people and human communication, which suggests the form of dialog as a relevant design factor. This especially pertains to the sensible field of technologies for self-improvement where interacting with a product becomes a form of digital therapy. A good relationship and fruitful communication between tool and user seems to be vital for change success.

In classical therapy, dialog has always played an important role. Sigmund Freud for example was using the dialog between himself and his patients as a central tool for his psychoanalysis (Friedman, 1987). Jung also admitted that the quality of the dialog is important, if the psychotherapy should be effective and equated therapy with a dialog between two persons (Friedman, 1987). Also Harlene Anderson, a US-American psychotherapist and founder of postmodern psychotherapy, emphasizes the dialog between therapist and patient as essential enabler for personal growth and well-being (Anderson, 1999). Also approaches to self-improvement and development opportunities in other areas, apart from therapy, e.g., leadership, cannot be imagined without a good and functioning dialog (von Rosenstiel, 2014).

All in all, not only content but also the style of communication is crucial for the resulting perceptions and actions of the communication partners.

5.2.2 Psychological Styles of Communication

In communication psychology, different models and taxonomies have been suggested to describe and distinguish different communication styles. In the following, we focus on two models, which later built the basis for our categorization scheme of communication styles of self-improvement technologies.

Schulz von Thun Schulz von Thun (1989) postulates eight different styles of communication: the needy- dependent communication style is about getting help and support from other people. People with this communication style present themselves as weak and helpless. The helpful communication style can be described as helpful, strong and resilient. Individuals with the selfless communication style consider themselves as irrelevant. Their feelings of being useful only manifest through the work they do on behalf of others. The aggressive-demeaning style of communication concentrates on the mistakes and weaknesses of others. For individuals with the self-praising style of communication it is important how they appear to other people. They constantly try to present themselves in the best possible light. People with the determining-controlling style of communication attach importance to rules, and they aim to control other human beings, as well as their environment. The self-distancing communication style is, as the name suggests, characterized through the importance of distance and a preference for a rational perspective. Individuals with the communicative-dramatizing style of communication like to be in the center of attention and tend to dramatize in their elaborations. However, the eight styles do not form distinct categories in those an individual uses only one style of communication all the time. Instead, Schulz von Thun Schulz von Thun (1989) suggests that most people combine tendencies of different styles.

Hofmann Hofmann (2011) based his taxonomy on the communication model of Schulz von Thun Schulz von Thun (1989). He narrowed the taxonomy slightly down to facilitate a better differentiation between the different styles, ending up with seven different styles of communication: Individuals with the self-centered style of communication are energetic and like to be in the center of attention. People with the dramatizing communication style live in a world full of color and intensity. They often show spontaneous and impulsive behavior. The cooperative style of communication is about being helpful and caring. The diligent communication style emphasizes the importance of principles. People with this style of communication aim to do everything 'the right way'. Individuals with the critical style of

communication display a gap between apparent and hidden behaviour patterns. At first glance they behave similarly to people with the co-operative communication style. But at a second glance they tend to behave rather sceptical and passive aggressive. Individuals with the rational-distanced communication style do not want to get to close to their fellow human-beings. It is important for them to stay objective and in control of their emotions. The sensitive-avoiding communication style can be characterized as kind, cautious and controlled.

5.2.3 Communication Styles in the Context of Self-Improvement Technologies

For several reasons, we think that the well-established taxonomy of communication styles by Schulz von Thun Schulz von Thun (1989) and the later simplification by Hofmann Hofmann (2011) might also be a useful lens on the communication of technologies for self-improvement. The definitions of styles are precise but still broad enough to integrate various aspects and ways a product might 'speak' to the user (e.g., voice output, textual reminders). Furthermore, Schulz von Thun Schulz von Thun (1989) puts emphasis on the situational context and the personality of the communicating person. We think that these two aspects are also essential aspects within a process of change or self-improvement.

Based on an expert discussion among psychologists on parallels and central characteristics of the different communication styles, we consolidated the styles, suggested by Schulz von Thun Schulz von Thun (1989) and Hofmann Hofmann (2011), into six communication styles. This was to provide a compact and convenient taxonomy for analysis, without neglecting central aspects of communication.

Table 5.1 presents the six summarized communication styles and short descriptions, which we used to analyze user reports in the domain of self-improvement technologies (see next sections).

5.3 RESEARCH QUESTIONS

Our analysis of the communication between self-improvement tools and users focused on three main research questions. (1) At first, we were interested to see to what degree users' actually perceive the interaction with technology as a form of communication, and whether we will be able to detect different communication styles in the user reports on their experiences with self-improvement technologies. (2) A second research interest was on the emotional consequences of different styles of communication for the user. This is based on the vital role of emotional change in classical therapy (Gerrig et al., 2010) and theoretical models of change processes (e.g., intentional change

Table 5.1: Summarized styles of communication and short descriptions

Style of communication	Short description
Helpful — cooperative	Is about helping and caring for other people
Diligent — determining-controlling	Is about guiding and controlling the environment
Rational — distanced	Considers all aspects from an objective, austere perspective
Critical — aggressive-demeaning	Focuses on imperfections and weaknesses of other people
Self-praising — dramatizing	Is impulsive and loves being the center of attention
Selfless — sensitive-avoiding	Is always kind and controlled

theory (Boyatzis, 2006)). (3) Finally, we aimed to explore possible relations between different communication styles and individual purposes or needs, e.g., whether the preferred style of communication depends on the kind of goal a user wants to achieve. In sum, we aimed to explore to what degree communication style may affect and influence the effectiveness of self-improvement tools, and whether models from communication psychology are useful to describe and (taking a future perspective) inspire the design of such technology.

5.4 METHODS

5.4.1 Participants and Procedure

We conducted 18 semi-structured in-depth interviews with users (nine female, nine male) of self-improvement-technologies (e.g., mobile apps). The mean age of the participants was 29.83 years ($SD = 10.48$, $min = 16$, $max = 58$). The sample included students in different fields (e.g., economics), employees in various areas (e.g., public sector) and one school student. Each participant was given a pseudonym and was assured of anonymity and confidentiality. Study participation was voluntarily and there was no incentive. The interviews were conducted in a quiet environment and special emphasis was placed on a relaxed and open atmosphere. All interviews were held by the first author, holding a master's degree in psychology and being trained in interviewing techniques.

Each interview started with some broad, open questions about the theme of interest. The participants were asked to name some interactive tools for self-improvement they know or recently had tried. In succession they were asked to pick one they used themselves and to describe it in more detail. Thereupon the interview focused on the perception of character and communication-style of this tool. In the last part of the interview, the questions got more specific and concentrated on different styles of communication, orientated on the taxonomy

listed in Table 5.1. Note that this structure helped to manoeuvre through the interview, but had not necessarily to be followed. To gain a deeper understanding of the theme it was the responsibility of the interviewer to enable the narrative thread of each participant and to guide him back to the subject of interest (Witzel, 2000). The interviews were audiotaped and lasted between 20 and 60 min (mean duration = 37.3*min*, SD=13.15).

5.4.2 Analytic Strategy

The interviews were fully transcribed with the transcription software f4. Data analysis included two steps. The first step was a non-focused, summarizing content analysis (Mayring, 2014) across the whole of interview data, including the following sub-steps:

- Paraphrasing of content-bearing text passages to the intended abstraction level (note that we checked every time before we wrote a new paraphrase down, if it is possible to include a new paraphrase to those who have been made already.
- Collation of the new paraphrases as a category system and the re-testing of the paraphrases as a category system.

The non-focused, summarizing content analysis (Mayring, 2014) was conducted to detect potential further recurring issues of relevance related to the topic of using self-improvement tools. Categories were communication between the tool and the user, usage motivation, frequency of use, the goal of the user and the consequences for the user and areas of use.

In a second step we implemented a structuring content analysis (Mayring, 2014), with a focus on the product-user-dialog. We used the six styles of communication (Table 5.1) to categorize those interview statements referring to the communication/dialog between product and user. Short descriptions and keywords related to the six styles of communication facilitated the coding process. Besides the six styles, the category system also included an open category in case there would be content which is unmatchable to the categories of the theory-based taxonomy. However, results showed that all statements concerning the communication between the interactive tool and the user could be assigned to one of the six theory-based categories.

The reliability of the allocation of statements to the categories of the category-system was verified by passing the allocation task to an independent rater holding a PhD in physics and a bachelor's degree in philosophy. The independent rater again processed 50% of the material, i.e. nine interviews, the interrater agreement was satisfying (Cohen's Kappa = .85).

Figure 5.1: Self-improvement categories and sample products

5.5 RESULTS

All statements regarding the communication between the interactive tool and the user were successfully assigned to the six different styles of communication (see Table 5.2 for sample statements). General statements on the importance of dialog further underlined the relevance of the topic. Thus, regarding research question 1, it can be concluded that users perceive the interaction with self-improvement technology as a form of dialog about their goals and progress and are sensible to the style of communication. Also, the interviews revealed particular emotional consequences for each of the styles (research question 2) and relations to individual goal characteristics, such as long term versus short term goals (research question 3). The participants mentioned self-improvement technologies from various fields. All six fields of usage and one mentioned sample product for each category are presented in Figure 5.1.

In the following, we describe such findings in more detail. We open with the general relevance of dialog. After this, we discuss the prevalence of the six different styles of communication and central aspects. Emotional consequences and relations to goal characteristics are exemplified by two styles of communication, i.e., helpful-cooperative and critical-aggressive-demeaning.

5.5.1 General Relevance of Dialog

Interview data confirmed the dialog as a central element within the interaction between self-improvement product and user. Participants noticed the way a product speaks to them and perceived it as an important factor for long term use and their process of self-improvement. Julian for example stated that the presetting somehow determines how the app talks to you.

> *What matters is, what kind of presetting you are selecting. You are able to choose how you want to be addressed or contacted by the app. (Julian)*

In line with our conceptualization of self-improvement tools as an interactive coach and a partner on the way to improved well-being, Simone explained:

> *Some people want to use the tool because they don't have a training partner. So the app is becoming their training partner or their nutrition coach. It's different when the app counts your working hours or your calories. It's the app as some kind of calculator or machine, versus the app as some kind of partner. (Simone)*

Also, participants saw a relation between the form of dialog and a successful usage history. For example, Dinah reflected:

> *I usually quit the apps after some time, because something is bothering me, I don't know, maybe it has actually something to do with the communication. (Dinah)*

5.5.2 Different Styles of Communication

The most prevalent styles were the helpful–cooperative, the diligent-determining-controlling and the rational-distanced style of communication. The helpful-cooperative style of communication was mentioned by 83% of the participants. The least represented communication style was the selfless-sensitive-avoiding, mentioned by only two out of 18 participants (11%). Participants' narrations revealed typical reoccurring issues and characterizations for the different styles, such as "a personal trainer" for the diligent-determining-controlling communication style or "a neutral assistant" for the rational distanced style of communication. Table 5.2 presents the six summarized communication styles, the frequency of total mentions and number of participants mentioning each style, as well as exemplary statements.

5.5.3 Emotional Consequences and Relations to Goal Characteristics

Regarding emotional consequences (research question 2) and relations to goal characteristics (research question 3), clusters of communication styles with similar consequences could be detected: For example, the diligent-determining-controlling, the rational-distanced and especially the helpful-cooperative style evoked mainly positive emotions. On the contrary, the consequences of the critical-aggressive-demeaning style of communication were described negative by some people and positive by others.

Regarding relations to goal characteristics, the data suggests that the preferred style of communication is linked not so much to the field of usage as to the individual goal of the user. For example, it seems more relevant in what time you aim to achieve a goal (e.g., 2 weeks

Table 5.2: Six styles of communication in self-improvement tools

Style of communication	Frequency: mentions (participants)	Central aspects, characterizations	Sample statement
Helpful-cooperative	41 (15)	Friendly instructor, motivator, caring	Then it said something like: It's not that bad. It happens. Have you checked your water intake and your vegetable consumption? Keep that in mind. If this doesn't help, try eating less fruit and more vegetables. Advice like that.
Diligent-determining-controlling	33 (13)	Personal trainer, strict	I wouldn't call it a drill sergeant, but it is a bit like a personal trainer, who tells you to work out now, about the upcoming exercise and how long it will take and when to take breaks, but it's also motivating.
Rational-distanced	21 (11)	Neutral assistant, reasonable	The app is quite neutral and rational, less personal.
Critical-aggressive-demeaning	17 (8)	Drill sergeant, mean, tough	It just shows you your slowest time of your entire run and there is a tortoise symbol and the fastest part has [...] a hare symbol or something similar. That is somehow mean and rubs salt into the wound.
Self-praising-dramatizing	11 (7)	Drama queen, exaggerating	Today you have exceeded your daily limit. And then there is always this notification: If you ate that or that over the next few days and weeks, you would weigh so or so much. So it likes to dramatize things as well.
Selfless-sensitive-avoiding	2 (2)	Cautious, timid	It (the product) tries to address this uncomfortable topic in a very kind, reserved way

versus 6 months) than in what area you want to improve (e.g., sports, nutrition). More specifically, participants' statements suggest that long-term goals go well with "softer" styles of communication (e.g., helpful-cooperative. rational-distanced) whereas short-term goals with the need for quick results go well with "harder" styles of communication (e.g., critical-aggressive-demeaning).

In the following, these relations are exemplified in more detail for two styles of communication. As useful representations of the broad spectrum of communication a tool can provide and in order to highlight the different consequences; we chose to contrast the helpful-cooperative style and the critical-aggressive-demeaning style.

5.5.4 Helpful-Cooperative Style of Communication

The helpful-cooperative style of communication is about helping and caring for other people. The communication style is polite, diplomatic, as well as resilient. Dinah, for example, described how she got some advice from her interactive product for self-improvement, in a nice and polite way:

> [. . .] *for example when it [the weight of the user] had stagnated or increased in some kind of way. Then it said something like: "It's not that bad. It happens. Have you checked your water intake and your vegetable consumption? Keep that in mind. If this doesn't help, try eating less fruit and more vegetables. Advices like that. (Dinah)*

Typically, the app is described as a friendly and motivated instructor, who also provides helpful feedback, for example, at the end of a run.

> [. . .] *like a fitness instructor* [. . .]. *Somebody that keeps hopping on one foot and then the other and wants to take me out for a run and runs beside me and keeps saying: You're doing fine. Keep up the good work!" When using the app it's also like that: now that I use an instructor in the app, a real instructor gives you feedback in the end and says: "Hey, good job seeing it through. That was a really good run. That's probably why I imagine it that way. (Flora)*

Eight participants explicitly referred to emotional consequences of that helpful-cooperative style of communication. The mentioned emotions were mainly positive, as demonstrated by the following statement.

> *It (the helpful-cooperative style of communication) has a positive effect. The emotions are. . . well I feel motivated and encouraged and afterwards I'm very pleased with my performance. (Flora)*

At this point it is important to emphasize that all the eight participants who had experienced the helpful-cooperative communication style as positive pursued long-term goals (e.g., pursuing a healthier lifestyle, managing and organizing free time, working hours and time for

studying over a couple of semesters in order to achieve the best possible outcome).

5.5.5 Critical-Aggressive-Demeaning Style of Communication

The critical-aggressive-demeaning style of communication focuses on imperfections and weaknesses of other people. People with this style of communication use the deficiencies of other people to make them feel small and insignificant. Within the domain of self-improvement tools, this could be, for example, a critical side blow from a running app:

> *Sometimes it can be a bit mean, there is one track where you have been your slowest and it will show you a tortoise symbol and stuff like that* [...]. *It just shows you your slowest time of your entire run and there is a tortoise symbol and the fastest part has a* [...] *hare symbol or something similar. That is somehow mean and rubs salt into the wound. (Laura)*

Similarly, Fabian talked about the demeaning style of communication of the abdominal muscle training program:

> *There is this abdominal muscle training program, also by Runtastic. That one is definitely male. That's what I'd attribute to it* [...]. *Also this program shows no mercy,* [...] *you are lying there and your legs are above your head and you think: "Actually, this hurts a lot" It just keeps going on and on and on. (Fabian)*

Four participants reflected on the emotional consequences of the critical-aggressive-demeaning style of communication, showing ambivalent perceptions. The ambivalence towards this communication style is reflected in the following statement.

> *Exactly, I am not that kind of/for example Chris is accessible for this, he is the bootcamp kind of guy, being yelled at and so on. He becomes totally aggressive, but very motivated at the same time. And I am becoming defiant and lose interest completely. (Dinah)*

The goals of the users mentioning this communication style were mixed. Five out of eight users pursued long-term goals and attributed negative emotional consequences to the critical-aggressive-demeaning communication style. Three of the eight users pursued short-term goals and described the emotional consequences as "not pleasant" but "very effective", so it seems to be the right form of communication for some participants in order to reach their goals.

5.6 DISCUSSION

The findings of the present interview study ($N = 18$) revealed, that users perceive the interaction with self-improvement tools as form of communication and they are able to distinguish between different communication styles (research question 1). Furthermore, the way a self-improvement product speaks to its user can possibly influence the effectiveness of the self-improvement tool. There seems to be a connection between the specific style of communication and emotional consequences of the user (research question 2). Additionally, the individual goal a user is pursuing seems to be connected to the preference of one communication style over another (research question 3). In order to analyze our data we used typologies of communication psychology. We see our findings as one possible starting point to inform designers of self-improvement technologies about the importance of communication aspects. Beyond the general relevance of the perceived communication, a particular important aspect to consider seems to be the type of self-improvement goal and its particular characteristics.

Our findings suggest a connection between the type of goal users are pursuing (long-term goals vs. short-term goals) and the preferred style of communication (e.g., helpful–cooperative vs. critical-aggressive-demeaning). On a more general level, it would be interesting to compare communication styles making use of intrinsic motivation techniques and communication styles making use of extrinsic motivation techniques (Monkaresi et al., 2013). While extrinsic motivation techniques may work best for fast changes (i.e., short-term goals), long-term goals may require communication techniques with a focus on intrinsic motivation. For example, in the present study, one participant had the short-term goal to get a six-pack as fast as possible, to look good on the beach vacation. He deliberately chose a very "strict" mobile app with a hard communication style (i.e., critical-aggressive-demeaning) in order to achieve this goal in the quickest possible way. Several users pursuing short-term goals described the critical-aggressive-demeaning communication style as unpleasant but effective. In contrast, long-term goals might require another form of communication. For example, one participant pursued the long-term goal of playing the guitar on a regular basis. She was intrinsically motivated and preferred the rational-distanced communication style, because she does "not need a motivator", she only needs "a little support organizing her practice time". One possible implication could be to offer alternative versions of the same tool, providing the "right" style of communication, depending on the user's specific goal.

Apart from the connection between the kind of goal a user pursues and the preference of one communication style over another, personality traits may also affect such preferences. Maybe there are some users

that would consider the critical-aggressive-demeaning style as quite effective, but are not able to handle that kind of interaction.

However, a tricky question seems to determine which communication style is the "right" one for which user. One position could be to assign this responsibility to the user, which was also what some of our participants demanded. Anna, for example, wished for a product that "You can personally set how you like it, to personalize your product. I mean, I think it would be good if you could really set the tool exactly how you like it, to adapt it to your needs". This is in line with the assumptions from solution-focused coaching (Bamberger, 2011), seeing the client as the expert for his life and knowing best what he or she needs to flourish. Indeed, there are also some examples of such self-improvement tools, putting a high responsibility in goal setting and self-regulation to the user. For example, the mobile app MoveMyDay allows the user to set their own, realistic goals concerning their physical activity, in order to lead to a higher performance (Herrmanny, Ziegler & Dogangün, 2016). However, there are also studies suggesting that users/coaches might not be the best experts for themselves when it is about choosing an effective approach for change. For example, studies in the field of coaching showed no advantages for coaching success depending on whether the intervention/way of goal attainment was self-selected or not (Silberman, 2007) (Silberman 2007).

A possible midway between one-fits-all solutions and total customization of self-improvement tools could include a brief analysis before the intervention starts, asking the user a few questions about their motives and their goals (Burke & Linley, 2007). Self-improvement technologies thus could supply general basic approaches and complement those with options for individualization for single aspects (Desmet & Pohlmeyer, 2013). The individual adaptation of the "coaching approach" can make the user feel more included and respected, and in turn increase the general commitment towards the intervention (Bamberger, 2011).

5.7 LIMITATIONS AND FUTURE RESEARCH

The study is subject to some limitations, which need to be addressed in future research. First, the present categorization of six styles of communication, based on models from communication psychology, and here applied in the domain of self-improvement tools, must be seen as preliminary. Though it served as a helpful frame to categorize participants 'descriptions of their products' perceived communication with satisfactory interrater agreement, next steps of research should critically test and further develop the present taxonomy. For example, to make it a more convenient taxonomy, further studies could aim for a reduction to the most common communication styles in the area of

interactive technology (or more specifically, self-improvement tools). Also, we would aim for clearer descriptions and definitions of the different communication styles in the technology domain, to make it easy to apply for other researchers as well.

Another limitation of the present study refers to the sample, mainly built of students younger than 35 years. Though self-improvement tools are indeed especially popular among younger users (C. Rau, Neyer & Möslein, 2012), further studies among more heterogeneous samples are recommendable. Especially the group of the elderly could profit from self-improvement technologies, for example to track their medication intake, reduce insomnia or support physical activity.

Finally, further insights are required regarding the usefulness of different communication styles depending on the users' specific goal and/or personal characteristics. While the present study revealed the differentiation between short-term and long-term goals as relevant, also the intensity of the desire to change or to improve oneself might affect the preferred or most effective style of communication. In sum, the present results already confirm the communication style of interactive products for self-improvement as an important aspect for a successful usage/change story. However, further research needs to substantiate the present findings and to provide grounding for the transformation of desired communication into design guidelines.

5.8 CONCLUSION

Surprised by the lack of psychological foundation of many existing technologies for self-improvement Conroy et al. (2014), the present research explored the dialog between product and user as a psychological factor with potentially high relevance. It showed that comparable to the dialog between coach and client, a product is only supportive in changing behavior if it speaks the "right language". Different styles of communication come with particular emotional consequences, and thereby form one possible contributing factor for the success and endured use of self-improvement tools. We suggest models from communication psychology as a helpful frame to describe the user product dialog. The herein applied approach is not restricted to the field of tools for self-improvement and change. Instead, it provides a specific perspective on the dialog between product and user that may be helpful in different areas of positive computing or interactive technologies in general. As such, our work forms one example of how psychological theory can be utilized in the field of user experience research and technology for well-being. We hope that the present approach will be helpful and inspiring for others and can add to a more intense interdisciplinary exchange, sharing the common vision of seeing technology as a means to enhance people's well-being.

6 PAPER II: COMMUNICATION STYLE, PHYSICAL ACTIVITY AND WELL-BEING

This chapter is based on:
Niess, J., Mayer, S., and Diefenbach, S. The impact of the "communication style" of a mobile fitness app on physical activity and well-being:A longitudinal study. Submitted for review.

6.1 ABSTRACT

Self-improvement technologies such as mobile fitness apps, sports wearables and trackers are regarded as a promising way to support well-being and positive behaviour change. However, research on relevant design factors and related psychological mechanisms is still limited. In human interactions, communication constitutes an important factor in supporting the process of change in various fields such as coaching, therapy or leadership. Similarly, the communication style of supporting technologies, i.e. the way they provide feedback and interact with the user, must also be a central design factor.

Previous research has shown that humans react to technical artefacts in a social way, applying norms from human-human interaction. In addition, it has been found that users differentiate between different communication styles of interactive technologies (e.g., friendly, dominant) and perceive the way a technology communicates as a relevant factor for subjectively successful change. However, to date, research is yet to explore the role of communication style in how interactive technologies that play the role of a sports coach or assistant can support positive change.

To address this challenge, we conducted a longitudinal between-subjects experimental field study (with $N = 69$ participants completing the study) and explored the impact of the communication style of a mobile fitness app on well-being and physical activity over five weeks. We designed and implemented a mobile fitness application for logging sport sessions. We manipulated the communication style of the application systematically (friendly vs. dominant). The application

sent push notifications and feedback that was given after the user reported a sport session.

We found that the communication style of the mobile application had a significant effect on reported total well-being and on the reported number of physical activities that the users performed during the study period. No effect of communication style of the intervention on reported sport duration was found.

We discuss our findings in the context of psychological theories and general challenges of field studies and Positive Computing/Technology. Subsequently, we present ways forward for practice and research for an increased understanding of user needs in terms of communication for e-coaching systems. Further, we show the implications of our work for supporting the design of interactive technologies that foster well-being.

6.2 INTRODUCTION

The positive influence of regular physical activity on psychological and physiological well-being and overall health is widely recognized (E. F. Churchill et al., 2015). Thus, increasing physical activity is a relevant topic on a socio-political as well as on an individual level. A steadily increasing number of self-improvement technologies (e.g., mobile apps, sport wearables, and trackers) available on the consumer market shows a need to understand them further. While these technologies have the potential to support users on their way to self-improvement and enhance their well-being (I. Li, Froehlich, Larsen, Grevet & Ramirez, 2013), empirical field studies often report limited success. For example, one study reported that people struggled to use their fitness-tracking device for more than two weeks (Gouveia, Karapanos & Hassenzahl, 2015b). Moreover, long-term studies in the medical field have shown that the benefits of health improvement technologies are limited (Jakicic et al., 2016). Epstein and colleagues showed that fitness tracker users were highly likely to experience one or more episodes of lapsing throughout their fitness tracking experience (D. A. Epstein, Kang, Pina, Fogarty & Munson, 2016). They emphasized that it should have been investigated how reengagement could be appropriately facilitated in order to create a more positive experience when returning to tracking. In addition, current reviews have shown that psychological factors are underrepresented in the design of self-improvement technologies (Conroy et al., 2014). A sensible design of self-improvement products with a psychological focus is important to address this challenge and take a step in the direction of building better systems that enable users to follow their path to improved well-being in the long run.

In this paper, we investigate how a self-improvement technology can foster well-being through providing the right communication with the user. Based on findings that showed that humans exhibit social reactions when they interact with technologies (Fogg, 2002; Z. Li & Li, 2014), we argue that the way the product and the user interact with each other is an important aspect to consider. Consequently, we explore the way the tool communicates with the user, i.e. the communication style. Providing effective feedback and studying its effects is an established research question in psychology (Kluger & DeNisi, 1996).

However, past research has not fully explored what factors contribute to building feedback that results in effective and sustained self-improvement. Therefore, understanding how interactive systems should communicate with the user to foster effective self-improvement emerges as a challenge for psychology. As recent research shows that users of self-improvement technologies are able to discern different styles in which the technology communicates with them (Diefenbach et al., 2016), we explore how the communication style affects the experience and the effectiveness of an interactive technology for fostering physical activity. The distinction between communication style and feedback is that communication style determines the tone in which a message is given (e.g., friendly tone), whereas feedback type determines the content of a message (e.g., emphasizing success).

We observe that the potential fidelity of technical devices is steadily increasing due to technical advancement. As a result, technologies can communicate with users in more advanced ways, even establishing a personal connection with the human (Woolf et al., 2009). The higher the fidelity, the higher the refinement of the way a self-improvement tool may interact with the user. Consequently, current interactive technologies can communicate with users in intricate ways and offer a complex communication experience. This leads to the necessity of differentiating between feedback and communication style. Furthermore, these aspects can be finely controlled in a self-improvement product, with the interactive technology assuming different roles once reserved to human experts.

We recognise that the question of how an interactive product can assume roles such as a coach or advisor is a highly complex one. In this work, we explore a key aspect of how users perceive the technology – the communication style - to contribute to a better understanding of self-improvement technologies. As self-improvement technologies are deeply embedded within the usage context, studying them with controlled experiments may introduce bias or limit the scope of the inquiry. Hence, ecological validity is key when building such an understanding. This paper uses an in-situ study to investigate the role of communication style in self-improvement technologies. Past research has shown that while such studies generate certain difficulties,

they offer unique insights into the practices of users (Rogers et al., 2007). These motivations prompted us to deploy a custom mobile phone application as part of our inquiry. In the remainder of this paper, we first present related work. Next, we provide the details of the method used. Afterwards, we present the results of the study. Then, the paper discusses the results, followed by the limitations and future research sections and the conclusion.

6.3 RELATED WORK

In this section, we first give a brief overview of two academic concepts that inspire our research: Positive Technology and Positive Computing. Next, we present past research that investigates the design of self-improvement technologies. Further, we discuss past findings about feedback and the importance of communication in the fields of coaching and therapeutical settings as well as in Human-Computer Interaction (HCI) as an important foundation for our work.

6.3.1 Positive Technologies: Technologies to Foster Positive Change

In a world where basic human needs are fulfilled, people strive for more complex goals. The focus of research has shifted from preventing diseases to promoting a healthy lifestyle and supporting people on their way to enhanced well-being (Delle Fave, Brdar, Freire, Vella-Brodrick & Wissing, 2011). Today, technologies have the potential to support users in this endeavour, aided by past research that explored how to design, build and understand technologies for self-improvement. Various technologies with many goals can be found on the consumer market. These tools support, inter alia, healthier eating, better sleep, improving fitness training, improving time management and managing stress levels. Consequently, we observe two emerging fields with similar interests: Positive Computing (Calvo & Peters, 2014) and Positive Technology (Riva, Villani, Cipresso & Gaggioli, 2016). While quite close in their goals and methods, these areas are defined differently:

'Positive Computing: The research and development of technology to support wellbeing and human potential.' (Riva et al., 2016)

'Positive Technology: The use of technology to manipulate and enhance the features of our personal experience, by manipulating presence and social presence, for increasing wellness, and generating strength and resilience in individuals, organisations and society.' (Riva et al., 2016)

In this work, we address the goals postulated by Positive Technology and Positive Computing, i.e. the research, development and use of technologies to support well-being and generate strength and

resilience (Riva et al., 2016). Self-improvement technologies for physical activity are a special case in the field of technologies built to support well-being and increase the physical and mental health of the user. Fostering increased physical activity poses different challenges than persuading the user to engage in passive activities such as meditation (Vidyarthi, Riecke & Gromala, 2012). The effectiveness of interactive technologies that aim at increasing physical activity is affected by many external factors, such as the fitness level of the user, injuries, weather conditions or equipment. Consequently, understanding how interactive technology can foster physical activity and what factors contribute to an application's success is a highly complex endeavour that needs to be conducted in many steps.

The work cited above shows that Positive Computing and Positive Technology have a meaningful and well-defined agenda. However, it remains an open question how to design technologies that aspire to the goals of these domains in the context of everyday life. The present study addresses the intersection of these two fields of research. We strive to generate knowledge that can support the development of better systems, which will help users reach their full potential and live a healthier and fulfilling life.

Positive Technology connects the three pillars of Positive Psychology i.e., the pleasant life, the engaged life, the meaningful life (Seligman, 2004) with three levels (Serino, Cipresso, Gaggioli & Riva, 2013): The hedonic level, the eudaimonic level and the social level. Based on recent findings, the communication style of interactive products for self-improvement is a relevant element that can moderate the effectiveness of these tools and positively affect user experience. In the next section we look at past developments in designing such technologies.

6.3.2 Designing Technologies for Self-improvement

The design of self-improvement technologies poses conceptual questions. Various theories for behaviour change in Psychology exist, such as self-determination theory (Ryan & Deci, 2000). Understanding self-improvement has been established as a worthwhile pursuit in the field of inquiry. With technology being omnipresent in a modern world, technical solutions become an unavoidable part of how the world is perceived thus becoming a factor in self-improvement. As a consequence, understanding the roles technology may play in supporting well-being and how humans behave when those roles are assumed emerges as a challenge for Psychology.

A self-improvement product not only transforms to a 'materialised argument' between the user and the designer (Redström, 2006) created to support the initiation of behavioural change. Self-improvement technologies may also take on the role of an interactive coach and advisor (Diefenbach et al., 2016), for example turning into a teacher

or a supervisor if needed. The aforementioned transformation has the potential to add a 'human touch' to the interaction between the self-improvement tool and the user, which could eventually lead to an improved product-user relationship. This, in turn, could improve adherence to health and mental health interventions. Hence, studying self-improvement technologies from a psychological point of view has the potential for improving experiences with these tools and subsequently supporting the long-term well-being of the population (Consolvo, Klasnja, McDonald & Landay, 2009).

Persuasive technologies are now present in everyday life (Oinas-Kukkonen & Harjumaa, 2018). Past research developed a number of designs that foster self-improvement in the domain of physical activity. Fit4life (Purpura, Schwanda, Williams, Stubler & Sengers, 2011) was an application designed to promote regular exercise in the general population. Chickclique (Toscos, Faber, An & Gandhi, n.d.) supported groups of teenage females in maintaining a regular exercise regime.

While there is a history of developing such systems, most studies have not investigated specific aspects of the application design in terms of communication. Instead, research focused primarily on evaluating the efficiency of the design intervention. Consequently, while past work indicates that interactive technologies can foster physical activity, it is not yet fully understood which aspects of the self-improvement system can be manipulated to achieve the most positive effects.

One way to tackle this challenge is to explore the way the interactive product for self-improvement communicates with the user. Current research has shown that users of self-improvement technologies are able to differentiate between communication styles of the tool. Further, the communication style offers a chance to influence the perceived potential for change success (Diefenbach et al., 2016). In classic therapeutic settings and coaching, an essential role for the success of change is the dialogue between the therapist (or the coach) and the patient (Greene, 2003). Two decades ago, research showed that users tend to perceive technologies as social actors (Nass et al., 1994). Ten years later, Fogg showcased the reactions from users towards technologies resembling interpersonal social reactions (Fogg, 2002). The issue of generating knowledge that can effectively inspire the design of systems that become social actors was further highlighted by Oinas-Kukkonen & Harjumaa, 2018

Having considered these findings, the 'personality' of the technology should be considered for self-improvement tools, as past research has shown that users have a tendency to ascribe a personality to interactive technologies (Kwon, Jung, & Knepper, 2016), the recognition of what factors contribute to defining the personality of a technical artefact is also necessary. The factors need to be charted to build an understanding of human behaviour and enable the design of improved tools. One of the characterising aspects of the tool's personality is

the communication style. However, more research is needed to build an understanding of how technologies can support self-improvement through effective communication. This paper examines these questions in detail.

Our work is inspired by and further explores two of these dialogue support principles, namely praise and reminders. An interactive system can offer praise using words, images, symbols, or sounds as a means of providing user feedback. Through being offered praise, users can become more open to persuasion. Reminders prompt users to conform to the target behaviour in order to increase the likelihood of users achieving their goal. In our work, we go beyond the principles postulated by Oinas Kukkonen and also include elements of negativity ('dominant communication style'). Moreover, we offer a systematic exploration of how the use of dialogue principles impacts the persuasive effectiveness of a fitness app.

Past research identified a multitude of different persuasion tactics and principles (Kaptein & Halteren, 2013), which cannot all be discussed in in the work at hand. In this paper, we discuss examples directly relevant to our research. Our work focuses on the intricacies of a specific strategy, i.e. providing motivational notifications. Past work postulated the need for user-specific strategies (Kaptein, De Ruyter, Markopoulos & Aarts, 2012), yet these strategies often require extensive user profiling and may not be feasible in all applications. In contrast, here we aim to identify insights for manipulating communication style in order to understand when to choose which style. In doing so, we strive for a deeper understanding of the factors contributing to designing successful self-improvement technologies and determining when using communication style as a design factor may be beneficial.

Kaptein et al., 2012 investigated the effect of tailored text messages on reducing snacking. They developed a text-based intervention based on the six social influence strategies by (Cialdini, 2009). Similarly, we use mobile phones as the platform to employ persuasive strategies (Kaptein et al., 2012). Kaptein et al. explored the persuasive potential of messages users receive on their phone on behaviour change. Our work is interestingly different as it explores the various ways how (generic) messages can be phrased in order to enfold their persuasive potential. While Kaptein et al. explored means to prevent undesired behaviour (i.e. snacking), our work investigates potential ways to promote target behaviour (i.e. physical activity). More specifically, we investigated the communication style of a mobile fitness application (feedback and push notifications) in terms of promoting behaviour. To the best of our knowledge, no past work in persuasive technology has investigated the effect of communication style on the effectiveness of the persuasion.

6.3.3 Communication Style of Interactive Products for Self-improvement

Users interact with interactive technical devices in a social way (Nass et al., 1994). Through the means of spoken or written prompts, a computer system can become a social actor (Beun et al., 2017). Furthermore, a tool can present itself as an active partner. In fact, Grudin (Grudin, 2017) predicts that more and more technologies will be like partners to humans. For example, Sleep Care, an automated e-coaching system in the domain of insomnia therapy, behaves like a proactive coach (Beun et al., 2017). Similarly, interaction between humans and robots can trigger emotional and psychological reactions, resembling reactions observable in human-human interaction (Hoffman, Bauman & Vanunu, 2016).

Designing systems as interactive social actors can enhance their expressive power and enable including meta-strategies based on social influence, e.g., supporting behavioural change (Beun et al., 2017). Altogether, the communication between 'the coach' i.e., a self-improvement technical application, and the user seems to be a relevant factor in effectively motivating the user. Therefore, it constitutes a vital aspect in determining the success of a desired change. Consequently, it should be better understood to effectively inform interaction design for self-improvement.

Based on recent research in communication styles of self-improvement technologies (Niess & Diefenbach, 2016; Diefenbach et al., 2016), we chose the friendly/cooperative communication style and the critical/dominant communication style for our experimental design. The friendly/cooperative communication style can be described as friendly, helpful and resilient. The critical/dominant style of communication focuses on the mistakes and weaknesses of the user. The style is about being critical and sceptical. The styles were extracted from models in communication psychology (Schulz von Thun, 1989; Hofmann, 2011). Schulz von Thun Schulz von Thun (1989) postulated eight different styles of communication, while Hofmann Hofmann (2011) proposed seven. The friendly/cooperative and the critical/dominant communication style were two of the most common in the research of Niess and Diefenbach Niess and Diefenbach (2016). For an exhaustive description of the communication styles see Niess and Diefenbach Niess and Diefenbach (2016). In addition, our decision was supported by research by Nass et al. Nass et al. (1994) who differentiate the valence of evaluation (praise and criticism), which shows similarities to the friendly/cooperative and the critical/dominant communication styles.

6.3.4 Feedback

Feedback is essential in supporting users in achieving their goals. For example, the feedback of a doctor can influence the patient to decide

whether to pursue a health-oriented goal. A teacher gives grades in order to help pupils assess their learning effort. Positive feedback focuses on success and strengths. Negative feedback focuses on weaknesses and the absence of success (Fishbach & Finkelstein, 2012). Negative feedback can activate compensatory measures to achieve a goal (Brehm & Self, 1989). In addition, negative feedback was shown to be more effective in prevention goals than promotion goals (Förster, Grant, Idsen, & Higgins, 2001) (Förster, Grant, Idson & Higgins, 2001).

Situations when negative feedback leads to negative affect can lead to procrastination or even inhibition of goal-oriented behaviour (Gollwitzer, Kappes & Oettingen, 2011).

In such a case, people will prioritise immediate pleasure, even if it contradicts the (long-term) goal (Sheeran & Webb, 2012).

Positive feedback can enhance motivation through heightening goal achievement expectation or the perception of the value of the goal. In addition, positive feedback can improve perceived self-efficacy (Fishbach & Finkelstein, 2012). In contrast, through putting emphasis on failure, negative feedback can have the opposite effect. More precisely, negative feedback or focusing on one's failures can be discouraging and can potentially undermine one's sense of self-efficacy (Bandura, 1991).

However, these findings about positive feedback are not easily generalizable or operationalizable for the design of self-improvement technologies. When people strive for very difficult goals, it is essential that they anticipate possible difficulties. This is easier if they are experiencing negative affect. Thus, football players sometimes prefer an 'angry-aggressive mood' before important games (Gollwitzer et al., 2011). Negative feedback can be seen as a signal for a challenging goal and not enough progress, which can lead to more effort (Fishbach & Finkelstein, 2012)

The difference between communication style (friendly/cooperative, critical/dominant) and feedback (positive, negative (Fishbach & Finkelstein, 2012) is that the communication style determines the tone in which the message is provided (e.g., friendly/cooperative style - 'Time to work out.' vs. critical/dominant style - 'You have to work out now!'; whereas feedback type determines the content of the message (e.g., positive feedback - 'You did it once. If you continue practising you can do it twice.' Negative feedback - 'You are continually failing. You have to practise more, otherwise you don't stand a chance.'). Thus, there can be friendly messages that give negative feedback and the other way around. This is a key aspect that differentiates our work from past efforts which investigated forms of feedback (Fishbach & Finkelstein, 2012).

The question remains if it is better to give feedback in a friendly/cooperative manner or if it is more meaningful to give it in a critical/dominant way. Furthermore, in the field of psychology, it remains unclear if positive or negative feedback is more effective

in supporting people on their way to goal achievement (Fishbach & Finkelstein, 2012). These questions lead us to examine the perception of interactive products in self-improvement scenarios as social actors, with special emphasis on communication and the interaction between the interactive tool and the user.

6.3.5 Summary

Overall, we showed how our work is embedded within the field of Positive Computing and Positive Technology as it aims to aid users in living a more fulfilling life. We then showed how our investigation is relevant for designing persuasive technologies by generating insights on how interactive systems should communicate with users to foster desired behaviours. Finally, we showed how we extend past research that investigated the effectiveness of different forms of feedback by exploring communication styles while not varying feedback content. Our work is interestingly different from past efforts as it specifically manipulates the communication style of a mobile app, while past research varied feedback content. Further, we explore the influence of communication on promising desired behaviours in contrast to preventive measures investigated in past work.

6.4 AIMS OF THE STUDY

Based on previous findings, the present study explores the relation between self-improvement and communication styles in a systematic manner in an experimental longitudinal field study. We first investigate general insights about the experience and use of self-improvement technologies over time. Next, we aim to build a more comprehensive understanding of how the way the product communicates with the user affects the effectiveness of such technologies. Based on previous findings, we expected a decrease of physical activity over time (Gouveia et al., 2015b).

While querying the participants about their activity in regular intervals was required to conduct a longitudinal study (asking for monthly statistics would produce unreliable results), we consider the effect on time on physical activity reporting as outside of the scope of this paper. A significant body of past research addressed these effects and proposed measure to improve the reporting (cf. (Tang et al., 2018)). Yet, our analysis still includes the time as we wanted to separate the effects of time and communication style on reported physical activity.

Further, we anticipated a more positive and supporting effect of the FRIENDLY communication style of the app on behaviour (number of logged training sessions, logged training session duration) and

Table 6.1: Measures, data collection methods and names of conditions used in the study.

Measure (short name)	Capture method	Qualitative Data	Quantitative Data	Additional Information
Perceived well-being (well-being)	Post-study questionnaire Mobile Application	NO	YES	5-point smiley scale
Training session count (session count)	Pre-study questionnaire, Post-study questionnaire, Mobile Application	NO	YES	Pre- and Post-study: per-week report
Training session duration (session duration)	Mobile Application	NO	YES	In minutes per week
Experience of IMove2Improve (experience)	Post-study questionnaire	YES	NO	

well-being, compared to the DOMINANT communication style based on Diefenbach Diefenbach et al. (2016).

Therefore, we performed experimental manipulation of a mobile fitness application's communication style and explored its influence on well-being, number of logged training sessions and logged training session duration. More specifically, we contrasted two communication styles; the friendly/cooperative (in the following labelled FRIENDLY) and the critical/dominant (in the following labelled DOMINANT), with a focus on the following hypotheses:

- **H1**: The session count will be significantly higher in the FRIENDLY condition than in the DOMINANT condition
- **H2**: The duration of physical activity will be significantly higher in the FRIENDLY condition than in the DOMINANT condition
- **H3**: The experience of well-being will be significantly higher in the FRIENDLY condition than in the DOMINANT condition

See Table 6.1 for an overview of all measures and names of conditions.

6.5 METHOD

Our work used a longitudinal between-subjects experimental field study (With initial N = 209 and N = 69 completing the study) that lasted five weeks. The following section describes the details of the experimental design, including the design of the mobile application *IMove2Improve*, the study procedure, sample and measures.

6.5.1 Experimental Design

We designed and implemented a mobile fitness application called IMove2Improve for logging training sessions. The app could present

all user messages in two different versions (i.e. FRIENDLY and DOMINANT) in order to enable studying how the communication style influenced the behaviour of the participants. Users were randomly assigned to one of the two experimental conditions.

6.5.1.1 *The IMove2Improve Application*

We developed IMove2Improve for the Android operating system, as it was the most commonly used platform in the target group . The app communicated with the user through push notifications and post-activity feedback. More specifically, users were requested to log each training session, its length (in minutes) and their perceived well-being. Then, they received feedback regarding their sport session.

To log a sport session, users were asked in what kind of sport they engaged. A list of 10 common sports was provided, but they also could enter any other sport using a text field. Further, they could enter how long the session lasted and how they felt (a measure of reported well-being) on a 5-point smiley scale (Kunin, 1955), see Figure 6.1). Finally, users may have added additional comments to the session. In addition, users received one push notification from the app every three days and they did not receive any additional reminders. Both post-activity feedback and push notifications were given in two versions, i.e. representing the two different conditions (FRIENDLY, DOMINANT). The wording of the feedback and notifications for the two communication styles were developed and verified in an expert discussion with six psychologists and a pretest (see next section). All materials were presented in German.

6.5.1.2 *Pretest*

An expert discussion with six psychologists served to formulate an initial set of 37 phrases for push notifications and feedback. In a pretest ($N_{pretest} = 29$), the fit of the selected phrases to the communication styles was verified. The participants were asked to rate the phrases on a 5-point scale (1 - critical/dominant communication style; 5 - friendly/cooperative communication style). For the critical/dominant communication style we picked the phrases with a mean under 3.00. For the friendly/cooperative communication style phrases with a mean above 3.00 were chosen. 14 items for each communication style were chosen. The originally used, final 28 phrases can be found (verbatim) in the appendix A.1. Figure 6.1 illustrates example notifications for the two communication styles and how they were presented in the application.

6.5.1.3 *Data Anonymisation*

The participant numbers (ID) were randomly generated by the system for data-matching purposes. No personally identifying or private

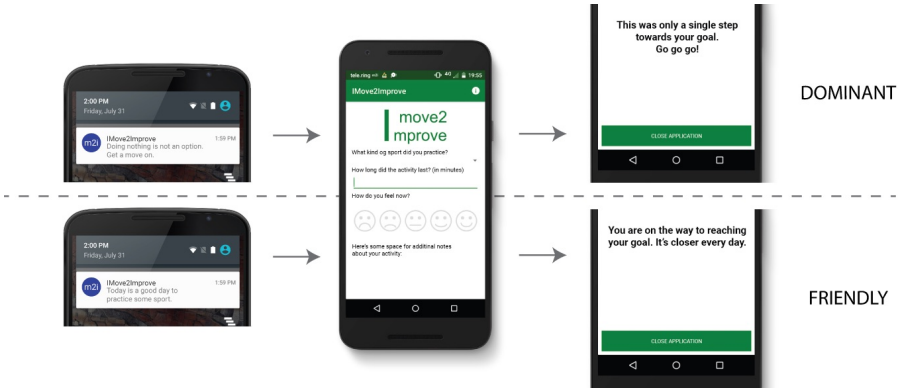


Figure 6.1: An illustration of the interaction flow of IMove2Improve. The user first receives a notification reminding them to exercise in the assigned communication style. By clicking on a notification, they can launch a screen to enter the details of the exercise and report their well-being. After reporting, feedback in the assigned communication style is displayed. The figure shows two example messages in the FRIENDLY (bottom) and DOMINANT (top) communication style. The examples were translated from German by the authors.

information was collected. The email addresses of the participants interested in receiving an Amazon voucher as an incentive were stored separately from the other data. Thus, no connection between the collected data and the email addresses was possible, which is in line with the GDPR (General Data Protection Regulation). Due to the automatic, random assignment of participant numbers by the server, it was impossible to retrieve data from the repository without the participant revealing their assigned number. The data entered by the participant was stored on their phone until it was delivered to the server. Then, the data was erased from the phone. The server used to store user data was located in the university buildings, and received all security updates during the study. Therefore, the data was fully anonymized.

6.5.2 Participants

We recruited $N = 209$ individuals to participate in the study. We used flyers, posters, and postings in social networks and mailing lists in Austria and Germany to recruit participants. The mobile application was distributed via the Google Play Store. The only participation requirement in the study was using a mobile phone with the Android operating system and an account to access the Google Play Store. As an incentive, participants were able to voluntarily participate in a raffle for Amazon vouchers (2 x 50 EUR, 3 x 20 EUR, 4 x 10 EUR). In addition, Psychology students were able to receive a confirmation that they had taken part in an empirical study, which they could use in

Table 6.2: Demographic information about the recruited participants and the participants who completed the study.

Participant group	N	Age	Gender
All recruited	209	$M = 24.94$, $SD = 16.23$	63 male, 145 female
Completed study	69	$M = 23.71$, $SD = 7.65$	22 male, 47 female

their study programme. Table 6.2 shows demographic information about the recruited participants.

6.5.3 Experimental Procedure

In the following sections we describe the experimental procedure and the measures used structured chronologically in terms of how the study was conducted (see Table 1 for an overview of all measures and names of conditions).

6.5.3.1 *Pre-exposure*

On the flyers, posters, postings in social networks and e-mails the potential participants found a link and a QR-code to download the app. After downloading the app, at the beginning of the study, participants were informed about the duration of the study and that they could terminate participation at any time. Furthermore, we clarified where and how the data would be handled and stored. Users were asked to give their informed consent for their participation in the study through selecting a tickbox and touching a button.

Next, we asked about their sport habits: which sports they normally practiced and how often they practiced sports. Training session count in the pre-study questionnaire was reported through self-assessment. Lastly, we asked general demographic questions (age, gender, employment). The complete pre-study questionnaire can be found in the appendix A.1.

After completing the pre-study questionnaire, the app presented a prompt to record a new sports session. An additional button to get further information was presented. Touching the button activated a page where participants found instructions, data privacy regulations, a contact email address, the names of all involved researchers, the app version and a participant number. Since the server made all assignments, the user did not need to know their assigned number. However, in case a participant would want to be removed from the study, we needed this number to ensure that we could erase all data connected to the participant.

6.5.3.2 *During Exposure*

During the five weeks of app usage participants assessed their perceived well-being on a 5-point smiley scale every time they logged a training session. Based on the work from Tadic et al. Tadic, Oerlemans, Bakker and Veenhoven (2013), we employed a simple, one-dimensional measure of well-being as past research indicated that such a solution is optimal when querying users at multiple intervals. The smiley scale can be found in the appendix A.1 (see Figure A.1). The way the input was provided is shown in Figure 1. Training session count during the five-week study was the number of logged training sessions per week. Training session duration was assessed in minutes during the five-week study duration. After participants logged their training session, they reported the length of their training session in minutes. In the following, we refer to training session length as 'session duration'.

6.5.3.3 *Post-exposure*

Five weeks after participants completed the pre-study questionnaire, the app automatically switched into the next phase of the experiment, where there was only one button displayed and the instructions to complete the post-study questionnaire were provided.

In addition, the app triggered a notification to inform them that the study was over and that they were kindly asked to complete the post-study questionnaire; an online survey. The app directed the user to the survey after pressing the button, and the participant number was entered automatically. The questionnaire included open and closed questions. We asked about the current training status of the participant (e.g., 'How often do you do sports?'), how the participants perceived the communication of the application, their overall experience with the application and reasons for possible lapses during the study period. Training session count in the post-study questionnaire was reported through self-assessment. In the following, we refer to the training session count in the pre- and post-study questionnaire as well as during the study as 'session count'. Well-being was assessed using the same scale as during exposure. In the following we refer to perceived well-being as 'well-being'.

In addition, participants described their experience with the mobile application IMove2Improve. They reported their assessment in an open text field in the post-study questionnaire. The complete post-study questionnaire can be found in the appendix A.1. In the following we refer to the aforementioned measure as 'Experience IMove2Improve'.

For the purposes of analysis and result reporting, we defined measurement time points T0, T1, T2, T3, T4, T5 and T6 as follows:

- At T0 participants self-assessed their training session count in the pre-study questionnaire.

- T1 accumulates the self-reported well-being (in app), the training session count (in app) and the training session duration (in app) of the first week of the usage of the mobile application (starting after the completed pre-study questionnaire after the download of the mobile application.
- T2 accumulates the self-reported well-being (in app), the training session count (in app) and the training session duration (in app) of the second week of the usage of the mobile application.
- T3 accumulates the self-reported well-being (in app), the training session count (in app) and the training session duration (in app) of the third week of the usage of the mobile application.
- T4 accumulates the self-reported well-being (in app), the training session count (in app) and the training session duration (in app) of the fourth week of the usage of the mobile application.
- T5 accumulates the self-reported well-being (in app), the training session count (in app) and the training session duration (in app) of the fifth week of the usage of the mobile application.
- At T6 participants self-assessed their well-being and their training session count in the post-study questionnaire.

6.6 RESULTS

In this section, we first show quantitative results of this study and then present qualitative insights extracted from the open questions in the post-study questionnaire.

6.6.1 Quantitative Results

We first report on study completion rates of the participants to investigate if the communication style of the mobile app had an influence on study completion. Next, we analyze the effect of communication style and time on the training session count, training session duration and reported well-being. Whenever p levels are reported, we present Bonferroni-Holm corrected values.

6.6.1.1 *Study Completion*

First, we investigate the dynamics of study completion. Table 6.2 shows the initial recruited sample and the group of participants who completed the study. We defined completion as not failing to provide a minimum of one training session in each of the study weeks (T1-T5). Reporting 0 activities in a week was interpreted as a dropout. Overall,

Table 6.3: Results of the survival analysis — Cox proportional hazards regression model.

	Coefficient (b)	SE	P	eb	95.0% confidence interval for eb
Communication style	-0.007	0.171	0.968	0.993	0.710 – 1.389

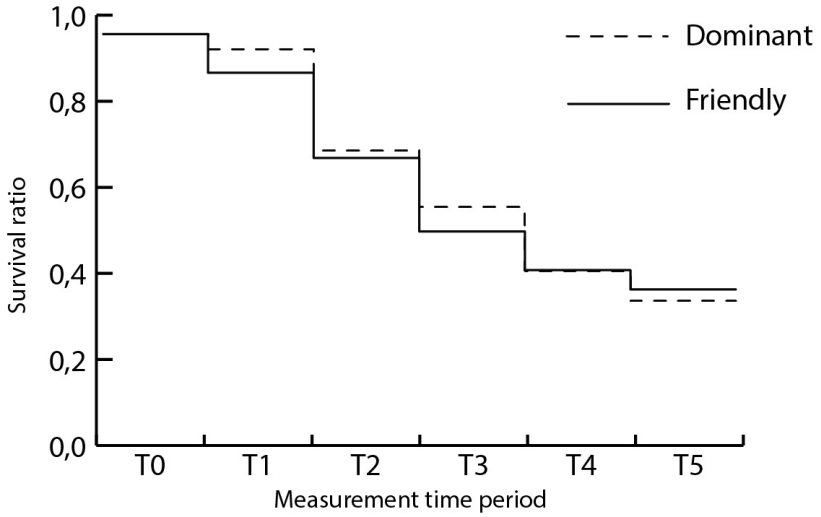


Figure 6.2: Kaplan-Meyer survival curves with communication style as the explanatory variable. Users who reported no activity in a week were considered as drop-outs. Note that for both communication styles, median survival is at T3. See section 4.4. for the description of the measurement time points.

67% of the participants in the DOMINANT condition and 64% in the FRIENDLY condition failed to finish the study. To investigate differences in dropout rates between the conditions, we computed Kaplan-Mayer curves. Figure 6.2 shows that median survival was at T3 for both conditions. We used a Cox proportional hazards regression model with communication style as an explanatory variable to investigate if there was a significant difference between the two communication styles. No significant effect was found. Table 6.3 presents the results. The following analyses use only data from participants who completed the study.

We computed a survival analysis in order to account for the effect of time. The results showed that our study was affected by time in the same way as previous studies (Tang et al., 2018).

6.6.1.2 *Training Volume*

We ran a repeated-measures MANCOVA with communication style (between-subjects) and time (within-subjects) as factors, initial re-

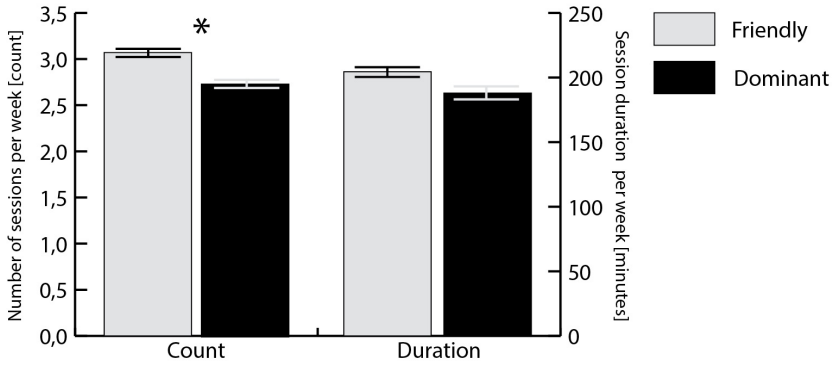


Figure 6.3: Mean session count per week (left) and session duration per week (right) in the two experimental conditions. Error bars show standard error. Significant effects were marked with an asterisk.

ported session count as the covariate and session count and session duration as response variables. The test showed a significant effect of the communication style, Wilks' $\Lambda(1) = 0.96$, $F(2, 332) = 5.67$, $p < .01$ and time, $\Lambda(4) = 0.88, F(8, 664) = 5.04, p < .0001$. The interaction effect was not significant, $p > .05$.

6.6.1.3 *Reported Training Session Count*

A two-way ANCOVA was conducted to determine the statistical effect of time and communication style on training session count controlling for the training session count reported before using the mobile application (To). There was no statistically significant interaction between time and communication style, $F(4, 349) = 0.62$, $p = .65$. There was a statistically significant difference between FRIENDLY ($M = 3.07$, $SD = 1.71$) and DOMINANT ($M = 2.74$, $SD = 1.69$), $F(1, 349) = 5.64$, $p = .018$. There was a statistically significant effect of time on session count, $F(4, 349) = 10.00$, $p < .001$. Figures 6.3 and 6.4 present the results. Thus, H1 is confirmed.

Post hoc comparisons using Tukey HSD indicated that the mean session count for the T1 time point ($M_{T1} = 3.85$, $SD = 1.96$) was significantly different than the T2 time point ($p < .001$, $M_{T2} = 2.96$, $SD = 1.62$), the T3 time point ($p < .001$, $M_{T3} = 2.52$, $SD = 1.34$), the T4 time point ($p < .001$, $M_{T4} = 2.67$, $SD = 1.57$) and the T5 time point ($p < .001$, $M_{T5} = 2.61$, $SD = 1.67$). Another difference was found between the T3 and T6 ($p < .05$, $M_{T6} = 3.46$, $SD = 1.8$) time points. No other significant differences between time points were found.

6.6.1.4 *Reported Training Session Duration*

A two-way ANCOVA was conducted to determine the statistical effect of time and communication style on training session duration per week controlling for the training session count reported before using

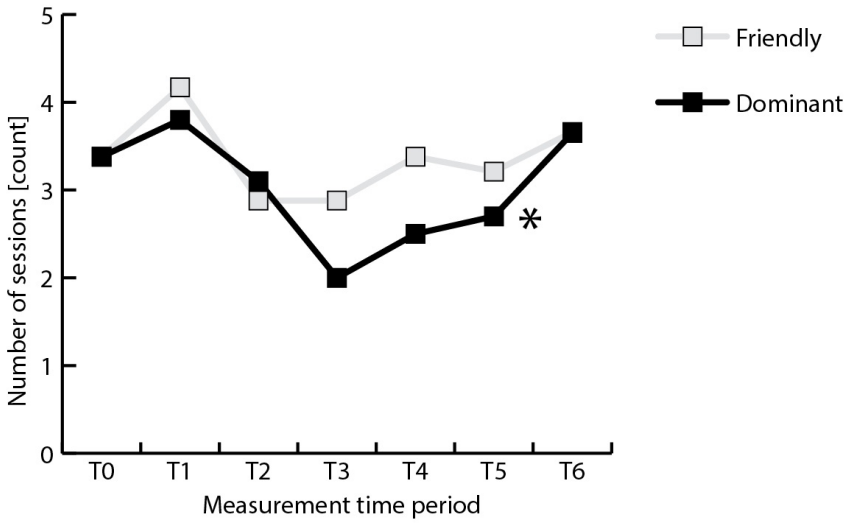


Figure 6.4: Mean session count over time in the two conditions. Significant effects were marked with an asterisk. Communication style had a significant effect on session count.

the mobile application (To). There was no statistically significant interaction between time and communication style, $F(4, 349) = 0.30$, $p = .88$. There was no significant effect of communication style, $F(1, 349) = 0.92$, $p = .34$. Figure 6.5 presents the training session count and duration at the different measurement points during the study. There was no statistically significant effect of time on session duration, $F(4, 349) = 1.86$, $p = .12$. Thus, H2 is not confirmed.

6.6.1.5 *Reported Well-being*

Next, we take a closer look on changes in reported well-being during the study. As we used a tailor-made Smiley scale to measure well-being, we cannot assure the normal distribution of the results in the general population and thus the linear model approach used for the previous measures cannot be applied. To offer reliable results, we analyze the data separately in terms of time and communication style using non-parametric methods.

REPORTED WELL-BEING IN TIME Based on the work from Wobbrock and colleagues (Wobbrock, Findlater, Gergle & Higgins, 2011), we used the Aligned rank transform to perform a one-way between subjects ANOVA to compare the effect of time on self-reported well-being at time-points T1–T5. There was a significant effect of time on reported well-being at the $p < .001$ level, $F(4, 340) = 10.05$, $p < .001$.

Post hoc comparisons using Tukey HSD indicated that the mean score for the T1 time point ($M = 0.84$, $SD = 0.34$) was significantly (all at the $p < .05$ level) different than the T2 time point ($M = 0.65$,

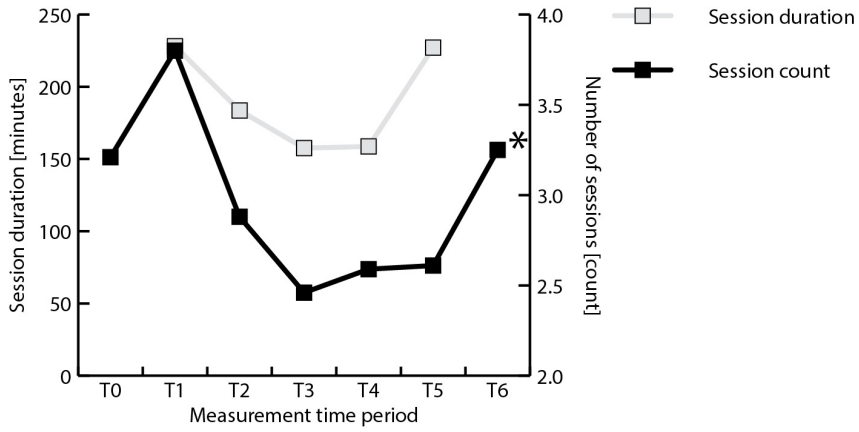


Figure 6.5: The session count reported (right axis) and session duration (left axis) at the different measurement points throughout the study. Significant effects were marked with an asterisk. Note that counts where sampled seven times (To–T6) and duration five times (T1–T5).

$SD = 0.28$), the T3 time point ($M = 0.57$, $SD = 0.23$), the T4 time point ($M = 0.57$, $SD = 0.20$) and the T5 time point ($M = 0.60$, $SD = 0.27$). No other significant differences between time points were found. Figure 6.6 presents the results.

REPORTED WELL-BEING BY COMMUNICATION STYLE Subsequently, we looked at the participants reported well-being in the two conditions. A Mann-Whitney test indicated that total self-reported well-being was greater for participants who were subjected to the FRIENDLY condition ($Mdn = 17$) than for participants using the app with the DOMINANT communication style ($Mdn = 15$), $U = 827.5$, $p = .005$, Figure 6.7 presents the results. Thus, H3 is confirmed.

6.6.2 Qualitative Results

We implemented a structuring content analysis (Mayring, 2014) and compared the qualitative feedback between the two conditions. Two independent coders followed the eight steps of the structuring content analysis. In step seven the two coders discussed the categories and concluded that no revision for the category definitions were needed. To verify the reliability of the allocation of statements to the categories of the category system, interrater agreement was measured and proofed to be satisfying (Cohen's Kappa = .87). Based on nature of the data, we used a qualitative top down approach (Blandford, Furniss & Makri, 2016).

The data was categorized as positive, negative or neutral regarding the assessment of the mobile application. Short descriptions and

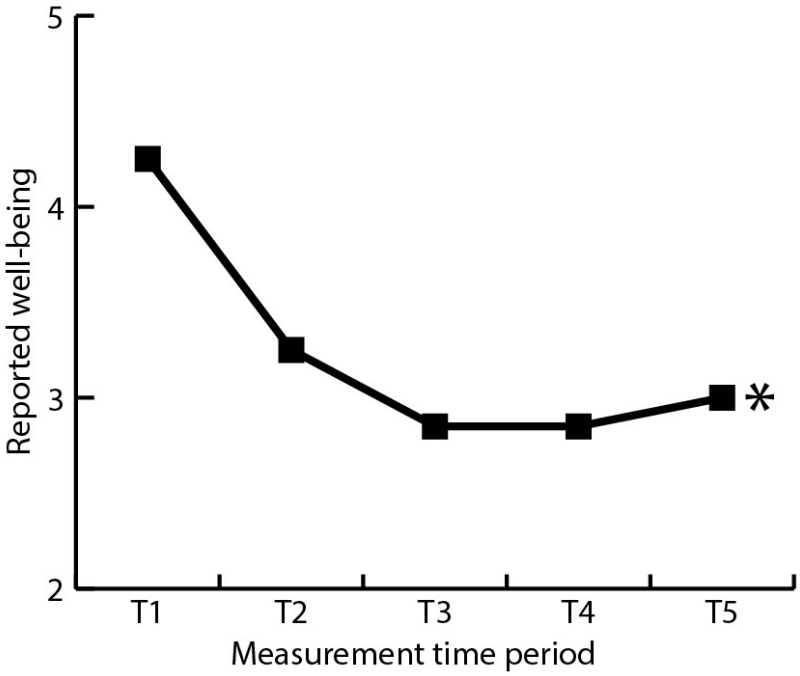


Figure 6.6: Average total well-being in the two experimental conditions. Error bars show standard error. Significant effects were marked with an asterisk.

keywords related to the three categories facilitated the coding process. Besides the three categories, the category system also included an open category in case there would be content which is unmatchable to the three aforementioned categories. However, the results showed that all statements concerning the assessment of the mobile application could be assigned to one of the three categories.

A positive assessment was either directly connected to the communication style of the mobile application or the consequences the interaction with the app could have (e.g., 'bold but stimulating'). Keywords were, inter alia, motivating, stimulating, fun, pleasant and enjoyable.

A negative assessment was either directly connected to the communication style of the mobile application or the consequences the interaction with the app could have (e.g., 'too nice to motivate me'). Keywords were, inter alia, demotivating, annoying, rude, boring and unpleasant.

A neutral assessment was either no assessment or no assessment regarding feedback/communication style (e.g., 'I did not read the notifications'. 'I was not able to detect any influence'. 'Nothing special'.). Keywords were, inter alia, indifferent, and neutral. In the following, we present the relative ratio of statements within the different categories and example statements.

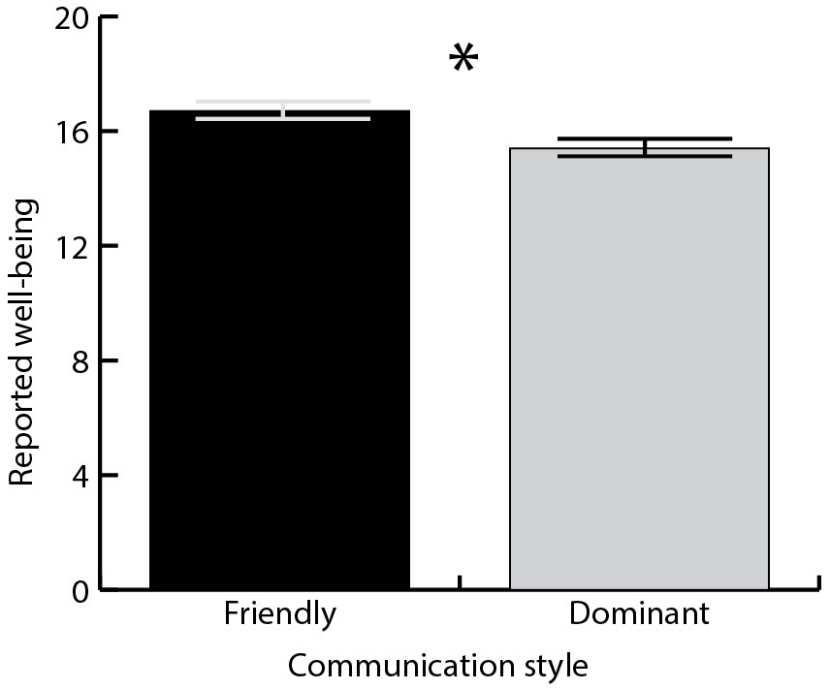


Figure 6.7: Average total well-being of the participants throughout the study. See section 4.4. for the description of the measurement time points. Significant effects were marked with an asterisk.

FRIENDLY COMMUNICATION STYLE The comments regarding the FRIENDLY communication style were mainly positive (74 %), while 17% of the participants provided negative statements, and 9% provided neutral assessments.

Among the positive statements, participants often emphasized that the push notifications and the feedback were motivating. Additionally, participants stated that it was important to have a pre-existing intention to practise sports.

> *The motivational phrases have been very good. They kept you motivated to keep working on yourself. (P48)*
>
> *'I like to do sports in general, the motivation of the app was only an additional advantage to my already existing motivation. The push notifications and feedback motivated me to keep pushing. It showed me that I was doing the right thing and that I should also try to be active even on lazy days. The drive to do sports was already there and the app contributed to my motivation even further.' (P17)*

Negative user statements often indicated that the app made users realize the gap between their self-assessment and the actual number of training sessions or a lack of commitment.

The push-notifications didn't motivate me to do more sports. Instead, they made me realize that I didn't do as much sports as I estimated. (P33)

The app was so friendly, sometimes I forgot to log my training sessions, but I didn't even feel bad about it, because the app was so nice. (P02)

DOMINANT COMMUNICATION STYLE The comments regarding the DOMINANT communication style were mainly negative (83 %). However, some users found the DOMINANT communication of the interactive tool positive (e.g., stimulating, 12 %) or made a neutral assessment (5 %). The negative statements in the DOMINANT condition often explicitly discussed the negative communication style of the app:

I do a lot of sports. If I am not able to a workout, I am already aware of that, I don't need the app to remind me that the day doesn't have enough hours for what I want to do, instead of motivating me. (P12)

Impolite and demotivating. Personally, I don't like the drill sergeant tone. (P20)

This is an interesting difference to the friendly condition, where negative feedback usually referred to the negative experience of oneself (i.e., realizing the gaps to one's personal ideals). However, few participants saw this trigger for reflection as stimulating and even praised the direct feedback in the DOMINANT condition.

Rather bold, but the critical feedback was stimulating. (P31)

The direct manner prompted me to reflect about the last time I worked out. (P47)

6.7 DISCUSSION

In brief, our results show that the number of training sessions reported decreased when one compares T1 to T2-T5. This indicates that participants experienced a general difficulty in maintaining their usage of self-improvement products. Additionally, we found no significant effect of time on reported duration of training sessions. We observe that over the five-week study period, the number of logged training sessions decreased, but the length of the logged training sessions did not change. Thus, H2 is not confirmed. The perceived well-being at T1 significantly decreased compared to T2-T5. Through combining the quantitative and the qualitative results, we hypothesize that the participants logged fewer training sessions over time, because they were unnerved by the communication of the mobile application, annoyed by the study per se or engaged in less physical activity. In turn, this could have possibly led to decreased well-being.

Furthermore, we found that there was a significant difference between the communication styles (FRIENDLY, DOMINANT) in the number of logged training sessions [H1]. The FRIENDLY communication style results in a lesser decrease in activity (or the reporting of activities). In other words, users dismiss the self-improvement device less often. Consequently, our results show that the FRIENDLY communication style led to more reported physical activity. We also found that only the participants subject to the DOMINANT condition reported significantly fewer activities irrespective of the effect of time. This suggests that a DOMINANT communication style may discourage users to continue using the application and thus discourage reporting activities. The data shows that the FRIENDLY communication style led to reducing the negative effect of time on reporting activities. Thus it suggests that the style could be the default one. However, the qualitative data suggest that there are corner cases where the DOMINANT style is appreciated. The DOMINANT style cannot be entirely neglected, especially when interactive technologies with personalization features are designed. Nevertheless, additional research needs to be conducted to explore the potential of the DOMINANT style in more depth. Furthermore, well-being was reported to be greater in the FRIENDLY condition than in the DOMINANT condition H3. Our data suggests that the FRIENDLY communication style better promotes sustained reporting of activities and results in an increased perceived well-being. Finally, survival analysis showed that being exposed to one of the communication styles did not affect the likelihood of ceasing to use the app. Thus, we can conclude that we found no effect of communication style on the willingness to continue using a mobile fitness app.

We are aware of the difference between actually performing activities and reporting activities. Since the current study did not work with activity trackers of any kind we can only interpret the reported training sessions. Furthermore, there is a difference between using the mobile application from time to time, compared to actively engaging with it. Our data hinted that the communication style could make a difference regarding active or passive usage of the mobile applications (e.g., reporting activities from time to time compared to reporting every activity). With the means of activity trackers it could be explored if and how different communication styles lead users to engage more or less actively with the technology, in future work.

By comparing the qualitative results with quantitative data, we observed that users did not perceive themselves as engaging in less physical activity, but they reported fewer sport sessions throughout the study. This claim is supported by qualitative results from the post-study questionnaire. This leads to the notion that reporting activities in the app regularly is a burden for the participants (D. A. Epstein, Caraway et al., 2016; Gouveia, Karapanos & Hassenzahl, 2015a). These results can be interpreted as indicating that the users who completed

the study made a conscious decision to manually log physical activity for the study period. This, in turn, suggests that these users saw benefits in activity tracking and were willing to commit extra effort for tracking. Past work has shown that those who exercise regularly find it easy to identify the benefits of activity tracking (Wozniak, Fedosov, Mencarini & Knaving, 2017). Despite the fact that the burden on users (and thus the required commitment) in both conditions was equal, being exposed to the DOMINANT communication style resulted in reporting fewer activities. On a more general level, the results of our study can be linked to existing conceptualizations of different user groups in the context of self-improvement technologies. For example, Stibe and Larson (Stibe & Larson, 2016) differentiate between self-contained, January 1st, and self-driven users. Self-contained users are most likely not interested in changing something about themselves. January 1st people are interested in changing their routines, but more often than not fail to do so. Self-driven users usually don't struggle to achieve what they have envisioned (Stibe & Larson, 2016). Our results can be interpreted by considering that IMove2Improve was able to encourage reporting a sustained level of activity in self-driven and January 1st users in the friendly condition. Consequently, a deeper understanding of the technology is needed to address specific needs of specific users (Knaving, Woźniak, Fjeld & Björk, 2015). More importantly, specific design factors that influence how the technology fulfills those needs should be investigated. In our study, we have confirmed that the communication style of interactive technologies for self-improvement potentially is one of these design factors.

Our study shows that many contextual factors are at play when studying the influence of the communication style. We can observe that the friendly communication style is generally more effective with a significant majority of users (i.e., it should be considered the default option in future designs). Yet, the communication provided in our application did not manage to prevent the number of activities reported dropping in time. Based on knowledge from coaching and therapy as well as research regarding personalization, it is known that the user must be considered the expert in the challenges they are facing (Greene, 2003). Thus, feedback personalization can be one factor supporting users in self-improvement (Forlizzi et al., 2009). Yet, while a significant majority of the participants in our study reported more activity when exposed to the friendly communication style, some were effectively persuaded by the dominant style. This may indicate that experience of a self-improvement product does not necessarily need to be pleasant to engage users in the long run. The interaction can also be periodically unpleasant (e.g., the coach who gave me a little, uncomfortable push to work out) and still engaging because the activity and, most likely, the feeling of achieving what one desires is pleasant enough.

Moreover, our results can be related to other studies that investigated behavioural change and the varying perception of interactive technologies as social actors and the impact of a technology's 'personality' (Hoffman et al., 2016). The perceived communication style of a technology may be considered as part of its personality, which adds to factors explored by past research such as visual design or interaction attributes (Lenz et al., 2013). In this vein, our results may inform the design of an intended 'product personality' beyond the field of self-improvement technologies. This aspect is especially relevant in the field of assistive technologies, which have recently proliferated thanks to products such as the Amazon Echo.

We argue that there is a relation between the perceived personality and the way a technology communicates, but stress that the personality is not the same as the communication style of an interactive tool. Which leads us to the probably more philosophical question: of what does the personality of a social actor consist? While a thorough answer is beyond the scope of the present paper, our work sheds some light on the issue. Due to difficulties in describing of what personality consists, the communication (style) of an interactive tool was often used to operationalize the personality of devices. Apart from interesting results stemming from this kind of operationalization, we stress that communication style is only one aspect of the perception of personality. While our study shows that the communication style influences how the feedback provided by the self-improvement technology is perceived, it only forms a part of the user experience of the technology.

A further question is how the communication style affects developing a relationship with the interactive product and whether it can contribute to joy of use (Hassenzahl, Beu & Burmester, 2001). While there is a clear difference between communication style and feedback, we recognise that the communication style of a self-improvement application can be a confounding factor that affects the feedback provided or, conversely, the communication style is affected by the content of the message to be presented to the user. In our study, we must have provided massages that were realistic and actionable. Thus, we were forced to choose certain combinations of feedback and communication style. However, more work is needed to build a fine-grained understanding of how feedback and communication style intertwine and ways to operationalize this knowledge to build actionable user communication.

6.8 LIMITATIONS AND FUTURE RESEARCH

The present study has several limitations to be addressed in future research. First, while our results offer an understanding needed to build better systems, they are prone to certain limitations connected

to many field-studies with high ecological validity. In general, many uncontrolled contextual factors may be at play, limiting the certainty of interpretation (Rogers et al., 2007). Furthermore, we chose a very simple mobile application design for the purpose of investigating the communication styles of the interactive product for self-improvement. However, we believe that we could improve the tool's appearance, which may lead to increased user engagement (Boratto, Carta, Mulas & Pilloni, 2017). Thus, additional studies on a product's communication style and its relevance for well-being and behavioural change in more controlled settings are required.

Due to the season (autumn, winter) when the study was conducted, many participants abandoned the study because of medical issues. We also recognise that our study did not explore the timing of the feedback. In our work, we presented feedback directly after the self-reported training session. Future research should explore how the timing of notifications may affect the effectiveness of the self-improvement tool.

Furthermore, baseline measures for session duration and well-being were not recorded. Since well-being is not a simple unitary entity, but has multiple facets (Diener, Suh, Lucas & Smith, 1999), it would have been preferable to assess the baseline for well-being over a longer period of time (e.g., one additional week pre-exposure). This would have extended our study, which is already a longitudinal design, and eventually further increased the number of participants failing to complete the study. Consequently, we decided that such a design was no feasible. Nevertheless, to replicate the present study with a reliable well-being baseline, possibly as part of a larger well-being study, is an intriguing question for future research.

Finally, the pre-study questionnaire data showed that many users were already interested in sports, so we were likely confronted with a ceiling effect. If a participant is interested in improving but already practising sports regularly, the assessment of their goal has to be quite specific to be able to assess improvement. In future studies, we want to explore this issue by contrasting different user groups, with higher and lower levels of activity when starting to use self-improvement technologies. Further, we aim to explore different details of the feedback provided through the app, as for example the timing, the frequency and the authenticity of the feedback.

6.9 CONCLUSION

In this paper, we introduced the communication style of an interactive product for self-improvement as one relevant factor regarding the design of interactive technologies for self-improvement. We conducted a longitudinal between-subjects field study to investigate the influence

of the communication style (FRIENDLY, DOMINANT) of an interactive self-improvement technology on the well-being and the behaviour of users. We found that the communication style had an influence on the well-being and the number of training sessions of the user, but not on the length of the training sessions. As this was a field study we argue that our results have high ecological validity, but need to be verified further in a more controlled setting.

Even though researchers started to consider the way the tool communicates with the user as an important supportive or persuasive strategy, this is (to our knowledge) the first study focusing on the communication style of interactive products for self-improvement. We hope that our work will help researchers and designers address new challenges within interactive technologies for self-improvement and build tools that offer users support on their way to enhanced well-being. In future work, we hope to investigate how well tailored communication between the interactive technology for self-improvement and its user can enhance the user experience on the road to future increased well-being.

6.10 ETHICS STATEMENT

The study was not subject to ethics review according to the ordinances of the conducting institution. The study followed the 'Ethical Principles of Psychologists and Code of Conduct' (American Psychological Association, 2017). Participants were free to terminate participation at any time. All subjects have given informed consent in accordance with the Declaration of Helsinki (Association et al., 2013).

6.11 SUMMARY

The two papers presented above focused specifically on the aspects of how a self-improvement technology can communicate with its users, see Figure 6.8. Having established insights in this area, this thesis proceeds to explore internal factors specific to the users that can inspire building better systems for well-being.

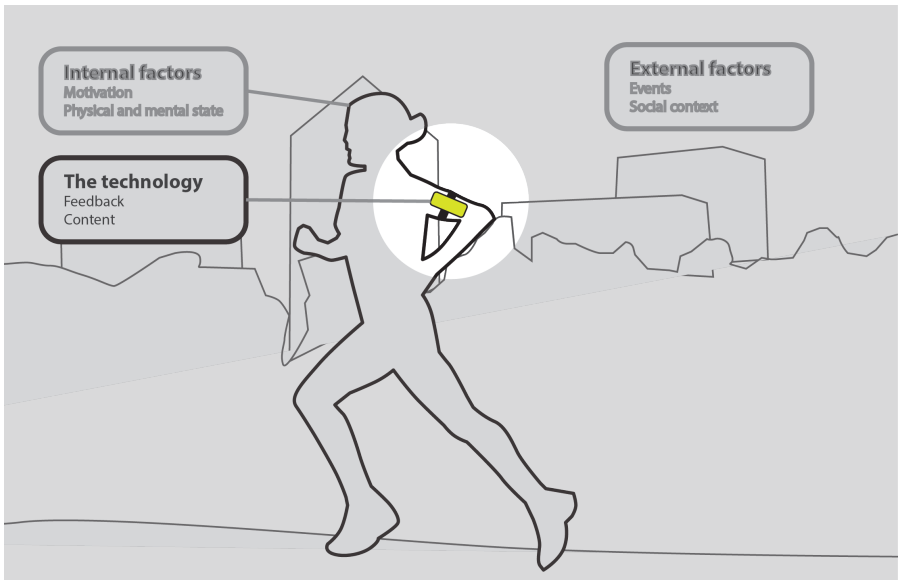


Figure 6.8: Influencing factors for designing self-improvement and well-being technologies with a focus on the technology

7 PAPER III: FEEDBACK, COMMUNICATION AND LEVEL OF CONSTRUAL

This chapter is based on:
Niess, J., and Diefenbach, S. The effect of construal level and communication style on responses to feedback in applications for physical activity. Submitted for review.

New media to support behaviour change (e.g., fitness trackers) have become increasingly popular among consumers and healthcare providers. However, studies show that such technologies often fail to offer long-term engagement and tangible health benefits. In this regards, the specific design of feedback messages provided by the device and users' affective reactions to it may play a critical role. Our research explores the potential of applying theories of construal level and communication style (the way the technology "speaks" to the user, here: friendly vs. dominant) to formulating feedback messages in self-improvement technologies. Two experiments (N=190, N=177) examine the influence of these two factors on goal commitment and affect-based evaluation for situations of fitness goal attainment and failure. Overall, across both studies, construal level and communication style appeared as relevant factors with independent, additive influence. In the positive situation of goal attainment, high construal level and a friendly communication style resulted in significantly more goal commitment and positive affect than low construal level and a dominant communication style. In the negative situation of failure, results were overall less unambiguous and need to be consolidated by further research. Implications for construal-level research and the theory-based design of interactive media for self-improvement are discussed.

7.1 INTRODUCTION

The growth of interactive media technology is significantly changing the media landscape (Skalski & Tamborini, 2007). The rapid development of new interactive communication media has led to new ways to use such technologies and new possibilities to users to change their behaviour and improve their well-being. From a psychological

perspective, one area of particular interest regarding this development is interactive media for self-improvement, behavioural change and persuasion (S. J. Katz & Byrne, 2013).

An ever increasing number of people are starting to use mobile applications to improve their fitness level and well-being (Niess & Woźniak, 2018). Due to the ubiquity of these technologies they can potentially have a positive effect on the mental and physical health of the society (Calvo et al., 2014). One essential aspect to make mobile fitness applications more meaningful is appropriate feedback. However, to date fitness apps struggle to deliver long-term health benefits (Jakicic et al., 2016). Most users stop using their apps after a short usage period (Gouveia et al., 2015b), partly due to frustration with feedback and goal setting modalities (Diefenbach et al., 2016).

The critical influence of the particular way the app provides feedback also becomes comprehensible when considering the role of technology as a social agent. Humans have a tendency to interact with media in a social way (Lieberman & Selker, 2003). Thus, one might conclude that technologies for self-improvement may slip into the role of interactive coach (Skalski & Tamborini, 2007; Niess & Diefenbach, 2016).

In parallel to a human coach, where communication is an essential part to support behaviour change in coaching and therapy (Gerrig et al., 2010), interactive coaches may be more or less successful depending on the way they "speak" to the user. For example, the communication style expressed through feedback messages and technology design may be friendly-cooperative (e.g. highlighting success rather than failure in visualizations; focusing on what has already been gained; using encouraging wording in feedback messages), or rather critically-dominant (highlighting failure and still necessary steps rather than what already has been gained etc.). First studies already lend support to this assumption, revealing the dialogue that unfolds between the product and its user as an essential part of technology-mediated behaviour change (Diefenbach et al., 2016).

Psychology provides a vast body of research focusing on feedback (Fishbach & Finkelstein, 2012) and goal setting techniques (Locke & Latham, 2006), which has been applied in a number of research areas including Human-Computer Interaction. However, it has so far mainly remained within the boundaries of system-based investigations. Thus, there is a need to investigate new ways to apply psychological theory to technologies for fitness in a meaningful way, and to make the gained insights actionable for researchers in Psychology, HCI and beyond. In general, the interpretation of communication (i.e. feedback in the present study) can be influenced by various factors beyond semantic feedback content, such as the tone of the message and the facial expression. Furthermore, the situational context as well as characteristics of the recipient, such as the cognitive strategy the recipient is using to

understand and interpret the message, can additionally influence the interpretation of a message (Wyer Jr & Shrum, 2015). In this article, however, we focus on a specific form of communication, namely the feedback given by interactive media to support behavioural change. Following the differentiation of Wyer Jr and Shrum (2015) we explore the degree of influence of the tone in which the feedback message is given (the communication style: friendly versus dominant) and the cognitive strategy of interpretation suggested by the formulation of the message (construal level, low/concrete versus high/abstract) impact the affective response and goal commitment of participants. In short, the construal level describes how concretely or abstractly something is represented in a person's mind, which is naturally affected by the words to describe it with; e.g. walking 1000 steps each day (concrete) versus becoming a fitter person (abstract).

In addition, we explore these effects for two types of feedback content; success versus failure (here: fitness goal attainment or lack thereof). Since our study explores written communication, namely messages sent from an interactive medium, facial expression and other factors of non-verbal communication in face-to-face conversations are not considered. The present research on effects of communication style and construal level in messages in self-improvement technologies builds on work from Katz and Byrne (S. J. Katz & Byrne, 2013), combining construal level theory with mobile technology messaging. In their construal level theory of mobile persuasion, they introduced eight theoretical propositions which led to three theoretically based message functions, namely shifting construal level orientation, bridging construal level perception of choice and traversing psychological distance to choice. In short, the idea is that depending on the recipients' activated level of construal, messages in mobile communication may be more or less effective. Furthermore, our research is based on findings from Niess and Diefenbach (Niess & Diefenbach, 2016). The authors found that users can differentiate between varying communication styles of interactive technologies for self-improvement. These communication styles seem to have distinct affective and emotional consequences. In addition, our approach is inspired by Control-Value Theory (Pekrun & Perry, 2014) which emphasises that emotions are relevant for achievement, and further motivated by the studies of Williams and colleagues, empirically proving that the level of construal has cognitive as well as emotional consequences (Williams, Stein & Galguera, 2013). Altogether, the present studies aim to investigate how psychological theory can be applied to phrase feedback provided by self-improvement technologies in a meaningful way, in order to support the behaviour change process.

The present paper is structured as follows: The next section discusses relevant theoretical background connected to our research endeavour, including construal level theory (Trope & Liberman, 2010),

the potential affective consequences of different construal levels, the construal level theory of mobile persuasion (S. J. Katz & Byrne, 2013; Williams et al., 2013), as well as research on communication styles of interactive tools for self-improvement and their potential emotional and affective consequences (Niess & Diefenbach, 2016). The subsequent sections present two empirical studies, followed by a general discussion of our study findings, practical implications, limitations and future research.

7.2 THEORETICAL BACKGROUND

7.2.1 Construal Level Theory

Construal Level Theory (CLT) represents one of the most generative theories in social psychology and has been explored and refined in various studies and application domains. It originates from work by Trope, Liberman and colleagues (Trope & Liberman, 2010). CLT differentiates between high level construals, which are relatively abstract, and low-level construals, which are relatively concrete. The construal level, in turn, has been identified as relevant for the further cognitive processing of information and a number of additional psychological variables. For instance, when a horse is construed more abstractly, i.e. as a mammal, the information regarding the species of the mammal, i.e. the horse, is omitted. Activities can also be construed in more abstract or more concrete terms. High construal level can be induced by providing the reasons for an activity; low construal by the information on how an activity is performed. This in turn means that superordinate goals should be more salient when construed more abstractly. Thus, depending on whether an object or activity is represented in a more abstract or more concrete way, we are considering or omitting certain attributes of it. Shapira et al. (2012) formulated two central relationships between attributes of higher and lower level of construal; namely, changing a low-level attribute affects a high-level attribute less than vice versa. Second, the meaning of low-level attributes depends more on high-level attributes than the other way round. This means that when we categorise an object more concretely (e.g. 'an apple') it could also be construed more abstractly (e.g., 'something to eat'). If we would change the low-level attribute of the apple, construing it now as 'a cucumber', this does not affect the high level attribute (i.e. 'something to eat'). However, if the abstract construal is changed from 'something to eat' to 'fruit,' the low-level category, i.e. 'a cucumber', does not match the high-level category anymore.

CLT further assumes that construal levels are related to psychological distance. The psychological distance describes how far away an object is perceived in relation to oneself, and can relate to various

aspects such as time (temporal distance; for example the summer holiday next year is more distant than the exam next week), physical space (spatial distance; for example the civil war on another continent is more distant than the robbery in the local supermarket) or interpersonal distance (felt distances between groups or people). Studies have shown that the psychological distance varies with the construal level to represent this object, and consequently the terms people use to speak about it (Trope & Liberman, 2010; Shapira, Liberman, Trope & Rim, 2012). For example, in one study it was found that participants who imagined a spatially distant rather than near event (helping a friend move into an apartment 3,000 miles away from where the participant resided, rather than in the local area) tended to describe the associated actions in terms of high-level states (e.g. "securing the house") rather than low-level means (e.g. "putting a key in the lock"). Furthermore, Fujita, Trope, Liberman and Levin-Sagi (2006) conducted a sequence of experiments using different manipulations to investigate the influence of construal level on self-control, showing that higher construal levels led to higher self-control. In conclusion, the authors claimed that any factor that influences the level of construal could potentially influence self-control and actions of individuals. One of such influencing factors could be a person's mood, given that a positive mood has been associated with processing visual information on a more global level than a neutral mood (Gasper & Clore, 2002). Along these lines, Labroo and Patrick demonstrated that being in a positive mood led to more abstract thinking and a focus on superordinate goals, whereas a negative mood shifted the focus more on subordinate goals (Labroo & Patrick, 2008). In consequence, a positive mood may activate a more abstract construal level and subsequently support self-control. Another strain of research explored the effects of construal level and psychological distance on affect based evaluations (Williams et al., 2013). More specifically, Williams and colleagues showed that construal level and psychological distance led to distinct affective consequences. More abstract construal levels improved evaluations of positive and negative experiences alike (Williams et al., 2013). Consequently, a bidirectional relationship between the construal level and affective experiences can be assumed, whereby one's mood affects the construal level of one's perception, and the construal level affects one's mood. However, Williams and colleagues call for further research to explore this relationship in more depth (Williams et al., 2013). Our research may provide another step in this direction, investigating how a shift in construal level is influencing the affective experience of mobile fitness app feedback. In addition, given the central relevance of emotions for achievement and motivation (Pekrun & Perry, 2014), we also consider the so-called communication style of interactive products (Niess & Diefenbach, 2016) as another potential influencing factor of peoples' affective experience in the context of goal achievement.

7.2.2 Construal Level Theory of Mobile Persuasion

Katz and Byrne introduced the construal level theory in the area of persuasive technology and persuasive communication (S. J. Katz & Byrne, 2013). Their work focuses on five dimensions of mobile technology, namely egocentricity, context-awareness, interactivity, simultaneity, and memory (S. J. Katz & Byrne, 2013), and connections of these to the concepts of construal level theory. Further, the authors point to three categories of persuasive message cues, namely (1) abstraction and distance cues (depending on the language and images used in persuasive messages they can be perceived as more abstract or more concrete), (2) message matching and congruence (persuasive messages are most convincing if the message cues, such as psychological distance and construal level are congruent), and (3) motivation cues. In line with their postulation regarding message matching and congruence, Kim et al. found that political persuasive messages where most convincing when construed in high level rather than low level terms when their voting decision was temporal distant (Kim, Rao & Lee, 2008). Our study plans to extend these findings and investigate how persuasive messages distributed by interactive media can be optimized regarding their level of construal as well as the communication style of the messages. More specifically, we combine previous insights on connections between affective experiences and construal level (Williams et al., 2013) as well as users' sensibility to different 'communication styles' of their technology (Niess & Diefenbach, 2016) (also see next section). We thereby aim to investigate the intricacies of construal level theory for mobile persuasion (focusing on motivation cues) in more depth and provide a basis for fine-grained design decision in the context of technology supporting behaviour change and self-improvement (here: fitness and physical activity).

7.2.3 Conceptualising Communication Style of Interactive Technologies

As already argued in the 90s by Nass and colleagues (Nass et al., 1994), society is heading towards a time where more and more technologies turn into interactive partners or coaches (Grudin, 2017). Scholars found that humans act towards computers based on behavioural scripts of human-human interaction, as for example, applying social norms such as courtesy or screaming at their computer if it doesn't behave the way they wished (Fogg, 2002; Nass et al., 1994). Given this natural tendency of humans to engage in social interaction with technology, the deliberate design of the communication and dialogue in HCI seems of vital importance for the resulting user experience, particularly for the context of technology supporting behaviour change such as the design of fitness apps. Indeed, there is a vast body of work situated in coach-

ing and therapy research pointing towards communication between client and coach or therapist as essential for a successful process of change. Thus, investigating how the interaction between product and user can be designed in a sensible way seems to be self-evident. Recent work on the border of Psychology and HCI found that users are able to perceive the communication style of interactive technologies for self-improvement and to differentiate between different styles (Niess & Diefenbach, 2016). Further, they found that different communication styles seem to be connected to different affective and emotional reactions (Diefenbach et al., 2016; Niess & Diefenbach, 2016). Based on recent research on communication styles of self-improvement technologies (Niess & Diefenbach, 2016; Diefenbach et al., 2016), we chose two communication styles to focus and operationalize in our experiments, namely, the so-called friendly/cooperative communication style and the critical/dominant communication style. The friendly/cooperative communication style can be described as friendly, helpful and resilient. When implemented in a self-improvement technology, the feedback messages of the medium would be friendly, understanding and supportive. For example, if a user failed to reach his or her fitness goal, the technology might comment on this with 'Keep pushing and don't give up'. In contrast, the critical/dominant style of communication focuses on the mistakes and weaknesses of the user. Hence, the feedback would reprimand the user and focus on his or her imperfections, e.g. 'You failed. You have to get a move on now'.

Based on recent research in communication styles of self-improvement technologies (Niess & Diefenbach, 2016; Diefenbach et al., 2016), we chose the friendly/cooperative communication style and the critical/dominant communication style for our experimental design. The friendly/cooperative communication style can be described as friendly, helpful and resilient. Given a user of interactive media to support self-improvement would fail to reach his or her goal, the feedback of the technology would be friendly, understanding and supportive (e.g., 'Keep pushing and don't give up.'). The critical/dominant style of communication focuses on the mistakes and weaknesses of the user. The style is about being critical and skeptical. Hence, the feedback would reprimand the user and focus on his or her imperfections (e.g., 'You failed. You have to get a move on now.').

7.3 RESEARCH GOALS AND CONTRIBUTIONS

Affective experiences have a bidirectional connection to construal leveland are of relevance for achievement (Pekrun & Perry, 2014). For instance Aarts and colleagues recently found that attaching positive affect to goal representations potentially leads to energisation in the

pursuit of goals, people investing more resources and effort (Aarts, Custers & Marien, 2008).

Thus, the present study investigates the effect of level of construal on affective response and goal commitment in a mobile fitness application context, following a call by Katz et al. to explore the role of construal level theory in the field of persuasion and communication (S. J. Katz & Byrne, 2013). We aim to combine this with an inquiry regarding the communication style of self-improvement technologies. Since previous research showcased the impact of communication style of self-improvement technologies on the behaviour change process and pointed towards a more positive reaction towards the friendly communication style, this research aims to examine the impact of communication style on affective response and goal commitment. The present paper is, to the best of our knowledge, the first study regarding communication style in a controlled environment and our findings can potentially extend the findings from Williams and colleagues, since we are investigating the effect of a shift in construal level regarding affective response in a fitness context.

7.4 STUDY 1 (GOAL ATTAINMENT)

Based on previous research showing that abstract construal prompts a focus on the positive reasons underlying experiences (Eyal, Liberman & Trope, 2008; Williams et al., 2013), we hypothesise that abstract construal should lead to a more positive affective response and higher goal commitment. Furthermore, we predict that a friendly communication style should lead to a more positive affective response and higher goal commitment in a positive situation (goal attainment). Specifically, we hypothesize:

- **H1a**: High level of construal results in a significantly more positive affective response than low level of construal.
- **H1b**: Friendly communication style results in significantly more positive affective response than dominant communication style.
- **H1c**: At high level of construal, the positive effect of a friendly communication style on affective response is more pronounced than at low level of construal.
- **H2a**: High level of construal results in significantly more goal commitment than low level of construal.
- **H2b**: Friendly communication style results in significantly more goal commitment than dominant communication style.

- **H2c**: At high level of construal, the positive effect of a friendly communication style on goal commitment is more pronounced than at low level of construal.

7.4.1 Design and Method

Our study used a 2 (construal level: abstract vs. concrete) x 2 (communication style: friendly vs. dominant) between subjects design with four different vignettes. In vignette studies, participants are asked to see the world through the eyes of a hypothetical person in a specific scenario. As shown in previous applications, vignette studies seem a promising approach to balance the benefits of experimental research with high internal validity and the advantages of applied research with high external validity (Aguinis & Bradley, 2014). The vignette study was conducted online and the participants were randomly assigned to one of four conditions.

7.4.1.1 *Participants*

We recruited 190 participants (111 male, 79 female), aged 19–69, $M = 35.97$, $SD = 11.56$ using Amazon Mechanical Turk (MTurk). Given that replications studies in different areas of research using MTurk led to comparable results as the original studies (Paolacci, Chandler & Ipeirotis, 2010), MTurk has become a popular means of recruitment for research in psychology (Williams et al., 2013) and Human-Computer Interaction (?, ?). The recruited participants resided in the United States or the European Union. We required participants to have completed at least 1,000 HITs with a 95% acceptance rate, in line with past work in psychology and HCI (D. A. Epstein et al., 2015). The survey took an average of 3min 14s to complete and the participants received $0.80 as compensation.

7.4.1.2 *Procedure*

In the online vignette study, users were presented with a neutral description of the situational context. They were asked to imagine that they have recently downloaded a fitness app, in order to become more active. Furthermore, they have been informed that they have used it all week and that they have recently increased their step goal to 8000 steps per day. The participants have been told that they wake up in the morning and the fitness app presents them with the following feedback, which they study carefully.

Afterwards, we showed a prototype phone screen with fitness advice in one of the randomly assigned conditions, informing them that they had achieved their goal. Figures 7.2–7.1 show examples of the screens.

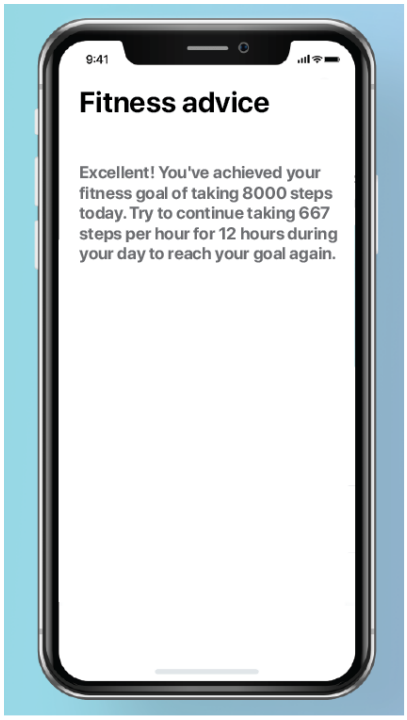


Figure 7.1: Example screen: Goal attainment, friendly communication style, low construal level

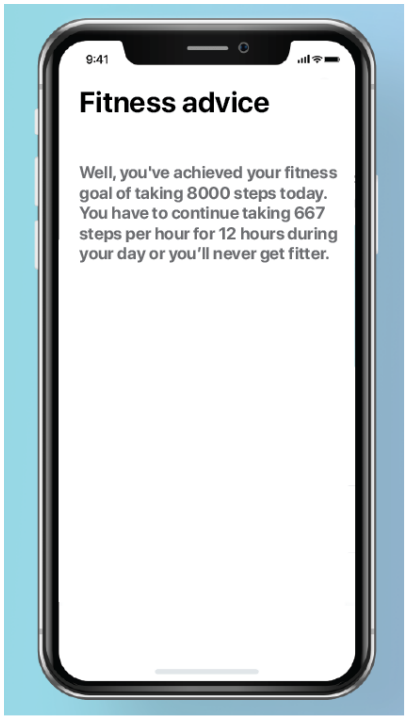


Figure 7.2: Example screen: Goal attainment, dominant communication style, low construal level

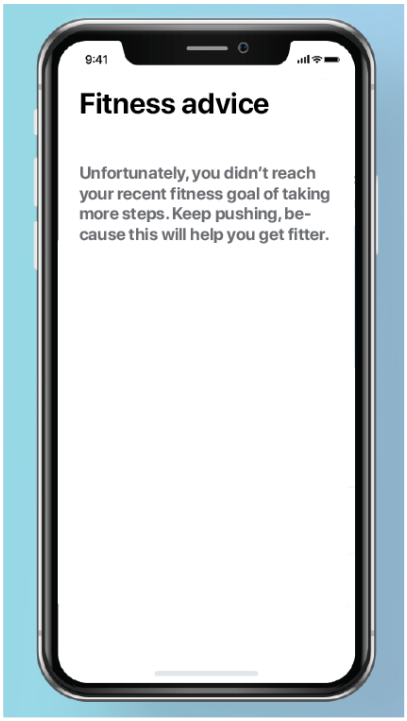


Figure 7.3: Example screen: Failure, friendly communication style, high construal level

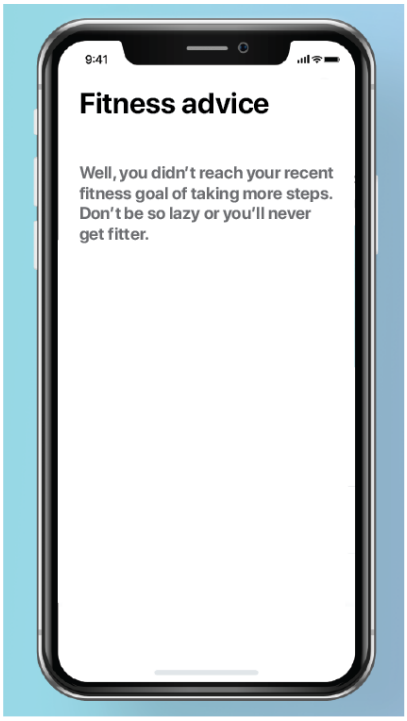


Figure 7.4: Example screen: Failure, dominant communication style, high construal level

7.4.1.3 *Measures*

After the survey introduction, we presented the participants with questions regarding their demographic data. We then inquired about their affective response and their goal commitment. The order of the scales has been randomised. We administered the Goal Commitment Scale from Hollenbeck, Williams and Klein (1989). The participants indicated their agreement on a Likert scale from very strongly disagree to very strongly agree. We queried the affective response of the participants based on the items used by Williams et al. (2013). The participants evaluated the extent to which the feedback of the fitness app felt "pleasant," "desirable," "painful," and "unpleasant" (latter two reverse-coded). These responses were made on 7-point scales anchored by "not at all" and "very."

7.4.2 Affective Response

How do level of construal and communication style of fitness app feedback influence users' affect-based evaluations of the feedback when they achieved their goal? To answer this question, a two-way ANOVA was conducted. This analysis revealed a significant main effect of the construal level manipulation ($F(1,186) = 4,709$, $p = .031$). Participants who were presented with the feedback in a concrete manner reported lower evaluations ($M = 16.85$, $SD = 7.26$) compared to those who were presented with the feedback in an abstract manner ($M = 19.52$, $SD = 7.12$). Thus, H1a is confirmed. There was also a statistically significant main effect of the communication style manipulation ($F(1,186) = 55,411$, $p < .001$). Participants who were presented with the dominant communication style reported lower evaluations ($M = 14.90$, $SD = 7.03$) compared to those who were presented with the friendly communication style ($M = 21.80$, $SD = 5.75$). Thus, H1b is confirmed. There was no interaction between the construal level and the communication style factors ($p > .05$). Thus, H1c is not confirmed.

7.4.3 Goal Commitment

How do level of construal and communication style of fitness app feedback influence users' goal commitment when they achieved their goal? To answer this question, a two-way ANOVA was conducted. This analysis revealed a significant main effect of the construal level manipulation ($F(1,186) = 7,589$, $p = .006$). Participants who were presented with the feedback in a concrete manner reported lower goal commitment ($M = 29.91$, $SD = 6.12$ compared to those who were presented with the feedback in an abstract manner ($M = 32.41$, $SD = 5.54$). Thus, H2a is confirmed. There was also a statistically significant main effect of the communication style manipulation ($F(1,186) = 5,564$,

$p = .019$). Participants who were presented with the dominant communication style reported lower goal commitment (M =30.27, SD = 5.93) compared to those who were presented with the friendly communication style ($M = 32.25$, $SD = 5.82$). Thus, H2b is confirmed. There was no interaction between the construal level and the communication style factors ($p > .05$). Thus, H2c is not confirmed.

7.5 STUDY 2 (FAILURE)

Study 2 replicates study 1 in negative situations (failure; i.e. where users failed to reach a goal and the fitness app is confronting them with an according message), in order to test the generalisability to both positive and negative situations. We expected the same effect as for study 1.

Hence, the present study also investigates the effect of level of construal on affective response and goal commitment in a mobile fitness application context. Similar to study 1, we are combining this approach with an inquiry regarding the communication style of self-improvement technologies.

In line with our previously described assumptions, we hypothesise that abstract construal would lead to a more positive affective response and higher goal commitment. Furthermore, we predict that a friendly communication style would lead to a more positive affective response and higher goal commitment. In the present study we are exploring these assumptions in a negative situational context (failure). Specifically, we hypothesize:

- **H3a**: High level of construal results in a significantly more positive affective response than low level of construal.
- **H3b**: Friendly communication style results in significantly more positive affective response than dominant communication style.
- **H3c**: At high level of construal, the positive effect of a friendly communication style on affective response is more pronounced than at low level of construal.
- **H4a**: High level of construal results in significantly more goal commitment than low level of construal.
- **H4b**: Friendly communication style results in significantly more goal commitment than dominant communication style.
- **H4c**: At high level of construal, the positive effect of a friendly communication style on goal commitment is more pronounced than at low level of construal.

7.5.1 Design and Method

Again our study used a 2 (construal level: abstract vs. concrete) x 2 (communication style: friendly vs. dominant) between subjects design with four different vignettes Similar to study one, the vignette study was conducted online and the participants were randomly assigned to one of four conditions.

7.5.1.1 *Participants*

We recruited 177 participants (104 male, 73 female), aged 20–69, $M = 33.45$, $SD = 9.35$ using Amazon Mechanical Turk (MTurk). The recruited participants resided in the United States or the European Union. We required participants to have completed at least 1,000 HITs with a 95% acceptance rate, in line with past work in Psychology and HCI (?, ?) The survey took an average of 3min 04s to complete and the participants received $0.80 as compensation.

7.5.1.2 *Procedure*

In the online vignette study, users were presented with a neutral description of the situational context. They were asked to imagine that they had recently downloaded a fitness app, in order to become more active. Furthermore, they were informed that they had used it all week and had recently increased their step goal to 8000 steps per day. The participants were told that they had woken up in the morning and the fitness app presented them with the following feedback, which they should study carefully. Afterwards, we showed a prototype phone screen with fitness advice in one of the randomly assigned conditions, informing them that they had failed to achieve their goal. Figure 3 and 4 show examples of the screens.

7.5.1.3 *Measures*

Similar to study one, we presented the participants with questions regarding their demographic data, after the survey introduction. We then inquired about their affective response and their goal commitment. The order of the scales has been randomised. We administered the Goal Commitment Scale from Hollenbeck et al. (Hollenbeck et al., 1989). The participants indicated their agreement on a Likert scale from very strongly disagree to very strongly agree. We queried the affective response of the participants based on the items used by Williamson et al. (Williams et al., 2013). The participants evaluated the extent to which the feedback of the fitness app felt "pleasant," "desirable," "painful," and "unpleasant" (latter two reverse-coded). These responses were made on 7-point scales anchored by "not at all" and "very."

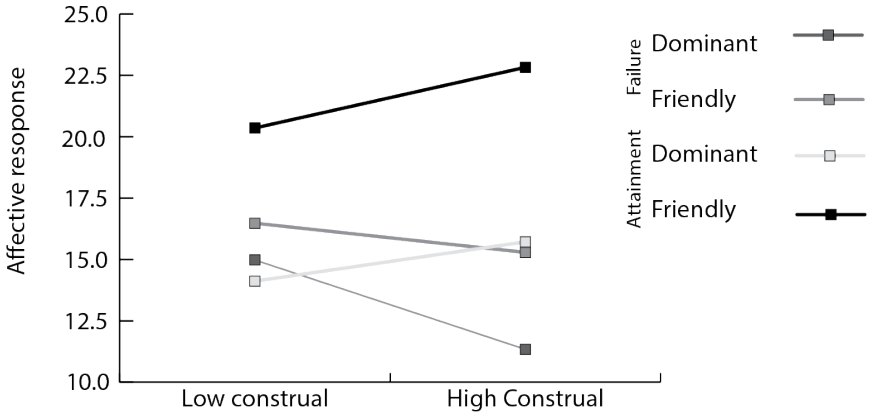


Figure 7.5: Average total affective response in the two experimental conditions (construal level, communication style) in both situations.

7.5.2 Affective Response

How do level of construal and communication style of fitness app feedback influence users' affect-based evaluations of the feedback when they did not achieve their goal? To answer this question, a two-way ANOVA was conducted. This analysis revealed a significant main effect of the construal level manipulation ($F(1, 173) = 7,069$, $p = .008$). Participants who were presented with the feedback in a concrete manner reported higher evaluations ($M = 15.62$, $SD = 5.64$) compared to those who were presented with the feedback in an abstract manner ($M = 13.77$, $SD = 6.16$). Thus, H3a is not confirmed. There was also a statistically significant main effect of the communication style manipulation ($F(1, 173) = 6,401$, $p = .012$. Participants who were presented with the dominant communication style reported lower evaluations ($M = 13.63$, $SD = 6.12$) compared to those who were presented with the friendly communication style ($M = 15.81$, $SD = 5.60$). Thus, H3b is confirmed. There was no interaction between the construal level and the communication style factors ($p > .05$). Thus, H3c is not confirmed. Figures 7.5 and 7.6 present the results.

7.5.3 Goal Commitment

How do level of construal and communication style of fitness app feedback influence users' goal commitment when they did not achieve their goal? To answer this question, a two-way ANOVA was conducted. This analysis revealed a significant main effect of the construal level manipulation ($F(1, 173) = 4,031$, $p = .046$). Participants who were presented with the feedback in a concrete manner reported lower goal commitment ($M = 29.77$, $SD = 5.70$) compared to those who were presented with the feedback in an abstract manner ($M = 31.37$, $SD = 5.48$). Thus, H4a is confirmed. There was no statistically significant

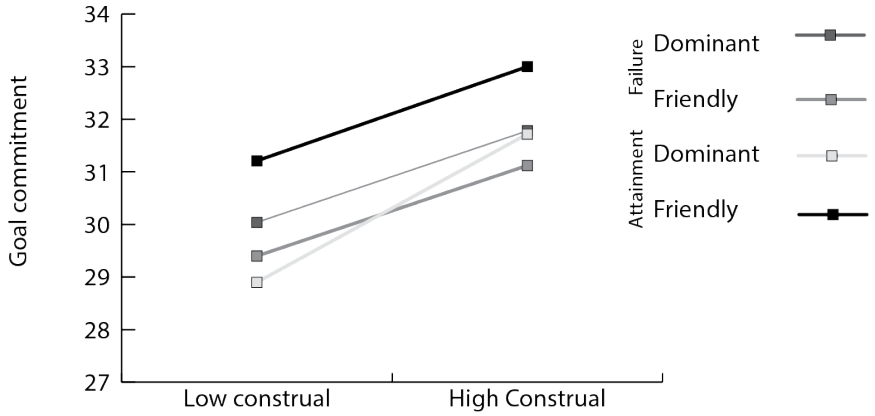


Figure 7.6: Average total goal commitment in the two experimental conditions (construal level, communication style) in both situations.

main effect of the communication style manipulation ($F(1,173) = 0.146$, $p > .05$. Thus, H4b is not confirmed. There was no interaction between the construal level and the communication style factors ($p > .05$). Thus, H4c is not confirmed.

7.6 DISCUSSION

7.6.1 Goal Attainment

In brief our results show that abstract compared to concrete construal leads to a more positive affective response in the event of goal attainment, as assumed in H1a and in line with the results from Williams et al. (2013). Williams et al. showed that a more abstract construal improves evaluations of many experiences (Williams et al., 2013). This in turn could have led to a more positive affective response. Additionally we found that affective responses varied significantly between the two different communication styles, as assumed in H1b. Depending on how the message of goal attainment was communicated, participants showed different affective reactions, with the friendly communication leading to more positive affect. These results could be explained through the mood-congruence recall effect – that suggests that people in a positive affective state tend to focus more on positive aspects than people in a negative affective state (Mayer, Gaschke, Braverman & Evans, 1992). Hence, our participants might have already been in a positive affective state due to attaining their goal, which in turn, might make them more receptive for the friendly communication style of the message.

Other than assumed (H1c), the interaction between level of construal and communication style regarding affective response was not significant. Construal level and communication style thus seem to

have separable influences on affect-based evaluations Furthermore we found that there was a significant difference between the message framed on different levels of construal regarding goal commitment in the positive situation of goal attainment. In line with H2a, the more abstract construal level led to higher goal commitment than the more concrete construal level. This finding may be explained through the relationship between construal level and self-control, with high construal level having a positive impact on perceived self-control (Fujita et al., 2006). In light of previous findings, linking higher self-control to higher goal commitment (Locke & Latham, 2006). It thus seems plausible that high levels of construal go along with higher goal commitment. However, future research is needed to get insights into the exact relations between the three variables (construal level, self-control, goal commitment) and possible mediating effects. Furthermore, in line with H2b, goal commitment was affected by the used communication style in the message on goal attainment, with the friendly communication resulting in higher commitment than the dominant communication style. We assume that the friendly, supportive communication style might increase participants' perceived self-efficacy, which in turn, in line with the results from Locke and Latham (2006), could have led to higher goal commitment. As also for affective response, the interaction effect between level of construal and communication style on goal commitment was not significant. Thus, other than assumed in H2c, the effects of construal level and communication style are merely additive.

Altogether our exploration of effects of construal level and communication style in the context of goal attainment found that abstract construal led to a more positive affective response, supposedly shifting the focus to higher level goals (seeing the forest instead of focusing on the trees). We assume that this shift in focus might enhance the positive experience of achieving a fitness goal through adding meaning to the achieved step goal. The participants perhaps perceive the situation as positive because they have not only achieved their step goal but also come a step closer to their overall goal of becoming fitter. Furthermore, the more abstract construal led to higher goal commitment, eventually due to an interrelation with self-control, which should be investigated in future research. The positive effect of the friendly communication style on affective response and goal commitment showcases that not only the content of the feedback, but also the way in which the media communicates the message, seem to be an influencing factor for the psychological reactions of participants.

7.6.2 Failure

In the negative situation of failure, our results showed a significant effect of the level of construal on the affective response. However, other than assumed in H3a, a lower, more concrete construal level

(instead of a more abstract construal level) resulted in a more positive affective response. This result contradicts previous findings regarding construal level and evaluations of experiences (Williams et al., 2013). A possible explanation can be construed in light of the studies by Eyal et al. (2008). They found that participants in a higher construal level mindset judged moral transgressions more harshly than participants in the low construal level condition, arguing that the abstract mindset might have promoted a focus on the higher level moral principles that have been violated, rather than the concrete deed. The level of construal thus affects the basis of evaluation, and negative events appear even more serious when considered on a high compared to a low level of construal, given that superordinate, moral principles have been violated. Our findings in the failure condition might be interpreted in a similar way: The superordinate goal of our participants was to become fitter, however, they failed in achieving their goal, i.e. a negative event. This failure might have appeared even more severe in the high construal level condition, which promoted a stronger focus on the superordinate goal than the low construal level condition. This might explain the less positive affective response in the high compared to the low construal level condition. As assumed in H3b, we found a significant effect of communication style on affective response, with the message of failure being communicated by a friendly communication style leading to a more positive affective response than the dominant communication style. Thus, independent of the varying message content between our two studies (i.e. goal attainment or failure), participants experienced a friendly communication as more positive. A friendly communication may be experienced as more positive experience in general. In addition, in the situation of failure, the friendly communication style might have decreased the emotional cost of the failure and increased self-efficacy. Our results in the failure condition also showed a significant effect of the construal level on goal commitment. In line with H4a, more abstract construal resulted in higher goal commitment. In parallel to study 1 and the positive situation of goal attainment, we hypothesise that a high construal level has a positive impact on self-control (Fujita & Roberts, 2010), which may also facilitate goal commitment. Furthermore, high level of construal may support participants to see the forest (getting fitter) instead of the trees (failure regarding the step goal today). In consequence, with a high level of construal, the single event of failure might not have appeared as drastic and discouraging as in the low construal level condition, and instead activated a defensive orientation in action, thus showing the participant that they can still push to reach their superordinate goal and therefore leading to less negative impact on goal commitment.

This line of reasoning, however, contradicts to some extent the interpretation of the (unexpected) finding on affective response, where

we speculated that failure might have appeared more severe in the high construal level condition, due to the activation of a superordinate goal and leading to a more negative affective reaction. In sum, it still requires further research to understand the exact mechanisms behind the effects of construal level and their impact on participants' experience and goal commitment in the condition of failure. Other than in study 1 and the positive event of goal attainment, in the event of failure, communication style had no effect on goal commitment, leading to the rejection of H4b.

In parallel to study 1 and the positive situation of goal attainment, in study 2 and the negative situation of failure no significant interactions between level of construal and communication style were found, either on affective response or on goal commitment. Thus, all our hypotheses assuming interaction effects (i.e., H1c, H2c, H3c, H4c) had to be rejected.

7.6.3 Effects of Level of Construal and Communication Style in Situations of Goal Attainment Versus Failure

Altogether, the many differences between the findings for situations of goal attainment (study 1) and failure (study 2) highlight the importance of distinct studies on the effects of construal level and communication style in light of the context, namely, the message being communicated. Depending on the message content and its valence, how the message is communicated (construal level, communication style) has varying consequences for peoples' experience and commitment to a goal.

Our results showed that a more abstract construal was related to higher goal commitment in both situations (goal attainment, failure to achieve the goal). This presents an opportunity for future work, which can apply these findings to formulating qualitative, superordinate goals as demonstrated by Niess and Wozniak (Niess & Woźniak, 2018).

Furthermore, our results showed ambiguous results regarding the effect of the level of construal on affective response. In the positive situation of goal attainment a more abstract level of construal led to a more positive affective response, whereas the more concrete level of construal led to a more positive affective response in the negative situation of failure. These ambiguous results showcase the need to investigate this connection in future research.

We found that the friendly communication style led to a more positive affective response in both situations, whereas the friendly communication style only had an effect on goal commitment in the situation of goal attainment. In the situation of failure communication style had no effect on goal commitment. Hence, we recommend to

apply the friendly communication style when formulating feedback in self-improvement technologies.

To summarise, the present study partly confirmed the results of (Williams et al., 2013) in two hypothetical fitness scenarios. It is, to the best of our knowledge, the first empirical investigation of the application of construal level theory and the communication styles of interactive technologies for self-improvementin a controlled, experimental setting.

7.6.4 Practical Implications

Throughout all our inquiries no significant interaction effect between level of construal and communication style has been found. This leads to the assumption that these two factors exert independent influence. Consequently, there are two separate dimensions that can be manipulated when crafting customised feedback for mobile fitness applications users. Furthermore we found a significant effect of the communication style on affective response and goal commitment across all our inquiries, except from goal commitment in the negative situation of failure. One practical application we can derive from these results is that, if no other information about prior preferences of the user is given, a friendly communication style for designing feedback can generally be recommended, because it is most likely to not provoke a negative response. Deriving practical implications based on our findings regarding construal level is more complex. Our findings showed that the direction of the mean difference varied for different scenarios (goal attainment, failure). In other words, based on our study it is not yet possible to provide a psychologically founded, evidence based recommendation, such as using a specific construal level throughout different scenarios for persuasive messages. Our findings are in line with previous work that showcased that a high level of construal can lead to more positive affective evaluations and can support psychological factors relevant for behavioural change (e.g. self-control (Baumeister, Vohs & Tice, 2007), and goal commitment (Locke et al., 1988). However, the results of the present study also mirror uncertainties similar to the results found in previous work. For instance, Eyal et al. showcased that participants tend to construe situations in more value-laden terms in the abstract level of construal manipulation, hence judging moral wrongdoings more harshly (Eyal et al., 2008). Connecting our results and results from Eyal et al. (Eyal et al., 2008), one could hypothesise that there are certain concepts, such as moral values, that can affect psychological outcomes in unexpected ways. Therefore more research is needed to investigate this.

We found that the direction of the mean difference was different in the positive and the negative scenario regarding affective response. In other words, our results showed a more positive affective response in the more concrete construal condition in the negative situation,

whereas the affective response was more positive in the more abstract construal condition in the positive situation. Hence, one could assume that the level of construal should be manipulated based on the valence of the scenario.

In contrast, the more abstract construal level led to more goal commitment in both scenarios (goal attainment and failure), which leads to additional complex considerations regarding the specific purpose of a self-improvement technology. Questions such as whether a self-improvement technology can successfully support users long-term and keep them committed when their affective response on feedback is negative, should be raised in future research.

7.6.5 Limitations and Future Research

Our work constitutes a first step towards designing mobile fitness app feedback based on psychological theory, yet we recognise that the approach used in this paper is prone to certain limitations. We used mainly MTurk to recruit the participants for our two studies. Even though previous research discussed advantages of that approach (Paolacci et al., 2010; Mason & Suri, 2012), we recognise that the target audience of mobile fitness applications most likely extends beyond the pool of participants available on MTurk. However, we studied participants from North America and Western Europe, in line with the majority of past work that focused on technologies for self-improvement and fitness. Furthermore, we used hypothetical data to study the potential effects of different theory-based ways to craft feedback given from mobile fitness applications. We believe that this decision was justified as we were striving for high internal validity. Our work is the first empirical investigation of principals of the construal level theory of mobile persuasion (S. J. Katz & Byrne, 2013), as well as of the communication styles of interactive technologies for self-improvement. Nevertheless, future research should explore if our findings can be replicated with real mobile fitness application users. Several future research directions may advance our understanding of the role of communication style and construal level on self-improvement and behavioural change. To adequately study affective response in the context of media to support self-improvement, we encourage use of an experience-sampling procedure in which participants rate their momentary affective responses immediately after receiving feedback from their technology (Feldman, 1995). Thus, we believe it is important to measure affective response at many time points during the process of behavioural change in order to build an in-depth understanding of the changing affect connected to the behavioural change process since these might recursively influence core affective experiences as people go through processes of goal setting and goal pursuit (Carver & Scheier, 2000). Our results regarding the

positive situation of goal attainment have been as expected. However, the question remains to what extent technology support is needed if users are managing to achieve their goal. Hence, implications regarding the design of self-improvement feedback in situations of failure are of particular interest. Nevertheless, our results regarding the negative situation of failure have been ambiguous and more research is needed to investigate the effect of construal level on goal commitment further. An interesting opportunity for future work is the investigation of whether our findings can be extended to other self-improvement goals communicated through self-improvement media, such as goals for healthy eating or integrating mindfulness into ones everyday life. Moreover, investigating goals with different temporal distance and exploring if the more abstract level of construal still has a positive effect on goal commitment is another direction for future work.

7.7 CONCLUSION

The present paper investigated the effects of construal level and communication style to communicate mobile fitness application feedback to participants who have either met or not met their fitness goal. We conducted two between-subject online studies with four conditions each — four different mobile fitness app messages displayed on a phone screen. We found that a more abstract construal level led to significantly higher goal commitment and positive affect compared to a more concrete level of construal when the participants achieved their goal. Further, our results showed that a friendly communication style resulted in significantly more goal commitment and positive affect than a dominant communication style. In the negative situation the concrete construal level led to a more positive affective response and no effect for communication style on goal commitment was found. In both situations no interaction effect between level of construal and communication style was found. Previous inquiries regarding construal level have, inter alia, focused on learning. Our work extends these findings to self-regulated processes of technology-mediated behaviour change. The present research broadens our understanding of the psychological effects of communication style and construal level of media feedback. Furthermore our studies showcase that the theoretically sound design of media feedback is an important, but at the same time, complex endeavour. Moreover since media support for behavioural change is dynamic and complex in its nature, additional factors beyond our inquiry might play a role, not the least of which is initial motivation (internal, external), we have not considered yet. However, the processes we have explored are likely to come into play, and influence people on their media supported process of change. We have outlined the first steps of how the design of future mobile fitness

app feedback could apply psychological theory in meaningful ways to design for a positive, long-term experience.

8 PAPER IV: TRACKER GOAL EVOLUTION MODEL

This chapter is based on:
Niess, J., and Woźniak, P. W. (2018, April). Supporting Meaningful Personal Fitness: the Tracker Goal Evolution Model. In Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems (p. 171). ACM.

While the number of users sporting fitness trackers is constantly increasing, little is understood about how tracking goals can evolve over time. As recent studies have shown that the long-term health effects of trackers are limited, we need to readdress how trackers engage users. We conducted semi-structured interviews and an online survey to explore how users change their tracking goals. Based on our results, we created the Tracker Goal Evolution Model. The model describes how tracker goals can evolve from internal user needs through qualitative goals to quantitative goals that can be used with trackers. It also includes trust and reflection as key contextual factors contributing to meaningful transitions between goals. We postulate showing how tracker goals relate to other personal fitness goals as key for long-term engagement with trackers. Our model is useful for designers of future trackers as a tool to create evolving and meaningful tracking goals.

8.1 INTRODUCTION

Wearable fitness trackers, available as standalone devices or part of smart watches have now established themselves on the consumer market. Trackers promise the users opportunities to improve fitness and lead a healthier life. The first longitudinal studies on the health effects of wearing a fitness tracker are now available, showing that while an initial health effect was observed, fitness trackers failed to offer long-term wellbeing support to users (Jakicic et al., 2016). Concurrently, past research reported that users find it hard to express their expected fitness levels through metric-based goals supported by fitness trackers (Gorm & Shklovski, 2016b). As a consequence, there is a need for a new generation of fitness trackers that support long-term health goals taking the complex facets of how the fitness and motivation of a user

evolves into account. Research in Human-Computer Interaction (HCI) is yet to address the next steps in understanding tracking in order to build better, long-term supportive trackers.

Recent work in HCI which explored issues such as lapses (D. A. Epstein et al., 2015), aesthetic appeal (Lee, Cha & Nam, 2015), adherence (Tang & Kay, 2017) and competition (Gorm & Shklovski, 2016b) for using a tracker indicates that goals are a recurrent theme when users interact with trackers. However, the field is yet to explore the intricacies of managing and setting goals. Thus, a better understanding of how users choose and use their goals is required. We propose readdressing the question of how, when and why to set goals in trackers. To this end, we studied users' relationship with goals, how they adapt and plan goals and how their goals relate to their data collection practices. Through a series of interviews and a survey, we established an account of the roles goals may play in fitness tracking. Based on our findings, we propose a new understanding of goals for fitness trackers in the form of the Tracker Goal Evolution Model. The model uses hedonic and eudaimonic wellbeing as underlying concepts that help create more meaningful goals for trackers. Hedonic wellbeing focuses on the presence of positive affect and the absence of negative affect. Furthermore hedonic wellbeing is often associated with pleasure and fun. Eudaimonic wellbeing is about self-fulfilment, finding meaning in life and developing one's potential (Ryan & Deci, 2001). Our model is intended to serve as a submodel for existing models of personal informatics. Our approach provides new insights for designing fitness goals that evolve with the user and support long-term tracker usage.

This paper contributes the following: (1) a qualitative study of the practices in using tracker goals consisting of 19 interviews and a survey with $n = 162$, (2) an account of the users' current practices with tracker goals and (3) the Tracker Goal Evolution Model — a new understanding of goals that uses the lens of hedonic and eudaimonic wellbeing.

In this work, we first introduce the reader to hedonic and eudaimonic wellbeing and review related work in HCI on understanding user practices around trackers. Next, we report on the details of how we conducted the interviews and the survey. We then introduce the Tracker Goal Evolution Model. The following section illustrates how the model describes user practices around fitness tracker goals. Finally, we propose how our results may be operationalised to enable designing meaningful goals for personal trackers.

8.2 RELATED WORK

In this section, we first introduce the reader to the hedonic and eudaimonic wellbeing literature to build the understanding lens we apply

in this paper. We then review past work in the HCI field in the area of personal informatics and showcase how an extended understanding of tracker goals is needed.

8.2.1 Hedonic and Eudaimonic Wellbeing

In this work, we use the lens of hedonic and eudaimonic wellbeing to understand a subset of the user's internalised needs that are manifested through goals. These goals can be supported with fitness trackers. These concepts form the theoretical basis of the understanding of current practices in our model. Research in Psychology has been using two different conceptualisations of wellbeing for the last two decades, hedonic wellbeing and eudaimonic wellbeing (Ryan & Deci, 2001; Waterman, 1993). The main focus in the field of wellbeing research lies in hedonic theories. This concept has mainly been associated with the presence of positive affect and the absence of negative effect. However, recently scholars have begun to recognize the potential of eudaimonic wellbeing as a means of gaining a deeper understanding of user behaviors and needs. Eudaimonic wellbeing focuses on self-fulfilment and meaning (Ryan & Deci, 2001). Positive psychology (the scientific study of positive human functioning and flourishing (Seligman & Csikszentmihalyi, 2014)), points out that the notion of subjective wellbeing is often used for the concept of hedonic wellbeing and the notion of psychological wellbeing for the eudaimonic approach (Delle Fave et al., 2011). Hedonia and eudaimonia are not opposites, nor are they mutually exclusive; they are complementary psychological functions (Huta, 2015). As the literature does not agree on a single conceptualisation of hedonia and eudaimonia (Huta & Waterman, 2014), we focus on recurrent characteristics of hedonic and eudaimonic wellbeing to use them to understand fitness tracker goals.

Four distinct categories of wellbeing definitions can be found (Huta & Waterman, 2014): *Orientations* focus on people's aspirations, motives, goals, values and ideals; *Behaviors* describe activities of individuals; *Experiences* are constituted through emotions, cognitive or affective appraisals; and *Functioning* addresses the individual's potential of living a healthy, functioning life. The concepts of hedonia and eudaimonia have been featured in recent HCI research. Notably, Mekler and Hornbæk (Mekler & Hornbæk, 2016) discussed how user experience research can benefit from embracing the concepts of hedonia and eudaimonia. Our work is the first, to our knowledge, to apply these concepts to tracking. Here, we do not address hedonic and eudaimonic experiences. Instead, our work addresses the concepts of hedonic and eudaimonic wellbeing with a focus on *orientations*.

8.2.1.1 *Hedonic Wellbeing*

The philosopher Aristippus introduced the term Hedonism in the fourth century BC. He postulated that the search for pleasure was the most desirable good (Telfer, 1980). Hedonic wellbeing is often associated with the term 'happiness' and its dimensions can be positive feeling, pleasure, enjoyment, positive emotions, painlessness, ease and satisfaction amongst others (Delle Fave et al., 2011; Huta, 2016). The hedonic concept can include physical pleasure as well as feelings of emotional or cognitive comfort. In a hedonic mindset people focus on wellbeing as an outcome (Fowers et al., 2010). However, the concept of life satisfaction does not fall into the classic understanding of hedonic wellbeing (Deci & Ryan, 2008).

8.2.1.2 *Eudaimonic Wellbeing*

The first one to define the concept of eudaimonia was the Greek philosopher Aristotle (Henderson & Knight, 2012). Aristotle postulated that the key to wellbeing was to develop one's potentials and live a meaningful and authentic life. Even though definitions of eudaimonic wellbeing vary widely, some recurring aspects can be found (Huta, 2016). Eudaimonic wellbeing can relate to many aspects of an individual's life such as: value, relevance, maturity ethics or autonomy.

We believe that hedonic and eudaimonic wellbeing, as it offers an operationalisation of needs related to oneself, offers a way to gain a deep understanding of fitness tracker goals. Fowers et al. (Fowers et al., 2010) found that hedonic and eudaimonic wellbeing are directly related to goal orientation. That is why, in our inquiry, we use the concepts to study and chart how users manage, change and define fitness tracker goals. We noticed that these can evolve like the ever-changing wellbeing needs of an individual. Using this analysis lens resulted in the emergence of our Tracker Goal Evolution Model.

8.2.2 Personal Informatics

A large array of past research efforts explored the understanding of user practices around trackers. As more and more users buy fitness-tracking wearables, it remains a challenge for HCI to enable designing trackers that offer tangible and reproducible benefits to wellbeing. This is a key consideration as currently available trackers have been proven to offer limited health and wellbeing benefits by studies in the medical field (e.g. (Jakicic et al., 2016; Bravata et al., 2007)). Consequently, HCI looked for design guidelines that understood fitness trackers as instances of persuasive technology. Notably, Consolvo et al. (Consolvo, Everitt, Smith & Landay, n.d.) built a mobile application prototype to establish design requirements for health support technologies. They stressed that fitness systems 'should give users credit for their activi-

ties' thus recognising that building a sense of achievement was key for fitness technologies. This indicates the importance of understanding goal practices and how systems can support goal setting.

8.2.2.1 *Challenges of Numeric Goals*

As fitness trackers became a mass-market phenomenon, HCI scholars began to study different aspects of the tracker experience. Particular attention was given to step goals and step programs. Gorm and Shklovski (Gorm & Shklovski, 2016a) found that workspace step counting programs affected the users' privacy concerns. They also determined that the competition caused by step goals in trackers called for users making moral choices and possibly raising social tension while providing no tangible health benefit (Gorm & Shklovski, 2016b). These examples show potential drawbacks to fitness goals that need to be addressed further.

8.2.2.2 *Understanding Lapsing*

Concurrently, understanding why users abandon and return to fitness trackers became a major question. Clawson et al. (Clawson, Pater, Miller, Mynatt & Mamykina, 2015) studied craigslist users disposing of tracking technology to find that it could be equally motivated by perceived failure, success or social pressure. Further, Epstein et al. (D. A. Epstein, Caraway et al., 2016) found that the practicalities connected with maintaining data or the practices revealed by tracking may also be reasons for lapses. To mitigate possible drawbacks of lapses, Agapie et al. (2016) proposed a design strategy to enable users to consciously lapse by using 'cheat points' and showed that this approach produced positive behavioral effects. Our work is interestingly different as, instead of mitigating or finding reasons for lapses, we investigate them as possible manifestations of insufficient motivation provided by the tracking system.

8.2.2.3 *Models of Personal Informatics*

Finally, a number of efforts aimed at building a holistic understanding of practices around fitness trackers. Notably, Epstein et al. (D. A. Epstein et al., 2015) proposed the lived informatics model of personal informatics that inspires designing for data-driven reflection and described cycles of tracker use. They extended earlier work by Li et al. (I. Li, Dey & Forlizzi, 2010) by, inter alia, accounting for users returning to trackers after lapsing. Epstein et al. model personal informatics as consisting of four major phases: (-) deciding, (-) selecting, (-) tracking and (-) acting and lapsing. The lived informatics model presents the most comprehensive view of personal tracking presented so far, yet the authors explicitly state that one consequence of applying their model is the need to harness goal migration. We aim to extend existing

models by focusing solely on the *tracking and acting*. Our work aims to take another angle from previous works as it looks specifically at goals related to fitness in order to aid in designing more engaging tracking experiences. We strive to understand goals better to help users continue what Epstein at al. call *tracking and acting*, thus possibly producing long-term benefits. Hence, a need for a model that specifically addresses goals emerges.

Additionally, Rooksby et al. (Rooksby, Rost, Morrison & Chalmers, 2014) identified tracking styles that characterised different data-driven needs of users. Tang and Kay (Tang & Kay, 2017) studied data practices of those using trackers long-term and found that users appreciate feedback about their adherence and can reflect upon their own tracker practices. In contrast, this work endeavors to understand user practices specifically around tracker goals, thus investigating how tracker goals can contribute to maintaining and/or improving the user's wellbeing. Our work is further motivated by the fact that past research has shown a large array of user behaviors and attitudes around trackers, yet current devices only support a small number of goals.

8.3 METHOD

In order to explore the users' relationship with tracker goals and the ways they choose, manage and interact with goals, we conducted a two-part inquiry. First, we conducted exploratory interviews with participants who were active users of fitness trackers. Based on the interviews, we designed an online survey to explore aspects of tracker goals in a larger population sample.

8.3.1 Interviews

The semi-structured interviews lasted an average of 31 minutes (20–65). Each of the interviews was a one-on-one session with a single researcher. We recruited $N = 18$ participants through snowball sampling starting with social media posts. The participants were aged 18–41 ($M = 26.67$, $SD = 5.42$). Nine interviewees were male and nine female. Interviews were only conducted with participants who identified as users of fitness trackers. All the sessions were audio recorded upon receiving consent from the participant. Table 8.1 shows an overview of the interview participants.

8.3.1.1 *Interview Protocol*

In the interview, we first obtained demographic data and information about their daily usage of the tracker. We then inquired about the goals set, the motivations behind setting the goal(s) and the interviewees'

Table 8.1: An overview of the interview participants. All participants were active tracker users. The duration reported is the time since the participants stated tracking and in some cases includes lapse periods. Participant IDs are used throughout the paper to indicate interview quotes.

ID	Age	Sex	Profession	Tracking Time	Primary goal	Device used
P1	29	M	IT specialist	2 yrs.	Steps	Fitbit
P2	30	F	Teacher	2 yrs.	Steps	Fitbit
P3	21	M	Student	3 m.	Steps	Xiaomi
P4	18	M	Student	2 yrs.	Steps	Polar
P5	29	F	Researcher	2 yrs.	Body mass	Xiaomi
P6	22	M	Engineer	8 m.	Active hrs.	Garmin
P7	29	F	Researcher	1 yr.	Steps	Xiaomi
P8	26	M	Engineer	5 yrs.	Steps	Fitbit
P9	29	M	Programmer	6 m.	Exercise sessions	Apple Watch
P10	35	F	Researcher	2 yrs.	Calories	Apple Watch
P11	28	M	Unemployed	9 m.	Exercise sessions	Apple Watch
P12	27	F	IT specialist	1 yr.	Steps	Xiaomi
P13	29	F	Data specialist	6 yrs.	Steps	Fitbit
P14	32	M	Car mechanic	1 yr.	Exercise sessions	Pebble
P15	41	F	Researcher	6 m.	Steps	Fitbit
P16	20	M	Student	2 yrs.	Steps	Xiaomi
P17	27	F	Unemployed	4 yrs.	Steps	Fitbit
P18	26	F	Student	6 yrs.	Steps	Fitbit

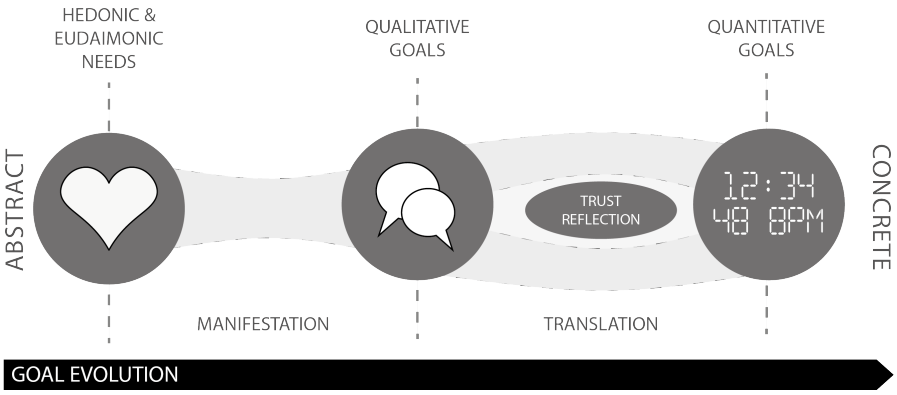


Figure 8.1: Our Tracker Goal Evolution Model. The model describes how qualitative goals emerge from internalised hedonic/eudaimonic needs. It then illustrates how qualitative goals are translated to quantitative tracker goals through reflection and trust.

history of changing goals. We paid particular attention to whether they planned the evolution of the goals and the reasons for changing (or not changing) them. In the next part of the interview, we investigated if the way users managed goals may have been connected to a history of lapses (which might have been key to understanding their tracker experience as shown by Epstein et al. (D. A. Epstein, Caraway et al., 2016)). Finally, we explored if and how users reviewed and reflected upon tracker data and how goals may have facilitated that process.

8.3.1.2 *Analysis*

All audio recordings were transcribed verbatim and imported into Atlas.ti analysis software. Two researchers coded a representative sample of 15% of the material using open coding. Next, a coding tree was established through iterative discussion. The remaining transcripts were split between the two researchers and coded individually. A final discussion session was conducted to finalise the coding tree after the material was coded. We then identified emerging themes in the transcript describing the practices around goals to further investigate in the survey.

8.3.2 Survey

Our online survey further investigated tracker goal practices identified in the interviews. The survey contained questions about whether the users had a goal set in their tracker and what kind of goal it was. Further, we explored how tracker goals related to qualitative personal fitness goals. We also asked participants whether they had a history of changing goals and reasons for (not) changing goals. Finally, we asked about the role of goals in their social environment. We used promoted social media posts and university mailing lists to recruit

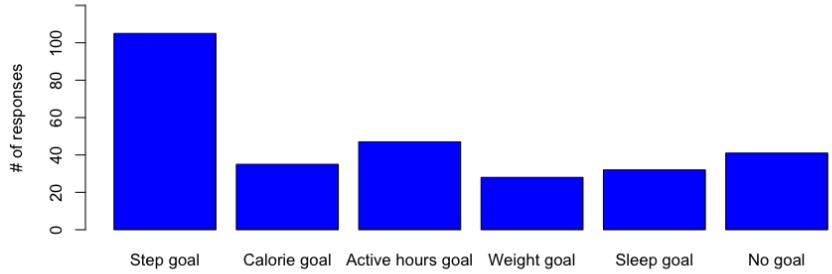


Figure 8.2: The quantitative tracker goals set by survey respondents. Note that users were able to report multiple goals as setting multiple goals is common in current commercial trackers. A free text field was provided for other goals, but none of the participants used it.

$n = 162$ participants (85 male, 77 female, aged 17–66, $M = 27.96$, $SD = 8.21$). The survey was available over three weeks.

All survey respondents were active users of fitness trackers. 137 participants were based in the European Union and 15 in the US. 75% (121 participants) of the participants had a goal set in their tracker, with the majority using a step goal. Figure 8.2 presents the different tracker goals the respondents used. Further, the majority (109 participants, 67%) of answers reported experiencing a lapse in tracking, defined as a break from using the tracker longer than a month. Most of the respondents (112, 69%) acquired the trackers themselves, but 50 participants had received a tracker as a gift.

8.4 THE TRACKER GOAL EVOLUTION MODEL

Based on the interviews and survey, we developed a new model of how fitness trackers goals evolve. The Tracker Goal Evolution Model focuses solely on understanding the needs of the users in terms of fitness tracking and meaningfully translating them into fitness goals. Further, it enables designing new goals and adjusting them as the user's fitness changes.

Our model is intended to be a subordinate construct to Epstein et al.'s (D. A. Epstein et al., 2015) lived informatics model and, to a lesser degree, the stage-based model of personal informatics (I. Li et al., 2010). We extend the lived informatics model by addressing goals in more detail. We found that assuring that the user's goals can effectively evolve and keeping them engaged may prolong the time in which the users stay in what Epstein et al. call the *tracking and acting* stage. Similarly to Epstein et al., we do not adopt a behavioral change goal,

but attempt to account for all motivations for tracking. However, while the lived informatics model addresses goals (discussed as *motivations for deciding to track*), it does not include changing goals and evolving needs, which we integrate into our model.

8.4.1 The Levels of the Model

Our model divides the understanding of fitness trackers into three levels: hedonic and eudaimonic needs, qualitative goals, and quantitative goals. We use the word 'levels' to distinguish them from Epstein et al.'s 'stages' as the constructs in our model are simultaneous rather than sequential. Each level in our model represents a different level of abstraction with regard to a fitness goal. The levels are highly coupled, so that success on any of the levels is tightly related to achievement on the other levels, and a lack of satisfaction on one of the levels negatively affects the rest of the model.

We define the most abstract level as *hedonic and eudaimonic needs*. This level refers to the highly internalised needs of a user which are often not explicitly verbalised. While these needs vary significantly between tracker users they form both the core of their motivation and the anticipated benefits of tracking. In our model, the user primarily evolves on this level and the consequences of that evolution are then carried onto the following levels.

Qualitative goals form the next level in our model. They constitute a manifestation of the *hedonic and eudaimonic needs*. *Qualitative goals* are often verbalised and users consider them rational. The verbalisation of needs is often connected with social exchange. Users are able to share and discuss their goal with their social environment, e.g. their peer group. Furthermore, they are often regarded as sources of motivation and provide a personal reference for fitness achievement.

We define the most concrete level in our model as *quantitative goals*. These goals are often expressed by numbers and can be input in a fitness tracker. *Quantitative goals* are translations of *qualitative goals* into a form that can be used in a tracker. We further define two supporting factors necessary for this translation to be successful. Building trust in the goal and in the tracker is required for the goal to be relevant and stay meaningful for the user. The goal must enable reflection so that it can evolve and connect to the higher levels of the model. Here our model differs significantly from Li et al. (I. Li et al., 2010). While they saw reflection as a necessary condition, our model suggests that reflection and trust reinforce a pre-existing connection between qualitative and quantitative goals.

8.5 UNDERSTANDING THE MODEL

In this section we show how our model relates to the data we gathered in our studies and how it describes the current user practices around fitness tracker goals. Here, we present the recurring themes from the interview and survey data. As the model is closely tied to fitness tracking practice, it can be used to support designing meaningful goals.

8.5.1 Hedonic and Eudaimonic Needs

Through the coding process we found that users often used vague descriptions of their needs and motivations in the tracking context. Even though a broad spectrum of needs was expressed by the interviewees, they struggled to explicitly describe qualitative goals and a desire to transition from hazy descriptions to something 'easier to access' (P6). They struggled to specify what they hoped to gain from tracking:

> [...] *it is just more gadget for me than something that I really need. But I bought another one when the first one broke, so it means something. (P7)*

Another user expressed that she lacked clear goals as obtaining a tracker was motivated simply by her curiosity:

> *I really like playing around with technology and I also wanted to get a little more active. (P2)*

Another interviewee mentioned that an important goal quality is that the goal should make you feel good. Yet they found it hard to provide a more detailed description of what 'feeling good' would entail and they questioned the meaning of quantitative metrics:

> [...] *all the metrics we look at right now are really subjective. Everyone has a different stride which is then counted as one step* [...] *a meaningful goal is when you're satisfied with yourself, so with your fitness level* [...] *on a meta level* [...] *When you're satisfied with yourself and the metrics are in a way that they feel right for you. For example, maybe you're already fit if you run only 6,000 to 7,000 steps but the tracker recommends 10,000 steps. That's a really stupid metric because some people are also fit even if they run much more or just less. I think this is a very, very important factor for this* [...] *the tracker says for each person 10,000 steps is the ultimate goal. That's probably a stupid metric. (P11)*

The interviews showed that many users assessed the meaning and value of what they were striving for through their own feelings, instead of specifying a goal based on how they would like to feel. The following statement of one of the users shows that the connection between the user's feelings and his goal remained intangible.

> [...] *every time when you realize that it has an effect on your life, health and condition. I also saw the difference on myself and how do I feel when I was running and when I was not. And the general awareness that when you train you are feeling better and you are in a better condition what affects on your family life in the future. (P8)*

Users would often communicate a general need to evolve. They outlined their striving to become a 'better person'. Yet, they were still vague when queried about the nature of what the goal to achieve that should look like:

> *Going with the goals helps me achieve more. I'm this type of person. It's simpler to make new habits and just be better. (P11)*

One user emphasised the desire to regain a former fitness level. Interestingly, the means to achieve that were not described in detail:

> *Ah, my idea is just to get back to where I was before pregnancy. That's it. I think I reached a plateau there. I couldn't do more than that. If I wanted to do more than that then I should stop working and do sports! (P10)*

Our results show that users often find it hard to express their fitness goals. It becomes especially hard if one tries to formulate goals using the means available in current commercial trackers. On one hand, this is caused by the multitude of motivations for tracking (here our finding connect to Epstein et al.'s model (D. A. Epstein et al., 2015)). On the other, we observed that participants often struggled with expressing their fundamental human needs with regard to wellbeing. That is why, in our model, we employ the theories of hedonic and eudaimonic wellbeing. Our model describes current practices as it shows that users need support for manifesting basic wellbeing needs (defined through hedonia and eudaimonia) in the form of qualitative goals. Hedonia and eudaimonia can manifest goals, needs or both.

8.5.2 Qualitative and Quantitative Goals

Models of personal informatics list different motivations for starting the tracking experience (D. A. Epstein et al., 2015), yet they do not discuss how these motivations relate to tracker goals. We observed that motivations (which stem from hedonic/eudaimonic needs) are often manifested through qualitative goals and then translated to quantitative goals that can be input into trackers. Thus, understanding the relationship between qualitative and quantitative goals is a key element in our model.

We noted that 97% of the participants in our survey reported having a qualitative goal. This was reflected in the interviews, where most users replied with a qualitative goal when asked about 'a goal'. One

participant explicitly stated that she did not find a quantitative goal meaningful in contrast to her qualitative goals:

> [...] *since I remember, I did a lot of sports. The numbers don't motivate me. (P17)*

Further, when we reflect upon perspectives on their desired fitness, participants would often refer to mental states and a personal perception of being on track as a reference. The ultimate goal for fitness was often described in terms of motivation and perception of progress:

> *The most important thing is that the goal actually is related to some kind known level/range to some extent, that we consider ourselves active or advanced and* [...] *also motivates us to perform better. (P1)*

We further observed that the users would set qualitative goals for fitness activities that were not explicitly tracked. They used quantitative metrics as approximations of their activity, but they were concerned primarily with the untracked activity. P18 reflected how step counting complemented her activity in football practice where team expectations were her main focus:

> [...] *in the past things that have motivated me have been being part of a team. Not necessarily for step count but I did play soccer for my university and knowing that I had a bunch of other team mates who were counting on me to be fit really motivated me to make sure that I was actually working out and getting steps in... well really, getting runs in at that point. (P18)*

Similarly, users reported making day-to-day decisions using qualitative goals. Participants would often aim to keep a perceived activity level without referring to qualitative measures thus prioritising their perception of activity over tracker metrics:

> [...] *OK, today I will work in the lab with my computer, so the day will be a bit lazy, so it will be good if I will take a longer walk and I'm OK with that. (P4)*

In contrast, our study also included users who had very well manifested hedonic needs which were easily translated into quantitative measures. These users would build their entire experience around documenting progress in numbers:

> *I'm just obsessed with the weight. I mean I have phases. At some point I was really obsessed with the steps, so then I would just really walk in the apartment,* [...] *so it's kind of claustrophobic.* [...] *But now I'm really obsessed with the weight. And the scale is really accurate. You can really see if there's 100g on or off. So I feel like I document this, I did it. (P7)*

While P7 experienced an effective match between her needs and the quantitative measures, other users stated that numeric metrics posed some challenges. One participant who had an active hours goal expressed that the time periods were arbitrary and could sometimes be

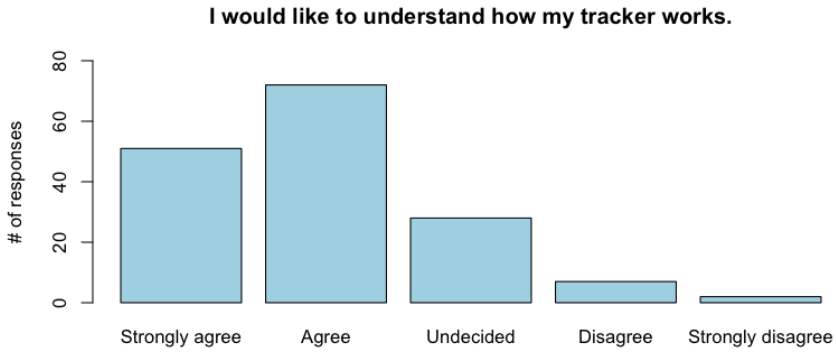


Figure 8.3: 76% of the survey participants reported that they 'strongly agree' or 'agree' with the sentence 'I would like to understand how my tracker works.'.

disruptive, which illustrates a mismatch between the qualitative goal ('be active throughout the day') and the quantitative translation in the tracker ('Make 250 steps in 9, 60-minute periods starting at the full hour'):

> *Yeah, I actually sometimes get annoyed, 'cause sometimes I'm pretty focused and then it interrupts me. I've never really appreciated that... being the middle of a thing and be like 'Yeah get up!' It's not really my behavior. (P18)*

It can be observed that the translation from qualitative to quantitative goals is a factor that determines the quality of the experience of tracker goals. Our model encourages making that translation explicit and empowering users to realise how the quantitative goals that their tracker uses relate to their perception of fitness. Our results show that the awareness of that relationship can lead to increased engagement and foster potential for long-term usage. Tracker goal designs should make this relationship approachable and ensure the users are aware of the purpose of their qualitative goals. We determined that two factors, reflection and trust, are key to strengthen the user's understanding of how tracker goals relate to their personal fitness goals.

8.5.3 Supporting Factors: Reflection and Trust

Our survey has shown that 76% of the participants expressed the desire to understand more about their tracker as shown in Figure 8.3. Simultaneously, 48% of the users perceived their tracker as accurate (see Figure 8.4). This illustrates that those using fitness trackers have a need for increased knowledge of how the tracker works. Further, they do not fully trust the data provided by current commercially available fitness trackers. These opinions also resonated in our interviews.

8.5.3.1 *Goals and Trust*

We noted that many of the interviewees explicitly requested that the tracker suppliers provide more information about the inner workings of the device:

> [...] *they have to describe precisely, or more or less precisely if they don't to want to show the algorithm, how is this calculated or something. Or, just to show a description would be enough. Here we take your heart rate variability and multiply it by 60. I don't know. That would be enough. (P8)*

Further, most interviewees recalled being surprised by tracker measurements or thinking that the measurement was incorrect. This often led to confusion or immediate doubt in the accuracy of the device. One participant was concerned by the discrepancy between their perceived sleep quality and the data provided by the tracker:

> *But when you're tired and you have the feeling that you've slept only for three hours and it shows you eight, you cannot believe. Or sometimes, I don't actually know how it works, but it shows how many times did you wake up at night and sometimes it shows 15 and you don't remember waking up at all. But then I still cannot say that it's true, 'cause you move when you sleep and you're not so sure that you woke up. Maybe just the device didn't recognise it. (P16)*

In contrast, another user also believed that the tracker provided sleep data that was not fully accurate. However, they decided to use the offered precision as an acceptable reference metric:

> *Yes, it's not 100% trustworthy, but you can get a hint of quite well of what was your sleep and how was your sleep. (P17)*

We also observed that a lack of accuracy and/or trust in the data may have led to partial abandonment. One of the interviewees reported initially tracking sleep, but then realising that the metrics provided did not enable him to understand his sleep patterns well enough:

> *Before I was also using it to track sleeping, but I'm not using it anymore, because it was not giving me enough data. (P9)*

The limited accuracy of current trackers caused some users to wonder how much knowledge about their body their trackers should provide. For users who aimed to get a deep understanding of the metrics, a mismatch potentially caused by lack of accuracy was a reason for concern:

> *For the heart rate it's very difficult because it's often very different and I'm not sure if this is a measurement error or is this my real heart rate? Because sometimes I am working really slowly and then I have a heartbeat of 140 where I usually have a heart rate of 90 or 100. (P7)*

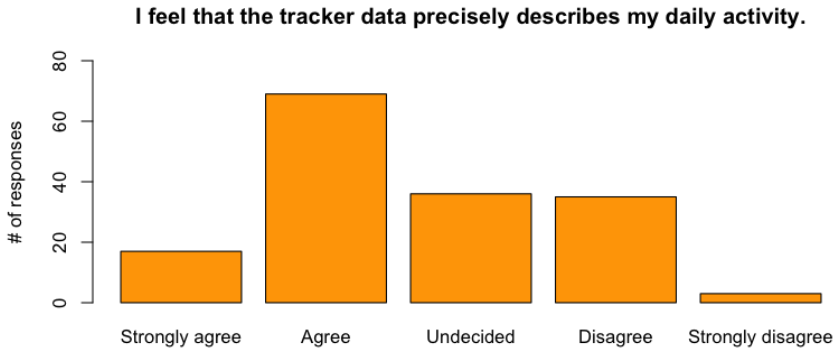


Figure 8.4: 47% of the survey participants reported that they 'strongly agree' or 'agree' with the sentence 'I feel that the tracker data precisely describes my daily activity.'

Another aspect of trust that we found in our data was trusting in the fitness goal being meaningful. Users endeavored to understand enough about the goal so that they could find it actionable and feel in control of their progress. They also expressed the desire to trust in their tracker helping them manage activity towards their goal. One user was disappointed at the notifications reminding them to move when they have already exceeded their goal for the day:

> *Maybe if I would understand a step goal a little bit more I could say 'OK, I [want to] accomplish 20k steps'. I think that I would appreciate it a little bit more* [...] *but when it tells me to move I'm kinda annoyed, when I've achieved this step goal* [...] *It usually happens when I've been walking a lot. (P12)*

Users also appeared to lose trust in their goal when it did not adjust with significant changes in their life. Participants found that they could not connect tracker goals with changing training regimes, nutrition patterns or family situations. One interviewee remarked that she found her goal useful before her pregnancy, but the goal became confusing after the birth. This shows how the user trusts the goal to be meaningful and expects to be able to reflect upon it.

> *But before pregnancy I was looking at the green cycle, circle, the exercise thing [referring to Apple Watch activity visualisation]. But I don't have really intense exercise right now, so doesn't really tell me more. But before I was looking at it, for example to cycle more, faster or something like that.* [...] *I don't really understand it, I don't know. Maybe I need an explanation why this is useful or not, I don't know. (P10)*

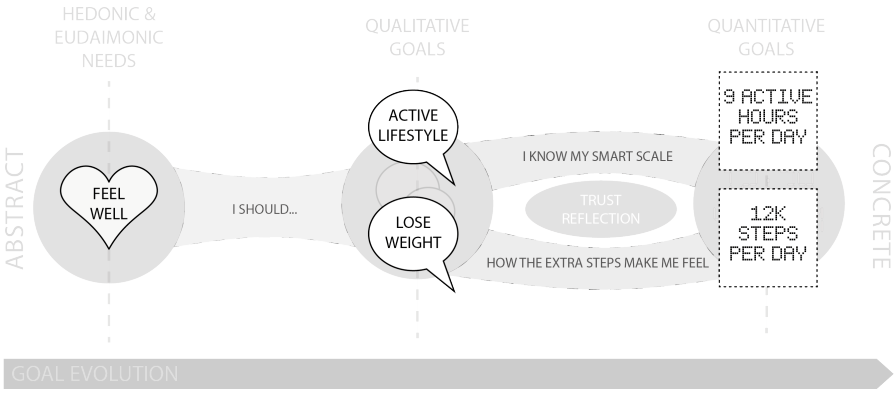


Figure 8.5: Example of how the Tracker Goal Evolution Model can be used to understand a part of the goal practices of a single user. The user's goals are built around the eudaimonic need to feel well in one's body. The need is then manifested through the desire to lose weight and lead an active lifestyle. The tracker can then help translate those goals into an active hours goal and a step goal. In order for the goals to provide engagement and allow for evolution, the user must know the relationship between the numeric metrics and their qualitative perception. They also need to trust and understand their goal and tracking technology.

8.5.3.2 *Reflecting on Goals*

Several participants reported that they not only expected the tracker to reflect profound changes in their lives, but also respond to slowly changing routines on an everyday basis. One reported that the tracker understood their erratic work and sleep patterns caused by a medical condition:

> *Sometimes when I work from home the step counter value is much lower. I can tell that I worked from home like 2 days or something over the weekend. Then I feel like* [...] *it's kind of nice to work from home, but then the step counter is not really active. So next time, maybe next week, I'll have a full work week, so I won't work from home next week.* [...] *My medication is actually influencing my sleeping patterns and I'm actively taking medications to avoid this. And I change them according to how effective they are. So I just check the sleeping time, not the quality but the time. So like when I went to sleep when I woke up and stuff like this. Yeah, it's kind of an overview of how things were this week. (P5)*

We further observed that users wanted to reflect upon activities that were not explicitly tracked and relate them to tracker metrics so that they could have an overview of their fitness. One participant tried to compare their car mechanic work with running:

> *If a wheel weighs 120 pounds and I have to move that around a lot, granted, it rolls, but you also have to pick it up half a meter-*

> *ish. The amount of work I do is generally in spurts. Translate that to the running side, it would be more like sprinting a lot, because I'll drive for an hour to a location, work on a couple trucks and even when I'm working on a truck, I'll work in one spot for 15 minutes to an hour. (P15)*

Some interviewees reported that they had moments when they explicitly decided to reflect on their data. To that end, they used opportune moments; periods when they had time to spare:

> *Last time I had some problems with falling asleep, I went to the beach, I synchronized my Fitbit with my smartphone and checked some data. It makes more sense to check it after a longer time because then the plots are showing better data. (P1)*

Another participant used the metrics explicitly to calm down and maintain a slow walking pace in a stressful situation:

> *During my master exams I was stressed and I didn't know what to do with myself. I wondered what I could do to just free myself from the surroundings and be less stressed out and I just started walking with my dog.* [...] *I had a slower pace, so I could chill and think about different things. (P16)*

Finally, many of our participants expressed the desire that the tracker should have provided them with an overall assessment of how well they were in general. They wanted an objective measure that would go beyond a perception that could be gathered from other sources:

> *I also consider my tracker as a good summary of what I do with my body. For example, for running, I do use a running app, which tracks my activity while running and I have in-depth stuff in it but for other activities I don't use any software or separate device to monitor the goal* [...] *'cause this I do more for fun and cause I like being active* [...] *but the tracking could give me an opportunity to sum it up and get a more or less precise view* [...] *on all these activities. (P4)*

Our results show that different dimensions of trust are instrumental in the user's interactions with a fitness tracker goal. In our model, trust must be mediated to maintain engagement with a fitness goal. Two aspects of trust are key: trusting the accuracy of the tracker and trusting that the fitness goal is meaningful. The first kind of trust can be built by making the operation principles of trackers available to users. We observed that participants need more information about how trackers store and process fitness data in order to maintain a more informed relationship with their fitness goals. Trust in the meaningfulness of one's fitness goals can be through providing a clear link between the numerical metrics and their envisioned consequences for health and wellbeing. This shows how trust is a mediating factor in our model that is necessary for users to connect qualitative and quantitative goals.

However, we observe that trust cannot exist without the ability to reflect. In our interviews, users often connected their qualitative achievements to quantitative goals through reflection. Through using opportune moments to reflect users are looking to qualitatively assess their progress towards their qualitative goals with the help of the measures provided by the tracker. Consequently, reflection is a necessary mediating factor in our model. Together with trust, reflection forms two intertwined requirements to keep the user engaged and provide a rich experience of fitness tracking. Our results suggest that these two qualities are necessary for the user's goals to keep evolving and empowering them to adjust their goals according to the changes in their life.

8.6 USING THE MODEL

Having illustrated how our model reflects current user practices around trackers, we now show how it can aid the design of tracker goals in a future generation of trackers. In order for users to maintain engagement with their tracking experience, they need to engage with goals on the three levels of the model.

Understanding of whether a goal stems from a hedonic or eudaimonic need can help to design how the goal is communicated and presented, and how progress is reported. However, *hedonic and eudaimonic needs* of users are highly internalised, so it may be hard to query the user and obtain explicit accounts. Thus, we propose that systems begin the interaction with goals on the *qualitative goals* level. This is in contrast with current systems, which usually propose an arbitrarily selected quantitative goal and, in some cases, help adjust it. Our model shows that **users require an explicit connection between the numeric values presented by trackers and their qualitative goals**. That is why we propose that tracker applications should ask users about qualitative goals first. Then, as the system processes the user's qualitative goals, it can propose a connected set of quantitative goals that would lead to their achievement. Figure 8.5 presents an example of how our model can be operationalised to map the goals of a specific user.

We argue that the process of explicitly translating between qualitative and quantitative goals is key for meaningful interaction with trackers. Our results show that **the translation needs to be accompanied by building trust**. On one hand, trackers should provide information on how goal metrics relate to goals. Numeric metrics should be directly linked to anticipated health and wellbeing benefits. On the other hand, we observed that users also desire to understand how the metrics involved in their goals are obtained. Consequently, trackers

should provide information on how progress towards a given goal is measured, in a form that is understandable by the user.

Further, our model can also be used to support the constant evolution of goals that go beyond the current practice of simply increasing goals by an arbitrary number. Firstly, trackers should **empower users to reflect on their qualitative progress by referring back to qualitative goals** and showing how daily quantitative goals contribute to a larger qualitative meaning. This will enable them to understand progress in qualitative terms and adjust their qualitative goals in conjunction with quantitative goals. Secondly, being aware of the user's qualitative goals will enable designing systems that link them to hedonic and eudaimonic needs. This, in turn, will enable suggesting meaningful qualitative goals that foster reflection.

8.7 DISCUSSION

While we built the Tracker Goal Evolution Model to be as descriptive of current practices around fitness trackers as possible, it still constitutes a simplification. Our model proposes a way of thinking about fitness tracker goals that highlights the key elements of goal evolution that are needed to keep the user engaged. However, our approach is neither exhaustive nor fully analytical.

8.7.1 Hedonia and Eudaimonia are a Spectrum

Mapping a user's needs into hedonia and eudaimonia is difficult and a topic of discussion in the field of Psychology. Our model does not require one to fully analyse a user's needs as this can only be done by the user themselves. Instead, the fact that hedonia and eudaimonia are directly linked to qualitative goals in our model stresses the fact that fitness goals are manifestations of internalised needs. Remembering about hedonic and eudaimonic wellbeing while setting fitness goals can assure that the user's internalised motivations are part of the goal setting process. While we recognise that the understanding of how fitness goals relate to hedonia and eudaimonia presented in this paper is not complete, our research shows that quantitative goals are hard for users to relate to wellbeing.

8.7.2 Emphasising Transitions

The two transitions in our model (manifestation and translation) form an axis of goal evolution that should be strongly supported by fitness tracker designs. As our results show that users are in need for additional aids in making those transitions, a challenge for future design emerges. Concurrently, users expressed a desire to understand how

trackers work and how the tracking metrics are obtained. Yet, current fitness tracking solutions usually offer a quick questionnaire at the beginning of the tracking experience and there is little engagement with the internals of the tracking system throughout the usage period. We believe that future trackers should make the infrastructure and the algorithms they use more transparent. In line with the concept of seamful design (Chalmers & Galani, 2004) trackers could show users parts of the details of their operations. Exposing the ways data is gathered in fitness trackers can help users understand the metrics they generate and thus build trust in the tracker. Showing how trackers decide to suggest goals to users and making their anticipated benefits explicit will help users understand how their qualitative goals translate to their quantitative goals better.

We recognise the possibility that some qualitative goals translate to quantitative goals better than others. For example, the interview data showed that participants concerned with weight were more number-driven. This creates on opportunity for future systems to offer multifaceted experiences that communicate with the user using a mix of qualitative and quantitative terms tailored to the user's personal goal. If future designs can chart where the user is on the hedonia-eudaimonia spectrum and how number-oriented their fitness goal can be, new trackers should be able to offer more effective feedback and more personalised experiences.

8.7.3 Relation to Other Models

In this work, we illustrated how our model is subordinate to other models of personal informatics. However, as our work also addresses a number of high-level concepts, there are other theories and models that can be used to understand elements of the Tracker Goal Evolution Model. While reflection features prominently in our model and we provided examples of how users engage with trackers to reflect, we do not offer solutions for designing for reflection nor does our work describe the process of reflection. We see an opportunity to apply the knowledge and practices in reflective informatics (i.e. the design and understanding of interactive artefacts that promote and support the process of reflection (Baumer, 2015)) to our model. Our model can contribute to understanding technologies for reflection by helping chart goal evolution that lead to developing reflective practice by users.

Further, we recognise that a model of trust could also be applied to our model. For instance, the trust-theory model from Castelfranchi and Falcone (Castelfranchi & Falcone, 2010) provides a socio-cognitive computational model that could potentially help unpack the concept of trust in the Tracker Goal Evolution Model. This, in turn, can enable a deeper understanding of the trust dynamics involved in trusting the accuracy of the tracker and finding one's fitness goal meaningful. Our

model shows that future tracker designs should embody trust to offer long-term engagement. Thus, we see that future research on building trust in tracker design is required.

8.7.4 Limitations

While we strived to make our model as comprehensive as possible, we are aware that it is prone to some limitations. Firstly, our user sample consisted primarily of Western European participants. Past work used primarily US-based populations recruited through Mechanical Turk. We recognise that our findings are still constrained within the Western culture. Fitness trackers are not only prominent in Asia, but they are also entering emerging markets and further studies are needed to understand the user practices around trackers in these settings. The user experience of personal informatics is likely to be affected by cultural biases. The risks and opportunities that come with the ubiquity of fitness trackers may be experienced differently based on the sociocultural context of the data collected.

Moreover, we decided to focus our inquiry solely on fitness tracking, while other models endeavored to cover the entire field of personal informatics. Our focus enabled us to engage with the intricacies connected to fitness, but it also limits the applicability of our model. The relationship between quantitative and qualitative goals in our model is described based on user practices with very specific metrics, e.g. steps and calories. Consequently, our model would need to be adjusted to scale to other domains of personal informatics.

8.7.5 Future Work

We believe our approach to understanding and designing fitness goals for trackers offers a more effective operationalisation than applying complex motivational theories from psychology to designing for fitness, in contrast to work by Knaving et al. (Knaving et al., 2015). However, we see further improvements to understanding fitness tracker goals that can be addressed by future research. Firstly, we envision that users can be queried about the nature of their goals to identify how their goals are placed in the hedonia-eudaimonia spectrum. This would enable designing goals that build on internalised motivations. How the tracker could communicate with the user to obtain such information is an open question, cf. (Niess & Diefenbach, 2016).

Secondly, we wonder how a better understanding of one's goals and the goals of others can enhance social interaction. Future research can explore how better fitness goals can help use tracking data in communication (much like HeartChat (Hassib, Buschek, Woźniak & Alt, 2017)) and sharing data to build insight, cf. (Wozniak et al., 2017). Our model also offers the possibility to understand the social dynamics

in families or groups behind goals to build situated reflection systems (like (Knaving & Woźniak, 2016)), but this potential must be verified in further studies. Finally, we wonder how our model generalises and if it needs to be adapted to domains other then fitness tracking, e.g. menstrual cycles, breastfeeding, diet tracking, or sleep. While our inquiry was limited to tracking physical activity, it may address other personal informatics experiences, much like the lived informatics model (D. A. Epstein et al., 2015).

8.8 CONCLUSION

In this paper, we introduced the Tracker Goal Evolution Model. Our model describes the user practices around fitness tracker goals on three levels: *Hedonic and eudaimonic needs*, *Qualitative goals* and *Quantitative goals*. These three levels are connected with two transitions: manifestation and translation. We based our model on a series of semi-structured interviews and an online survey. Our model enables charting an individual's goals in order to build more engaging and evolving tracking experiences. The model can be used as a complement to models of personal informatics as it offers a new perspective on how a user's goals evolve through the journey through personal tracking.

We hope that our work will help researchers and designers address new challenges with personal tracking and build trackers that offer long-term benefits. Our model aims to contribute to a new generation of trackers that offer engaging experiences and tangible benefits. In future work, we hope to investigate how it can help generate alternative designs for fitness trackers and ways to communicate its levels and transitions to the user in a meaningful way.

9 PAPER V: FORMULATING FITNESS TRACKER GOALS

This chapter is based on:
Niess, J., Woźniak, P. W. and Kucharski, P. P. 'It Decided without Even Asking': Formulating Fitness Tracker Goals that Foster Understanding and Commitment. Submitted for review.

9.1 INTRODUCTION

Fitness trackers are now commonplace on our wrists, in our pockets or integrated into smartphones. In 2017, 29 percent of the US population tracked their physical activity using a wearable device (gfk, 2018). Most of those users did so with the hope of increasing their overall well-being, health and life satisfaction. Yet, despite the apparent commercial success of fitness trackers, clinical research has not yet confirmed potential health benefits to using a fitness tracker (Jakicic et al., 2016; Chan, Ryan & Tudor-Locke, 2004; Bravata et al., 2007).

To determine how to build trackers that do contribute to the users' well-being, research in Human-Computer Interaction (HCI) has been attempting to understand the experience of activity tracking. Notably, Epstein et al. (D. A. Epstein et al., 2015) found that most personal informatics experiences were interrupted and users often lacked the motivation necessary to prevent lapsing in their use of the tracker. Furthermore, Spiel et al. (Spiel et al., 2018) showed how fitness trackers were designed for a very narrow user group. Niess and Woźniak (Niess & Woźniak, 2018) determined that users often experience a mismatch between their fitness goals and the feedback provided by the tracker. This body of work shows that while trackers are gaining popularity, they still require significant improvement.

Consequently, understanding more about how fitness trackers affect users and how data produced by fitness trackers can be used for personal benefit remains a challenge for HCI. A key hurdle is finding ways to provide sufficient motivation to prevent lapses and thus offer a holistic long-term personal informatics experience (D. A. Epstein et al., 2015). In this work, we address this challenge by investigating ways

in which fitness trackers can promote sustained engagement through suggesting goals, providing a tailored challenge and supporting an ever-improving physical activity routine. Specifically, we investigate if and how fitness trackers can suggest meaningful fitness goals.

To explore goal suggestions for fitness trackers, we conducted three studies in which we analysed different aspects of goal setting. We focused on step goals as these are the most commonly used goals (Niess & Woźniak, 2018; Yang, Shin, Newman & Ackerman, 2015). As there are no widely recognised ways to compute goal suggestions, we first compared different goal suggestion algorithms sourced from commercial applications and social step campaigns. Next, we conducted a vignette study where we focused on the importance of transparency, i.e. explaining how a suggested goal was computed when suggesting the fitness tracker's goals. Finally, we validated our results in a third study, which used fitness tracker data from the participants' own trackers to suggest new step goals.

This paper contributes the following: (1) three studies on methods for suggesting new fitness goals for physical activity trackers; (2) empirical proof that transparency in goal suggestions fosters goal commitment in fitness tracker applications; and (3) implications for designing future tracking technologies that support physical activity.

We begin this paper by reporting on past research that inspired our inquiry. We then report on the details of the three studies conducted, and discuss and interpret the obtained results. Finally, we show how the results of our inquiry impact the way fitness tracker experiences should be designed.

9.2 RELATED WORK

In this section, we contextualise our research within past efforts. First, we review past work in the area of personal informatics. We then discuss physical activity support and goal setting in HCI and beyond, followed by related work focusing on trust and transparency.

9.2.1 Personal Informatics

Aiming for a holistic understanding of personal informatics is a recognised pursuit in HCI. Notably, Epstein et al. (D. A. Epstein et al., 2015) presented the Lived Informatics Model of Personal Informatics. Their work extends the stage-based model of personal informatics systems from Li et al. (I. Li et al., 2010). The Lived Informatics Model consists of four stages: deciding, selecting, tracking and acting, and lapsing (D. A. Epstein et al., 2015). Consequently, a key design goal for a fitness tracker is to keep the user in the personal informatics loop without lapsing. The Tracker Goal Evolution Model by Niess and

Wozniak (Niess & Woźniak, 2018) extends the work from Epstein et al. (D. A. Epstein et al., 2015) by addressing goals in more detail. The authors emphasise the importance of goal evolution for sustaining long-term engagement. Additionally, trust in the goal and the tracker and reflection about the goal are needed for goals to be relevant and to stay meaningful for users. Our work is inspired by these models. We aim to gain a deeper understanding of how to communicate fitness goals with the aim to make them more transparent and foster user trust, thus keeping the user engaged and preventing lapses.

9.2.2 Physical Activity Support and Goal Setting

As recent studies have shown that it remains a challenge for fitness trackers to deliver long-term health benefits (Gouveia et al., 2015a; Chan et al., 2004; Jakicic et al., 2016; Bravata et al., 2007), the HCI field is constantly exploring new methods to keep a user engaged in physical activity. Morrison and Bakayov introduced a social activity tracking system that encouraged face-to-face encounters. The system triggered discussions regarding physical exercise (Morrison & Bakayov, 2017). Similarily, Rooksby et al. developed a mobile application that supported users in tracking, reflecting on and discussing physical activity with others (Rooksby, Rost, Morrison & Chalmers, 2015). Fish'n'Steps encouraged physical activity through creating an environment of cooperation as well as competition (Lin, Mamykina, Lindtner, Delajoux & Strub, 2006). These works highlight social interaction as an important aspect to enrich the fitness tracking experience. In addition, Fish'n'steps showcases how combining different methods to foster engagement with the tracker can be beneficial (Lin et al., 2006).

Other researchers focus on promoting physical activity through reward systems. EdiPulse created chocolate treats to offer playful reflections on physical activity (Khot, Aggarwal, Pennings, Hjorth & Mueller, 2017). Similarly, Khot et al. explored presenting physical activity data as artefacts to prompt reflection (Khot, Hjorth & Mueller, 2014) and Loop (Sauvé et al., 2017) used a moving artefact for the same purpose. Another strain of research explored how users can be helped in pursuing sustained physical activity by allowing cheating. Gal-Oz and Zuckerman conceptualised cheating as a potentially positive behaviour (Gal-Oz & Zuckerman, 2015). Agapie et al. implemented a system utilising cheat points to support users managing their lapses (Agapie et al., 2016). This variety of systems exemplifies multiple ways to address the need for achievement by fitness tracker users. Additonally, prior research aims at integrating lapsing, one of the stages characterising a tracker process (D. A. Epstein et al., 2015) into their personal informatics systems (Gal-Oz & Zuckerman, 2015; Agapie et al., 2016). However, as Niess and Wozniak have shown, it

is still a challenge to integrate self-tracking that accounts for varying goals into everyday life (Niess & Woźniak, 2018).

Past research also addressed goal setting techniques as a means of engaging users (Consolvo et al., 2009). Psychologists have determined that specific goals lead to better outcomes than vague goals (Locke & Latham, 2002). Furthermore, studies have shown that difficult goals lead to higher levels of performance than easier ones (Lacroix, Saini & Holmes, 2008). Munson and Consolvo (Munson & Consolvo, 2012) found that having both secondary and primary goals were perceived as beneficial to help users be physically active. In contrast, ribbons and trophies have not been perceived as motivating by most users. Our work is interestingly different as it explores ways to explain fitness tracker goals in a way that fosters transparency and trust in the tracker rather than specific goal setting techniques or reward systems.

9.2.3 Trust and Transparency in Technology

Trust is a key component in continued usage of technologies (Riegelsberger, Sasse & McCarthy, 2005). Previous works in HCI have investigated how different interfaces support transparency and foster trust (Kizilcec, 2016). Early HCI work showed that if users understand how a system works, they are able to focus on themselves instead of on the system (Shneiderman & Maes, 1997). However, Höök notes that it is not necessarily desirable to have a system explain how it works in full detail because these might be alienating to a layman user (Höök, 1998). In line with that statement Kizilec (Kizilcec, 2016) found that there was a need to balance interface transparency when designing for trust. Too much transparency can be as counterproductive as too little. Other studies found mixed results on the effect of transparency on trust; some showed positive effects while others did not (Kizilcec, 2016). However, Niess and Wożniak found that trust is one of the key contextual factors to foster meaningful fitness tracker goal engagement. Furthermore they found that transparency can help users understand how the tracker works and thereby support building trust (Niess & Woźniak, 2018).Thus, our work aims at investigating how to formulate transparent fitness tracker goals and how this affects attitudes towards and trust in these goals.

Recently, Rader, et al. (Rader, Cotter & Cho, 2018) investigated how explaining Facebook News Feed algorithms affects user assessment of the News Feed. Their results show that the explanations increased participants' awareness of how the system works. Binns et al. conducted three consecutive experimental studies. They explored how users assess the fairness of algorithm decisions and how explanations affect that perception (Binns et al., 2018). They found that there is no simple answer to whether an explanation helps individuals assess the fairness of an algorithmic decision. Binns et al. (Binns et al., 2018)

stressed that more research was needed to gain deeper insights regarding algorithm explanations in different application areas. Eiband et al. (Eiband et al., 2018) combined designing for transparency and interactive technology for physical activity in a fitness application. They introduced a stage-based design process to support the integration of transparency in real-world scenarios, which is now successfully integrated into the commercial Freeletics Bodyweight Coach[1]. Our work builds on this research and explores whether explaining how step goals are computed can potentially increase transparency, help users understand how the tracker works and, consequently, build trust. We are inspired by initial results that showed the benefits of transparency for supporting physical activity. We complement past work by specifically investigating fostering transparency and trust in fitness tracker goals in order to stimulate designing more engaging tracking experiences.

9.3 RESEARCH QUESTIONS

We endeavour to understand how fitness goals suggested by trackers can be perceived as meaningful and keep the user engaged in the tracking experience. This leads to the following research questions:

- **RQ1**: How can fitness tracker goals be presented to users to foster goal commitment and trust?
- **RQ2**: Does transparency in how a fitness goal was computed result in improved goal commitment?

.

9.4 METHOD

To explore how fitness trackers can effectively suggest goals to users, we conducted a series of three studies. We used step goals in all three studies as they represent the most commonly used goal type (Yang et al., 2015; Niess & Woźniak, 2018). While goal setting was explored in theoretical terms, no studies (to the best of our knowledge) investigated goal suggestion algorithms for fitness trackers. That is why our inquiry started with a study where we compared algorithms sourced from commercial applications. We call this study *Algorithm study*. We then chose two algorithms from the *Algorithm study* and carried out a *Vignette study* to explore if transparency in disclosing how fitness goals were computed affected goal commitment and trust in the goal

1 https://help.freeletics.com/hc/en-us/articles/115004675329-The-Freeletics-Bodyweight-Coach-Explained

suggestion. Finally, we revalidated our findings in the *Tracker study*, where we presented transparent and non-transparent goal suggestions to users based on their own current Fitbit data. Before each of the three studies participants were presented with a page informing them that the study was fully anonymous and asking for informed consent. The studies were conducted according to the ethics standards of the conducting institution. According to these rules, the survey was not subject to review by an ethics board. All three studies used participants recruited from Amazon Technical Turk. Theoretical works and empirical studies highlighted potential benefits of Amazon Technical Turk (Paolacci et al., 2010). Paolacci et al. replicated studies from previous judgement and decision making studies and obtained similar results to the original studies (Paolacci et al., 2010). Further, the platform enabled us to source a sample representative of active fitness tracker users worldwide (Mason & Suri, 2012).

9.5 ALGORITHM STUDY

Determining the most beneficial algorithm to suggest a step goal for an individual falls primarily within the scope of the medical and sports sciences. Yet, understanding how to design interactive systems that support effective goal suggestions requires examples of such algorithms. Consequently, we conducted a between-subjects survey comparing five algorithms inspired by those used in commercial devices.

9.5.1 Conditions

In order to establish which algorithm could be the most appealing to users and produce most goal commitment, we searched for algorithms already used in fitness trackers. We were unable to find any official information from fitness tracker manufacturers or research work that would discuss step goal setting algorithms. Consequently, we turned to internet fora where users tried to determine what the algorithms in their trackers were based on. This resulted in five experimental conditions for our study (resulting statements show the value of tomorrow's step goal):

Goal 1, often recommended by step campaigns, e.g. (Attitude, 2018)

```
If (step goal met minimum 5 out of 7 last days):
(today's goal) + 10%
```

Goal 2, a common variation of Goal 1 (Attitude, 2018)

```
If (step goal < 10000):
(mean steps for the last 7 days) + 10%
else (mean steps for the last 7 days) + 5%
```

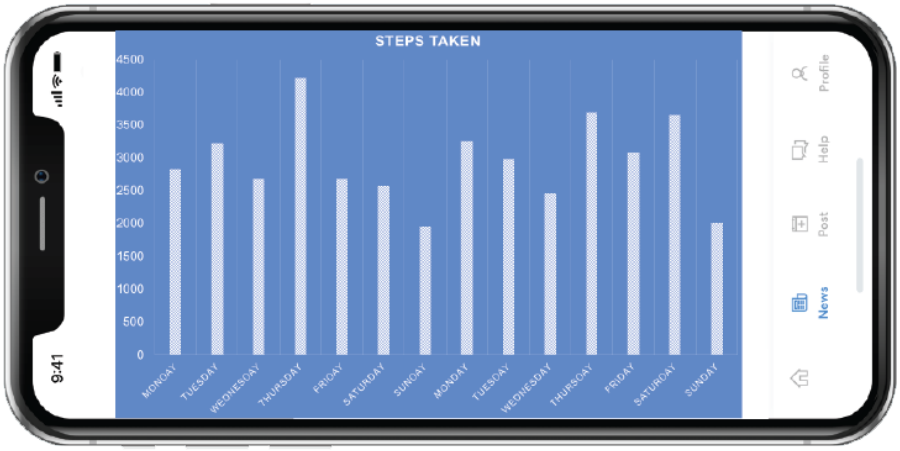


Figure 9.1: A mock fitness app screen with step statistics presented to users in the *Algorithm study* and *Vignette study*.

Goal 3, most likely used in some Garmin tracker models (Garmin, 2018)

```
(today's steps) +5\%
```

Goal 4, most likely used in the Apple Activity app (Allison, 2018)

```
If (step goal met on 5 out of 7 days):
(mean steps for the last 7 days) + 10%
```

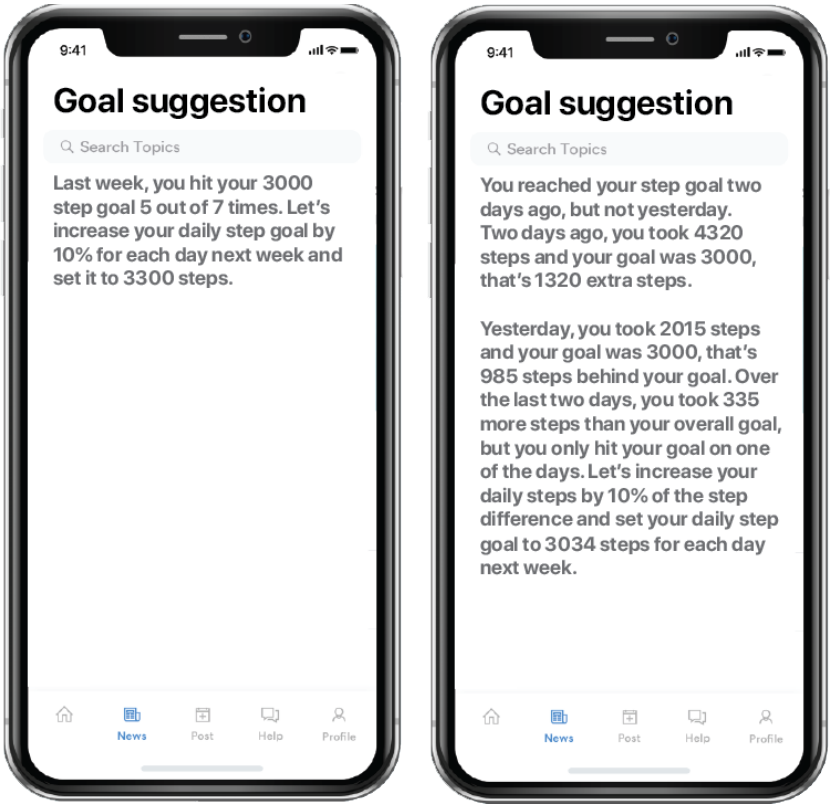
Goal 5, probably used in other Garmin devices (Garmin, 2018):

```
difference = (today's steps) - (today's goal)
If (step goal met today and yesterday):
(today's goal) + 20% * difference
else if (step goal met yesterday, but not today):
(today's goal) - 10% * difference
else if (step goal met today, but not yesterday):
(today's goal) + 10% * difference
else:
(today's goal) - 20% * difference
```

In the survey, users were presented with hypothetical step statistics for two weeks presented as part of a tracker application prototype, as seen in Figure 9.1. Afterwards, we showed a prototype phone screen with a goal suggestion and explanation computed according to the algorithm in one of the randomly assigned conditions. Figure 9.2 shows examples of the goal screens.

9.5.2 Participants

We recruited $n = 67$ participants, aged 19–59, $M = 33.58$, $SD = 10.57$ using Amazon Mechanical Turk (MTurk). Forty four participants were



(a) Goal 1 **(b)** Goal 5

Figure 9.2: Two goal suggestions from the *Algorithm study* presented as mock fitness application screens.

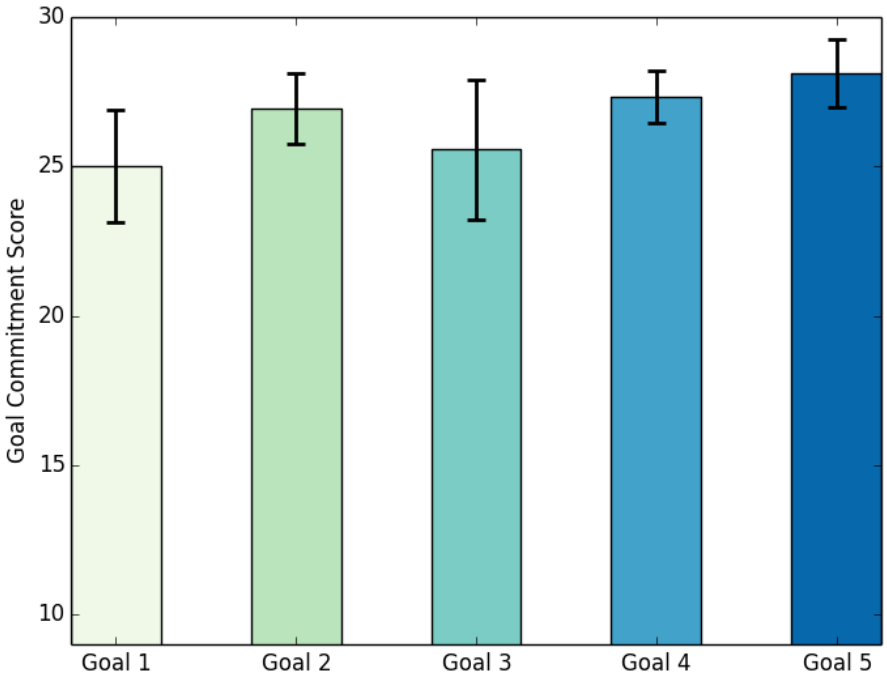


Figure 9.3: Mean scores on the Goal Commitment Scale for the five goal suggestion algorithms in the *Algorithm study*. Error bars show standard errors.

(1) I am confident in the recommended step goal from the fitness app.
(2) The recommended step goal from the fitness app is deceptive.
(3) The recommended step goal from the fitness app is reliable.
(4) I trust the recommended step goal from the fitness app.

Table 9.1: The Trust Scale used in our studies, adapted from work by Cramer et al. Items were scored on a 7-point Likert scale and item (2) was scored inversely.

male and 23 female. The participants resided in the United States or the European Union. We required participants to have completed at least 1,000 HITs with a 95% acceptance rate, in line with past studies of fitness (D. A. Epstein et al., 2015). The survey took an average of 3min 35s to complete and the participants received $1.00 as compensation.

9.5.3 Measures

After the survey introduction, we presented the participants with questions regarding their demographic data. Afterwards, we administered the Goal Commitment Scale (GCS) from Hollenbeck et al. (Hollenbeck et al., 1989), then conducted a scale measuring trust in the system (Trust Scale, see Table 9.1). The participants indicated their agreement on a Likert scale from very strongly disagree to very strongly agree. The trust scale was a modified version of the scale used by Cramer et al. (Cramer et al., 2008). We used the scale to assess if the way the goal was calculated provided potential user benefit. Lastly, we inquired about the participants' propensity to trust, using the faith and trust in general technology scale by McKnight et al. (Mcknight et al., 2011). Propensity to trust has previously been identified as a personality trait independent of a specific trustee as well as independent of the context (Rotter, 1980). Applied to technology this means that trust in technology is given across different technologies and different contexts of use (Mcknight et al., 2011). Thus, we investigated if the trait of propensity to trust technology was correlated to trusting goals suggested by technology, as the literature would suggest.

9.5.4 Results

We conducted a one-way ANOVA to determine the effect of the algorithm used on goal commitment, and found no significant difference, $F_{4,58} = 0.94$, $p = 0.45$. Goal commitment scores for the algorithms are shown in Figure 9.3. Another ANOVA with the aligned rank transform (ART, (Wobbrock et al., 2011)) applied revealed no significant difference for the effect of the algorithm used on trust in the system, $F_{4,58} = 0.74$, $p = .57$. Additionally, a Pearson's product-moment corre-

(1) I understand why the fitness app recommended the step goal it did.
(2) I understand what the fitness app bases its recommended step goal on.
(3) I understand how the fitness app calculated the recommended step goal.

Table 9.2: The Transparency Scale used in our studies, adapted from work by Cramer et al. Items were scored on a 7-point Likert scale.

lation test was computed to assess the relationship between general faith in technology and goal commitment. There was a moderate positive correlation of $r = 0.43$, $p < .01$.

As our study showed no significant differences or even a trend between the goals, we decided to disregard the details of the algorithm in the following studies. We chose Goal 5 as the algorithm to use for further investigation as the highest scoring version. Additionally, we concluded that general faith in technology was a factor affecting trust and goal commitment, as suggested by past work, and would be included in further analyses.

9.6 VIGNETTE STUDY

The second stage of our work was a *Vignette study* that explored how transparency in step goals affected goal commitment and trust in the goal. We decided to use a vignette study (i.e. a study where we ask participants to see the world through the eyes of a hypothetical person in a specific scenario), motivated by past work showing that vignette studies offer the means to balance the benefits of experimental research with high internal validity and the advantages of applied research with high external validity (Aguinis & Bradley, 2014). An additional reason for conducting a vignette study to study tracker goals is the possibility of involving participants who do not own a fitness tracker or would not be willing to contribute their fitness data for the purposes of a study. This is confirmed by privacy research, e.g. (Karlson, Brush & Schechter, 2009), which has shown that users have different attitudes towards their own data than towards the data of others. Thus, we decided to first explore our research questions in a more controlled setting with a higher internal validity and a bigger sample.

Our between-subject *Vignette study* used the same step scenario as the *Algorithm study*. Participants were presented with the same application screen (Figure 9.1) and then with a goal suggestion calculated according to the algorithm we labelled Goal 5 above. In one of the randomly assigned conditions, BLACK BOX, we only presented the calculated number. In the other condition, TRANSPARENT, the full explanation was provided, as shown in Figure 9.2b.

	Black Box		Transparent		ANCOVA	
	M	*SD*	*M*	*SD*	$F_{1,102}$	*p*
Transparency	14.94	4.97	17.31	2.72	11.70	$< .001$
Trust	19.04	5.66	21.09	3.78	5.61	$< .05$
Goal Commitment	25.57	7.08	28.00	4.82	4.93	$< .05$

Table 9.3: Means and ANCOVA results for the *Vignette study*. Levene's test and normality checks were performed and the assumptions met. In all cases, the covariate, propensity to trust technology, was significantly related to the measure, $p < .001$

9.6.1 Participants

Using MTurk, we recruited $n = 105$ participants, aged 21–68, $M = 33.71$, $SD = 9.47$, out of whom 65 were male and 40 female. The residence and MTurk performance requirements applied were the same as in the *Algorithm study*. The participants spent an average of 5min 43s on completing the survey and were remunerated with $1.00.

9.6.2 Measures and Hypotheses

We used the measures used in the *Algorithm study*. Additionally, we wanted to investigate if the systems were perceived as transparent. To that end, we added a scale adapted from Cramer et al. (Cramer et al., 2008). The items in the scale are presented in Table 9.2.

We hypothesised that explaining how the system works would make users perceive it as more transparent and thus build trust and foster commitment. Thus, we formulated three research hypotheses:

H1: Presenting a Transparent tracker goal to users will foster significantly more goal commitment than a Black Box tracker goal.

H2: A system using a Transparent tracker goal will be perceived as significantly more transparent than a system using a Black Box tracker goal.

H3: A Transparent tracker goal algorithm fosters significantly more trust in the system than a Black Box tracker goal.

9.6.3 Results

We conducted three one-way ANCOVAs to determine the effect of disclosing the details of the goal setting algorithm on trust in the system (ART applied), perceived transparency (ART applied) of the system and goal commitment, controlling for the users' propensity to trust technology. We found a significant difference for all three measures. Table 9.3 presents detailed results, shown in Figure 9.4.

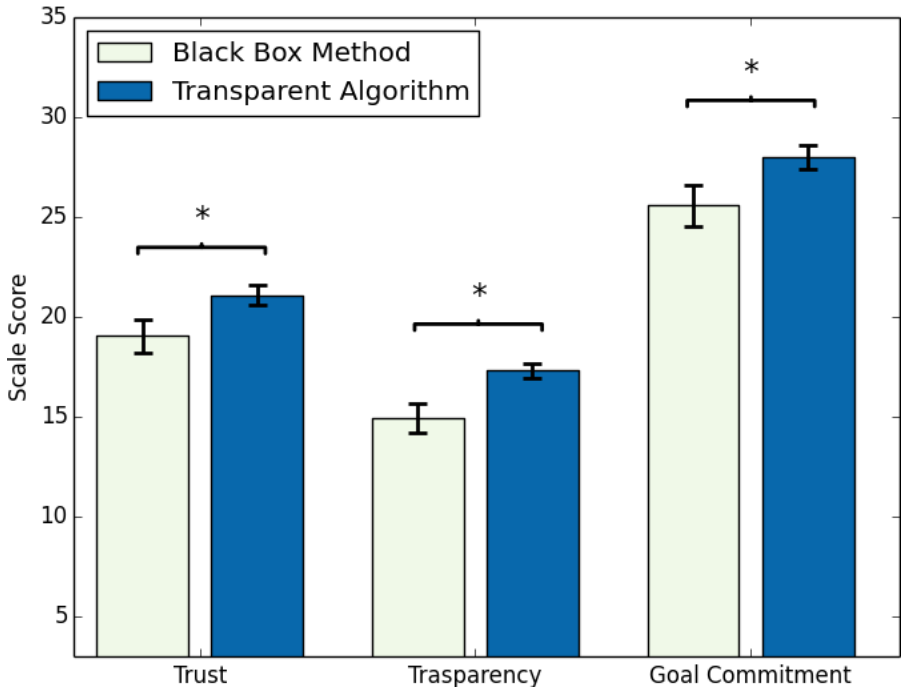


Figure 9.4: Mean scores on the Trust, Transparency, and Goal Commitment Scale for the two conditions in the *Vignette Study*. Error bars show standard errors. Note that the scales have different scoring ranges.

9.7 TRACKER STUDY

Finally, we conducted a study that used the participants' own data to suggest new goals to them. The conditions and measures used were the same as in the *Algorithm study* with the addition of an open text field where we asked participants if they were willing to pursue the presented goal and explain their decision. Participants were asked to provide at least one full sentence. The suggested goals were computed based on the data collected by the participant using their Fitbit fitness tracker. To that end, we built a custom survey web page that first asked the users to provide two weeks of step data to the study. That request was accompanied by an extensive explanation that the study was fully anonymous and only 14 values of daily steps would be collected. When obtaining the data, we collected step value for the most recent 14-day continued usage period of the tracker. This allowed us to ignore days with very low step values, which were most likely instances of the user forgetting to wear the tracker or the device running out of battery.

In the survey, the participants were first presented with a graph of the 14-day step data that was used for calculating a goal suggestion. They were then shown the goal suggestion with a full explanation of how it was computed (Transparent condition) or just given a plain number (Black Box). The conditions were randomly assigned

to participants in a between-subjects design. We explored the same research hypotheses as in the *Vignette study*.

9.7.1 Participants

We recruited $n = 47$ participants through MTurk and calls on social media. Their ages ranged from 22 to 78, $M = 38.06$, $SD = 11.06$. Thirty five were male and 12 female. They received $2.00 as compensation. The participation criteria were the same as in the previous studies with the added requirement of owning a Fitbit tracker.

9.7.2 Results

The fitness tracker users participating in the study were physically active, taking an average of $M = 13496$, $SD = 413$ steps per day. The step goals that they had set on their trackers ranged from 1500 to 20000 steps, $M = 9408$, $SD = 2895$. Interestingly, 31 out of the 47 participants used the default 10000 step goal.

Similarly to the *Vignette study*, we computed a one-way ANCOVA with ART to investigate the difference between the Transparent and Black Box tracker goal in terms of trust in the system, controlling for the users' propensity to trust technology. We found no significant difference, $F_{1,44} = 0.02$, $p = .88$.

We used another one-way ANCOVA with ART to assess the effect of disclosing the details of the goal setting algorithm on the perceived transparency of the system, controlling for the users' propensity to trust technology. We observed a significant effect, $F_{1,44} = 6.19$, $p < 0.05$. The covariate was significantly related to the perceived transparency of the system, $F(1, 44) = 5.07$, $p < .05$.

A final one-way ANCOVA investigated the effect of disclosing the details of the goal setting algorithm on goal commitment, controlling for the users' propensity to trust technology. A significant effect was found, $F_{1,44} = 7.43$, $p < .01$. The covariate was significantly related to the goal commitment, $F(1, 44) = 8.59$ $p < .01$. We present the results in Figure 9.5

9.7.2.1 *Qualitative Responses*

Two researchers classified text submitted in the open text field in the survey using affinity diagramming in an iterative discussion (Blandford et al., 2016). Here, we present the different views emerging from the data. Four themes were identified: *trustworthy goals*, *meaningful experience*, *contextual factors* and *commitment*.

We found that multiple participants assessed the recommended step goal as *trustworthy*. Even though the participants in the Black Box condition did not receive an explanation about how the fitness

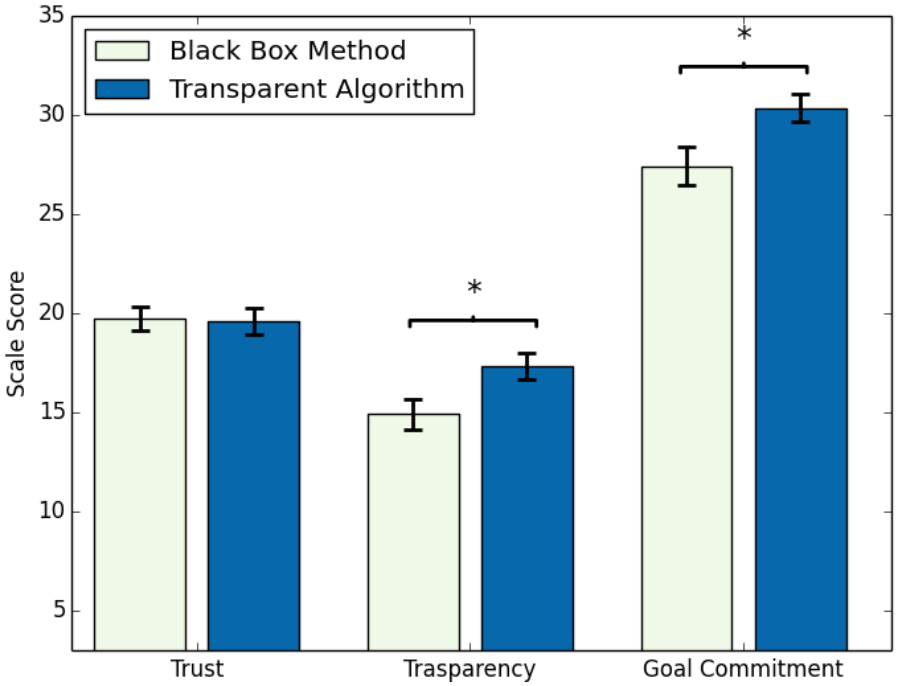


Figure 9.5: Mean scores on the Trust, Transparency, and Goal Commitment Scale for the two conditions in the *Tracker study*. Error bars show standard errors. Note that the scales have different scoring ranges.

tracker goal was computed, they often voiced their confidence in the goal. Interestingly, some participants additionally expressed their uncertainty regarding the computation of the goal at the same time:

> *I'm not completely sure why it calculated the goal that it did, but I don't think there was anything bad about it. (P22,* Black Box*)*

In contrast, one participant from the Black Box condition expressed an unwillingness to pursue the recommended goal. The user emphasised the importance of being involved in the decision making process regarding goal recommendations:

> *I don't want to take on this goal. The app decided without even asking me if I wanted to do it (P12,* Black Box*)*

One user in the Transparent condition emphasised his trust in the fitness tracker goal. The participant directly referred to the algorithm and not the goal:

> *I trust the algorithm that the fitness app uses. (P41,* Transparent*)*

We further observed that participants reflected on the ways to make the tracking experience more *meaningful*. One user emphasised that it was important to gain increased self-awareness. He recommended making goals personally meaningful:

> *Why do we need the app to recommend step goals for us? I prefer to recommend my step goals by myself. There was a recom-*

> *mended goal at the beginning when I started to use it [the fitness tracker], but it was difficult to interpret the goals into something meaningful. What does 10,000 steps mean to people? After a few days of tracking, I started to get to know myself, and I was able to adjust the goals. (P9,* Transparent*)*

Similarly, another participant highlighted the importance of the connection between life goals and the numeric tracker goals. She emphasised goal evolution as a means to keep users 'inspired' instead of 'demoralising' them:

> *If someone increases their step goal by 10% every X months, there will be a point where they will regularly fall short of that goal, demoralizing rather than inspiring them. (...) If the goal is cardiovascular health, then have the goal be to get into a certain heart rate for a certain amount of time every day. (P23,* Transparent*)*

Users mentioned various *contextual factors* that influenced their tracking experience. A statement of a participant in the Black Box condition showed general goal commitment, but also mentioned commitment outside of fitness:

> *(...) a new video game expansion was released, so I sat at my computer all day instead of being active. (...) Normally, I would try to meet that goal. (P19,* Black Box*)*

Other users struggled to integrate their tracking into their everyday lives, even when they were committed to track. One participant wondered about the fitness tracker taking the interactions with her child into account:

> *I am not exactly sure what other information it [the fitness tracker] could take into account. It is difficult to count my steps when I am holding my child while walking since I hold him with the arm that is wearing my Fitbit. So that could be taken into consideration, because you are not supposed to wear your Fitbit on your dominant hand/arm (P03,* Transparent*)*

Another theme that we identified in the qualitative data was *commitment* towards the fitness tracker goal. Users eagerly expressed their determination to achieve their goal. One user was striving to meet the goal even when the work conditions hindered it:

> *I am willing to increase my step goal. I have a job throughout the week that doesn't allow me to wear any kind of watch or jewellery, but I will place my Fitbit on my leg so it won't be noticeable. (P13,* Transparent*)*

9.8 DISCUSSION

In this research, we explored the role of transparency in suggesting goals for fitness tracker users. We found that disclosing the algorithm for computing a fitness goal offered perceived benefits to users. Here, we summarise key findings from our study, then discuss challenges and opportunities for future systems that support physical activity by suggesting fitness tracker goals.

9.8.1 Communicating the Algorithm Behind a Suggested Tracker Goal Fosters Goal Commitment

We observed that showing users how a fitness goal was computed increased declared goal commitment both in the *Vignette study* and the *Tracker study*. Thus, **H1** was confirmed. As the qualitative data shows, users found it easier to relate to the suggested number of steps if accompanied by an explanation. This effect may be caused by a number of reasons. Firstly, showing how a goal was computed illustrates that the system uses the collected information to better understand the user, which Gulotta et al. (Gulotta, Forlizzi, Yang & Newman, 2016) previously identified as a means to build engagement with personal informatics. Secondly, it appears that transparent goals not only help users understand how the fitness tracker works, which was identified as a currently unmet need for fitness tracker systems (Niess & Woźniak, 2018), but also contribute to a more personalised experience that results in increased goal commitment. Thus, we recommend using transparent goals in future trackers that support evolving personal fitness goals.

9.8.2 Showing How a Suggested Goal was Calculated Results in the System Being Perceived as More Transparent

The *Vignette study* and the *Tracker study* showed that providing the details of the goal calculation algorithm resulted in the fitness tracker application being perceived as more transparent, confirming **H2**. While we did observe a significant effect of providing an algorithm description on perceived transparency, we also note that absolute scores for both conditions were high. This result illustrates that transparency and understanding are connected as the users presented with a more complete explanation of the data reported more transparency, which reflects previous work in other domains, e.g. (Cramer et al., 2008). On the other hand, we hypothesise that the fact that the collected data was displayed to the participants in all conditions already built a base perception of transparency. Consequently, disclosing available information both about the data collected and the processing of that data could improve the user experience of fitness tracking.

9.8.3 Disclosing How a Tracker Goal is Calculated Fosters Trust in Some Users

We observed a significant increase in trust when the goal suggestion algorithm was disclosed to the users in the *Vignette study*, but no such effect was observed in the *Tracker study*. This implies that **H3** is partially confirmed. We believe this difference can be primarily attributed to the differences in the participant sample between the two studies. The *Tracker study* required participants to be active Fitbit users with enough collected data to enable computing a goal suggestion. This implies that these participants trusted the technology enough to purchase and wear the tracker for a certain time. Our work suggests that, while transparency can increase goal commitment in existing fitness tracker users, their level of trust in the tracking system may remain unaffected. However, the fact that we observed an effect on trust in the general sample suggests that transparency is also important for novice tracker users or those who have not yet decided to start tracking fitness in learning to trust their device. This resonates with Epstein et al.'s (D. A. Epstein et al., 2015) findings on motivations and hurdles to tracking. As many users are attracted to tracking through curiosity, transparency may help them enter the tracking experience. Consequently, future tracking systems could use transparency as a means to build trust specifically at the beginning of the fitness tracking experience.

9.8.4 Transparency in Designing Fitness Tracker Experiences Contributes to Building Engagement

Our results showed that disclosing information about how the tracker works is essential in order to create engaging fitness tracking experiences and foster goal commitment. This finding complements the work by Epstein et al. (D. A. Epstein et al., 2015) who emphasised that deciding upon the will to change was a key element in the tracking experience. Our results shed light on how tracker systems can make that decision more informed. Based on our results, we hypothesise that trust dynamics with regards to fitness trackers follows a cycle similar to the Lived Informatics Model (D. A. Epstein et al., 2015). Novice fitness tracker users trust their tracker to some extent, enough to begin tracking. This trusting stance, before the direct experience of the tracker, can be interpreted as *initial trust* (Mcknight et al., 2011). Initial trust can diminish quickly. In contrast, *knowledge-based trust* (Mcknight et al., 2011), which builds on previous trustor-trustee interactions, can potentially last longer. This leads to the assumption that trust in the tracker evolves over time, in line with previous work focusing on technology in general (Mcknight et al., 2011). Further, we

believe that we observed primarily initial trust in the *Vignette study* and knowledge-based trust in the *Tracker study*.

Thus, explaining how the tracker works is one step towards building trust (Niess & Woźniak, 2018). We see this as an opportunity to build further engagement with the tracker by capitalising on the knowledge-based trust once established. According to the Tracker Goal Evolution Model, once the users feel they know how their tracker works and trust is established, trackers can help users relate data to their qualitative goals (e.g. becoming fitter). If future trackers can use transparency to effectively build trust and then facilitate the connection to qualitative goals, they will be able to offer a long-term experience that keeps users committed and motivated (Locke & Latham, 2002).

9.8.5 Meaningful Goal and Life Context

The results of our qualitative analysis in the *Tracker study* show that users reflected on a suggested goal by immediately contextualising the requirements of fulfilling it. In addition, we found that users took various contextual factors into account. Multiple participants perceived their recommended step goals as reasonable and trustworthy, partly independently of their experimental condition Black Box, Transparent). This suggests that while a goal recommendation and the reasons behind it are important in committing to a fitness goal, many other factors are at play. In the *Tracker study*, we also observed that the attitude towards a goal was influenced by a general commitment towards fitness tracking. These findings illustrate the challenge to integrate current fitness trackers into everyday life in a meaningful way, which is reflected in past research (Tang et al., 2018; Niess & Woźniak, 2018).

Users assessed their goals as reasonable. They showed a general commitment towards their goal, but anticipated that they would struggle to pursue it for a variety of reasons. Integrating fitness tracker experiences into everyday life and connecting quantitative tracker goals with qualitative life goals still remains a challenge (Niess & Woźniak, 2018). The eventual failure of the fitness tracker to support users in achieving their qualitative fitness goals may lead to a loss of confidence in the device and a decrease in trust. Kizilec (Kizilcec, 2016) emphasises that transparency of a system is only relevant when user expectations have not been met. As a consequence, future systems for suggesting fitness goals should enable users to incorporate those contextual factors (e.g. life events, injuries or health issues) into the decision process of committing to a goal and/or include those factors in how the goal is calculated. This can be especially useful if hurdles to physical activity such as injuries or eventual lapses in tracking are present.

9.8.6 Goals and Algorithmic Complexity

Finally, we reflect on the *Algorithm* study which showed no differences between the five algorithms that we investigated. As we wanted the study to be close to the current lived practice of fitness tracking, the conditions examined were heavily inspired by solutions from presently available fitness trackers. However, one could easily imagine that trackers would use more complex algorithms, models or even machine learning solutions, especially if contextual factors were considered in the goal suggestion process. Concurrently, recent work showed that automated and crowdsourced exercise plans (and thus exercise goals) are likely to grow more complex and become more useful to users (Agapie et al., 2018). As suggestions grow more complex, explaining how they are computed to users emerges as a key challenge. We envision that future fitness trackers should incorporate regularly communicating how user data is processed in a transparent manner so as not to jeopardise user engagement, even for the user group which is currently actively tracking fitness.

9.8.7 Limitations

Our work constitutes a first step towards designing transparent fitness tracker goal recommendations, yet we recognise that the approach used in this paper is prone to certain limitations. We used mainly MTurk to recruit the participants for our three consecutive studies. Even though previous research discussed advantages of that approach (Paolacci et al., 2010; Mason & Suri, 2012), we recognise that the target audience of fitness trackers most likely extends beyond the pool of participants available on MTurk. We studied participants from North America and Western Europe, similar to the majority of past work focused on fitness trackers. However, in line with the work from Spiel et al. (Spiel et al., 2018), we believe that our findings may be applicable only to a subset of the general population. Future research should explore cultural and social factors in the perception of transparency in fitness tracker goals.

Further, as our work primarily investigated transparency and trust in the tracker, the choice of a goal suggestion algorithm was a secondary concern. While we wanted to use goals inspired by commercial solutions, we see that the design of the algorithms might have affected the results of the study. We were unable to find related work that would suggest better algorithms, and research in public health is focused on establishing general step goals rather than evolving challenges. Finding goal suggestion algorithms that are meaningful to users and beneficial from a health (or sports performance) perspective is a challenge for future research. Once these methods are available, our work should be revisited.

Finally, most of the participants in the *Tracker study* used the default 10000 step goal, which suggests that they might not have changed or even considered changing their step goal before. There is a possibility that our study primarily promoted them to consider a goal adjustment and thus produced a novelty effect. On the other hand, this would show the benefits of providing goal suggestions and thus the need to better understand how to suggest evolving goals effectively. Given that goal stagnation was previously identified as an issue in personal tracking (Niess & Woźniak, 2018; D. A. Epstein et al., 2015), it appears that the group of users who regularly reflect on their tracker goals is limited.

9.9 CONCLUSION

This paper investigated the effects of transparency in communicating fitness tracker goals on perceived transparency, trust in the system and goal commitment. We conducted three studies: *Algorithm study*, *Vignette study*, *Tracker study*). We asked users to express their views of proposed fitness goals for both hypothetical scenarios and suggestions based on their own data. We found that disclosing how a suggested tracker goal was computed resulted in significantly increased goal commitment and perceived transparency of the system. We also found limited evidence that a transparent step goal also fostered trust in the system. Our results show that there are complex trust dynamics involved in users contextualising and committing to a suggested step goal. We discussed how future trackers could use transparency to foster increased engagement with fitness goals and offer a more meaningful long-term tracking experience. Further, we recommend that future trackers allow users to explicitly address contextual factors such as life events when setting goals.

Our work sheds new light on the complexity of communicating transparent fitness tracker goals. We hope to stimulate further studies in personal informatics in areas beyond fitness tracking. We believe that building an understanding of how to communicate to users how their tracker works can support building more engaging fitness tracker experiences and assist users on their way to well-being. Future work can investigate how our findings can be applied to more complex models of personalising a tracker experience.

10 PAPER VI: VISUALISATIONS FOR UNMET GOALS

This chapter is based on:
Niess, J., Knaving, K. and Woźniak, P. W. 'Those two red days are awful': Understanding Visualisation for Unmet Goals in Fitness Tracking. Submitted for review.

Fitness trackers often encourage users to set goals to improve well-being, yet these goals may remain unmet. Understanding how to communicate failure for fitness goals could ensure that fitness trackers do not reduce the users' motivation for physical activity. To address this challenge, we studied the ways unmet fitness tracker goals can be visualised. We designed prototypes of bar graphs and polar charts that visualised unmet fitness goals, in both single-coloured and multi-coloured versions. In a survey, we explored the four visualisations and a textual description of the unmet goal by asking participants what reflections and ruminations the visualisations might have triggered. We found that bar graphs offered a significantly better potential for reflection and multicoloured charts triggered significantly more rumination. We contribute insights into designing reflection systems that use goals and avoid potential negative effects of personal tracking.

10.1 INTRODUCTION

Personal informatics systems to support users to reflect about their data and monitor their behaviour have become ubiquitous. This is mirrored in considerable research into personal informatics in the field of Human-Computer Interaction (HCI). However, as previous studies have shown, designing meaningful and supportive personal informatics experiences remains a challenge (Gouveia et al., 2015a). Clinical studies found no long-term health benefits of physical activity tracking (Jakicic et al., 2016). Epstein et al. found that, due to certain barriers (e.g. supporting reflection (I. Li et al., 2010)) users lapse throughout their tracking process (D. A. Epstein et al., 2015). In line with that, Niess and Woźniak pointed out in their *Tracker Goal Evolution Model* that fitness tracker users often struggled to connect

their numeric tracker goals to their qualitative life goals (Niess & Woźniak, 2018). Consequently, despite the fact that more and more users wear a fitness tracker every day, we still do not know how to use them to profoundly improve people's lives.

Researchers in HCI and related fields have explored various strategies to exploit the full potential of personal informatics systems and design for engaging, motivating and meaningful tracking experiences. One of the most extensively studied strategies in the area of personal informatics to help users on their way to well-being and foster engagement is goal setting (Consolvo et al., 2009). Almost all commercially available fitness tracking devices are designed around goals and goal fulfilment. Studies in Psychology also confirm that goals are an effective strategy for fostering positive change. A study by Lacroix et al. showed that difficult goals lead to higher levels of performance than easier goals (Lacroix et al., 2008). These findings show opportunities for engaging fitness tracker design. However, since fitness tracker goals evolve over time and users might not eventually reach them (Niess & Woźniak, 2018; D. S. Katz, Price, Holland & Dalton, 2018) the question of how to communicate failure without demotivating users emerges. Consequently, understanding how negative thought cycles (i.e. *Rumination*) can be prevented is a challenge. Recent work has advocated designing for diversity in personal informatics and avoiding negative effects for diverse user groups (Spiel et al., 2018). In this work, we are motivated to investigate how to communicate failure in personal informatics in a way that mitigates negative effects on users.

To that end, we study different visualisations that communicate unmet fitness tracker goals. We conducted a between-subject online study which evaluated prototype visualisations or a textual description of unmet fitness tracker goals. We explored how these visualisations were perceived and if they exhibited potential for users to reflect upon or ruminate about their data.

Studying designs that might trigger negative thought cycles (*Rumination*) is a challenging task, not least due to ethical considerations. For example, presenting participants with designs that might trigger rumination and thus risk their well-being is neither in line with our standards as researchers nor with the Declaration of Helsinki (Association et al., 2013). Hence, we decided to conduct a hypothetical study, meaning that we inquired participants regarding their perception of different visualisations or a textual description of unmet fitness goals, but we did not expect them to be active fitness tracker users at the time.

We decided to explore visualisations based on visualisations currently used in commercial products. In line with Olson and Kellogg (2014), we believe that building an understanding of systems currently used in commercial products has merit to foster informed future design decisions. Note that our study is, to the best of our knowledge,

the first empirical exploration focusing on the potential of such visualisations to prompt rumination and reflection. We are aware that our methodological approach, a so-called *experimental vignette study*, where participants are asked to see the world through the eyes of a hypothetical person in a specific scenario, is somewhat unusual in the HCI field. We believe however, that, in line with previous work (Aguinis & Bradley, 2014), it has the potential to lead to valuable insights and spark new ideas that may lead to intriguing future research and potentially inspire the design of improved systems to foster fitness.

This paper contributes the following: (1) a between-subject vignette study for visualising unmet goals in physical activity trackers; (2) to the best of our knowledge, the first empirical exploration that showcases how different visualisations of unmet goals affect reflection and rumination; and (3) implications for designing future personal informatics systems to avoid potential negative effects of tracking.

In the remainder of this paper, we first introduce the reader to reflection and rumination literature in Psychology that inspired our inquiry, then review related work in HCI on personal informatics as well as motivational design strategies utilising mobile interfaces. We then report on the details of our study, including the design of the visualisations. This is followed by the discussion and interpretation of the study results. Finally, we propose how our results may inform the design of future fitness tracker experiences.

10.2 RELATED WORK

Our work is inspired by previous research on reflection and rumination in Psychology. Trapnell and Campbell stated that reflection and rumination are distinct but related concepts (Trapnell & Campbell, 1999). Both concepts describe a process where the attention is focused inwards upon oneself (Morin, 2017). Reflection has a positive connotation associated with it (Trapnell & Campbell, 1999): It is motivated through a curiosity about oneself and usually accompanied by positive emotions. If short-term negative emotions occur they are assumed to motivate exploring oneself in more depth and leading to self-development (Watkins, 2008). In Psychology, different conceptualisations of rumination can be found (for an overview see (Smith & Alloy, 2009)), however, there are some areas of agreement. Rumination is generally agreed to be negative, repetitive thoughts focusing on oneself, circling around personal failure or loss (Smith & Alloy, 2009; Morin, 2017). Since reflection is seen as a crucial part of the fitness tracking process with the aim to generate self-knowledge and support users on their way to self-improvement (Baumer et al., 2014), the question remains how this knowledge can enrich personal informatics research. In our work, we aim to gain a deeper understanding of ways

different visualisations and a textual description of how unmet goals might trigger rumination and support reflection.

10.2.1 Personal Informatics

Reflection is considered as a catalyst for positive change (Rooksby et al., 2014) in multiple application areas of personal informatics (D. A. Epstein et al., 2015). It is one of the main components of a successful personal informatics process (Niess & Woźniak, 2018). Even though the concept is widely applied in personal informatics systems, there is no shared understanding of how reflection is defined within the HCI community (Baumer, 2015). Notably, researchers are striving to build a holistic understanding of the personal informatics experience and what role reflection plays throughout this experience (Niess & Woźniak, 2018; I. Li et al., 2010; D. A. Epstein et al., 2015). In addition, multiple systems have endeavoured to integrate reflection into their designs.

Morrison and Bakayov presented a social fitness activity system that encouraged face-to-face encounters with other users in which they discussed and reflected on their physical exercise (Morrison & Bakayov, 2017). Khot et al. created chocolate treats to offer playful reflections on physical activity (Khot et al., 2017). The same authors explored presenting physical activity data as artefacts to prompt reflection (Khot et al., 2014). Even though interestingly different personal informatics systems succeeded in providing the means for reflection, trackers still struggle to offer engaging, long-term personal informatics experiences (Jakicic et al., 2016). Fitness tracker goals evolve (Niess & Woźniak, 2018) and negative feelings may be associated with changing a goal (Gulotta et al., 2016). Gulotta et al. (Gulotta et al., 2016) identified a number of problems that hinder engagement with achievement-based personal informatics systems. Amongst other aspects they emphasised avoiding the feeling of failure as important to foster reflection (Gulotta et al., 2016). Katz et al. explored user interactions with diabetes self-management apps (D. S. Katz et al., 2018). They analysed benefits and limitations of these apps and found, amongst other things, that being confronted with failure can be counterproductive for the long-term adoption of these technologies.

On a similar note, the Lived Informatics Model of Personal Informatics pointed out that it was highly likely that users would lapse at some point of their personal informatics process (D. A. Epstein et al., 2015). This, in turn, leads to another strain of research focusing on the communication of failure throughout a tracking experience. Agapie et al. endeavoured to support users to integrate their lapses into their tracking process in a positive way (Agapie et al., 2016). Clawson et al. (Clawson et al., 2015) studied craigslist users disposing of tracking technology to find that it could be equally motivated by perceived fail-

ure, success or social pressure. On another note, Tang et al. discussed that users don't wear their fitness tracker all the time (Tang et al., 2018). The authors emphasise the need to account for these differences in usage. They define adherence as a measure of data completeness in order to provide means to study fitness tracking experiences in a meaningful way (Tang et al., 2018). Our approach is interestingly different as we explore different ways to communicate unmet fitness tracker goals and how this affects reflection and rumination in users.

10.2.2 Motivational Design and Visualisation

Moreover, scholars have explored a variety of visualisations to foster reflection and behaviour change. For instance, UbiFit provided feedback for participants regarding their physical activity behaviour on a mobile display (Consolvo et al., 2008). The feedback was presented in two versions; one condition displaying the physical activity progress on the mobile phone background screen (*glanceable display*), the other not utilising a glanceable display. The results of the longitudinal, qualitative study showed that participants appreciated the glanceable display and maintained their activity level, but the activity level of the participants in the condition without the glanceable display dropped significantly. This study showcases the potential impact subtle differences regarding visualisation and study design can have. This in turn was a contributing factor for our decision to explore designs that might trigger negative thought cycles in an empirical, hypothetical cross-sectional study. In line with the findings from the UbiFit study, Gouveia et al. also showed the potential of glanceable feedback (Gouveia, Pereira, Karapanos, Munson & Hassenzahl, 2016). The results of the authors also point towards the importance of taking subtle differences in the visualisation design into account, since these can lead to behavioural differences (e.g. walk more frequently versus reaching one's step goal). We aim to explore the effect of such subtle differences (e.g., single-coloured versus multicoloured visualisation) in our study.

Epstein et al. (D. Epstein, Cordeiro, Bales, Fogarty & Munson, 2014) explored different visualisations of location and activity data to support self-trackers to make sense of their data. The combined location and activity data was presented in a variety of visualisations such as tables, graph or maps, among others. In their longitudinal qualitative study the authors found that participants preferred tables and graphs for finding patterns in their data. On another note, Huang et al (D. Huang et al., 2015) explored visualisations on the meta level. They developed a taxonomy of design dimensions of personal visualisations and personal visual analytics, and called for more research to investigate how the visualisations that 'are already out there and actively used' may impact people's lives and how they can be im-

proved. Our work follows their call and aims to explore the potential of visualisations used in commercial products to trigger reflection and rumination.

10.3 RESEARCH QUESTIONS

We endeavour to understand how unmet fitness tracker goals can be communicated to users without triggering negative thought cycles and foster reflection. This leads to the following research questions:

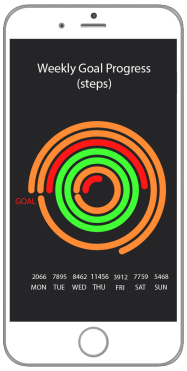
- **RQ1**: How can unmet fitness tracker goals be presented to avoid negative thought cycles in users?
- **RQ2**: How can unmet fitness tracker goals be presented to foster reflection?

10.4 VISUALISATION DESIGN

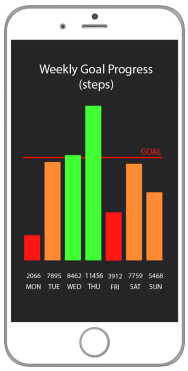
To explore how the communication of failed goals in fitness trackers may trigger reflection and rumination, we designed four visualisations based on commercial fitness tracking products. Based on the visualisation currently used in commercial products, we designed two different graph types, a radial bar chart and a bar chart, both in a single-coloured and multicoloured version. We are aware that these visualisations are not similar regarding the information they provide (e.g. identifying if a goal was exceeded is easier in the bar chart). However, we do believe that building an understanding of technologies that are currently in use has merit, can lead to profound insights and can inform the design of future systems (Olson & Kellogg, 2014). The four graphs are presented in Figure 10.1.

Both the bar chart and the radial bar chart were chosen because they are both popular in step count applications and commonly used tracking devices, such as Fitbit, Apple Watch and Samsung Gear Fit. However, while the bar chart is arguably one of the most frequent graph types users encounter, the radial bar chart presents a less obviously understood form for the data.

The bar chart maps quantity through bars whose height is measured by position on a vertical scale. Cleveland and McGill (Cleveland & McGill, 1984) found that 'position along a common scale' was the easiest of the more common perception tasks; tasks that also included curvature and angle. Furthermore, Croxton (Croxton & Stein, 1932) found that compared to circles, cubes and squares, bars were more effective for comparing values. Furthermore, the bar chart is one of the oldest and most common chart types, considered to have been invented by William Playfair in 1786 (Playfair & Corry, 1786).

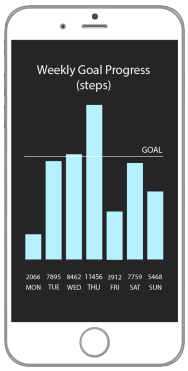


(a) Radial bar chart, multicoloured, R–I



(b) Bar chart, multicoloured, B–I

(c) Radial bar chart, single-coloured, R–O



(d) Bar chart, single-coloured, B–O

Figure 10.1: The four visualisations designed for the purpose of our study.

Radial bar charts, also called circular bar charts, are fairly new and there is still some confusion on naming: the name is used to denote either bars plotted on a polar coordinate system, or bars extending from a circular floor. In this case we intend the first chart type. The bars in the single coloured chart are greyish blue, while the multicoloured version colours success with a green hue, and failure in the signal hues orange and red. Colours are pre-attentively processed, so have a high chance of being singled out for conscious attention (Ware, 2012). Both colourings are similar to those of visualisations in commercially available fitness tracker apps.

The visualisations are designed to have similar qualities as those used in commercial fitness apps. We believe that these choices do influence how users interpret their data. According to literature, we expected that the radial bar chart would be less well known and also more difficult to interpret and compare values correctly, thus making it more open to the reader's interpretation and possibly softening the blow of a bad week by obfuscation. We also predicted that colouring by failure and success would have an effect on how users interpreted the weekly result.

Furthermore, the values visualised — the step count for each day — were chosen to look random, but with a number of days almost reaching the goal. Given that there seems to be little evidence for a very specific step count (Tudor-Locke & Bassett, 2004), the goal point itself is arbitrary and unlikely to be important to reach except for psychological reasons. However, failing even by very little is sometimes shown as failure in commercial apps — through, for example, colouring. We chose another value - 8000 - rather than the popularised 10000. This is in line with a usage scenario where the users set their own goal, and also closer to estimated step counts of a non-sedentary people (Tudor-Locke & Bassett, 2004). The four screens have been carefully designed to have the same information apart from colour and visualisation type.

10.5 METHOD

This study explores how different ways to visualise unmet fitness goals might affect reflection and rumination of users. To that end, we conducted a between-subject online vignette study with five conditions — four visual representations and a textual description of unmet goals. The visualisation prototypes presented a bar graph or a radial bar chart in an single-coloured or multicoloured design, see Figure 10.1. We decided to use a vignette study (i.e. a study where we ask participants to see the world through the eyes of a hypothetical person in a specific scenario), because this method offers the means to balance the benefits of experimental research with high internal

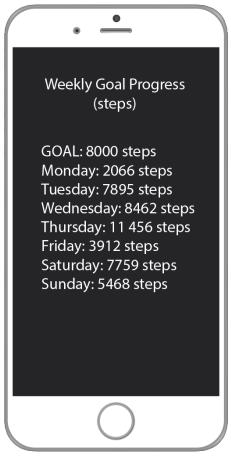


Figure 10.2: The text feedback condition — no visualisation, NV used in our study. The text feedback used the same visual style as the other conditions.

validity and the advantages of applied research with high external validity (Aguinis & Bradley, 2014).

Before the study, participants were presented with a page informing them that the study was fully anonymous and asking for informed consent. The studies were conducted according to the ethics standards of the conducting institution. According to these rules, the survey was not subject to review by an ethics board.

10.5.1 Conditions

In order to establish ways to communicate unmet fitness goals to fitness tracker users we designed four different visualisations with two different graph types and two different colour versions. We also included a textual description as a fifth condition. Each condition presented the weekly goal progress towards a specific step goal. Since there may be a possible interaction effect between feedback and reporting, we did not include additional feedback but instead solely focused on the representation of the weekly step goal progress in our study. This resulted in five experimental conditions for our study:

- *Radial bar chart, multicoloured*, R–I, presented in Figure 10.1a
- *Bar chart, multicoloured*, B–I, presented in Figure 10.1b
- *Radial bar chart, single-coloured*, R–O, presented in Figure 10.1c
- *Bar chart, single-coloured*, B–O, presented in Figure 10.1d
- *Textual description, no visualisation*, NV, presented in Figure 10.2

10.5.2 Participants

The participants for our study were recruited through Amazon Mechanical Turk (MTurk). Theoretical as well as empirical research has pointed out potential benefits of MTurk (Paolacci et al., 2010; Mason & Suri, 2012). Furthermore, previous work assessed participants recruited through MTurk as suitable for visualisation research (Heer & Bostock, 2010) and also utilised MTurk for personal informatics research (D. A. Epstein et al., 2015; Agapie et al., 2016).

We recruited $n = 165$ participants, aged 18–86, $M = 34.59$, $SD = 9.46$ using Amazon Mechanical Turk (MTurk). Sixty-six participants were male and 99 female. The participants were uniformly distributed among conditions and resided in the United States or the European Union. We required participants to have completed at least 1,000 Human Intelligence Tasks (HITs), which means a single task such as 'Identify the colour of the object in the picture', presented on MTurk, with a 95% acceptance rate, in line with past work in HCI (D. A. Epstein et al., 2015). The survey took an average of 6min 21s to complete and the participants received $1.00 as compensation.

10.5.3 Measures

After a brief survey introduction we asked the participants for their demographic data. Afterwards, they were randomly assigned to a condition and presented with the corresponding visualisation. The visualisation was visible at the top of the screen for the entire duration of the survey. Then we presented the participants with an open text field where we asked them how looking at the display made them feel. Next, we administered the following measures:

- Rumination Scale, 5 items on a 5-point Likert scale, see Table 10.1.
- Reflection Scale, 5 items on a 5-point Likert scale, see Table 10.2.
- Trait rumination scale, 12 items on a 5-point Likert scale.
- Trait reflection scale, 12 items on a 5-point Likert scale.

The rumination scale and the reflection scale were modified versions of the rumination-reflection questionnaire (RRQ) (Trapnell & Campbell, 1999) and presented in randomised order. We used the reflection scale and the rumination scale to assess if the way the unmet goal was communicated triggered rumination or reflection. We also inquired about the participants' trait rumination and trait reflection, using the original rumination-reflection questionnaire (RRQ) from Trapnell and Campbell (Trapnell & Campbell, 1999). Trait rumination and trait reflection have previously been identified as personality traits independent of a specific situational context. Thus, we administered the RRQ to account for these individual differences regarding trait

Table 10.1: The Rumination Scale used in our studies, adapted from work by Trapnell and Campbell. Items were scored on a 5-point Likert scale and items marked with (R) were scored inversely.

(1) This app would tend to make me 'ruminate' or dwell over my fitness tracker data for a really long time afterwards.
(2) This screen would not make me waste time rethinking training sessions that are over and done with. (R)
(3) When I look at this app I feel I would spend a great deal of time thinking back over my embarrassing or disappointing workout moments.
(4) This app would make it easy for me to put unwanted thoughts about my fitness tracker data out of my mind. (R)
(5) This app would make me focus on aspects in my fitness tracker data I wish I'd stop thinking about.

Table 10.2: The Reflection Scale used in our studies, adapted from work by Trapnell and Campbell. Items were scored on a 5-point Likert scale and items marked with (R) were scored inversely.

(1) I would like to explore my fitness tracker data more with this app.
(2) I would often look at this app and analyse my data with it.
(3) I would like to analyse why and how I work out with the help of this app.
(4) Analysing my fitness tracking data with the help of this app doesn't appeal to me that much. (R)
(5) Contemplating about my fitness tracker data with the help of this app isn't my idea of fun. (R)

rumination and trait reflection of the participants. Hereby we would be able to separate the general inclination to reflect or ruminate about fitness tracker data from the potential of the different visualisations to activate rumination or reflection.

10.6 RESULTS

10.6.1 Rumination

We conducted a one-way ANCOVA to investigate the effect of the type of visualisation used on the rumination scale score, controlling for the participants' rumination trait. We found a significant effect, $F_{4,157} = 2.78$, $p < .05$. Post hoc test with Tukey's HSD revealed significant differences between the condition pair B–O — B–I, with $p < .05$. Figure 10.3 shows the results. There was no significant effect of the covariate, rumination trait scale score, $p > .05$.

Since the results presented above found a significant difference between the single-coloured and the multicoloured bar chart (see figure 10.3) we analysed the data further and investigated the effect

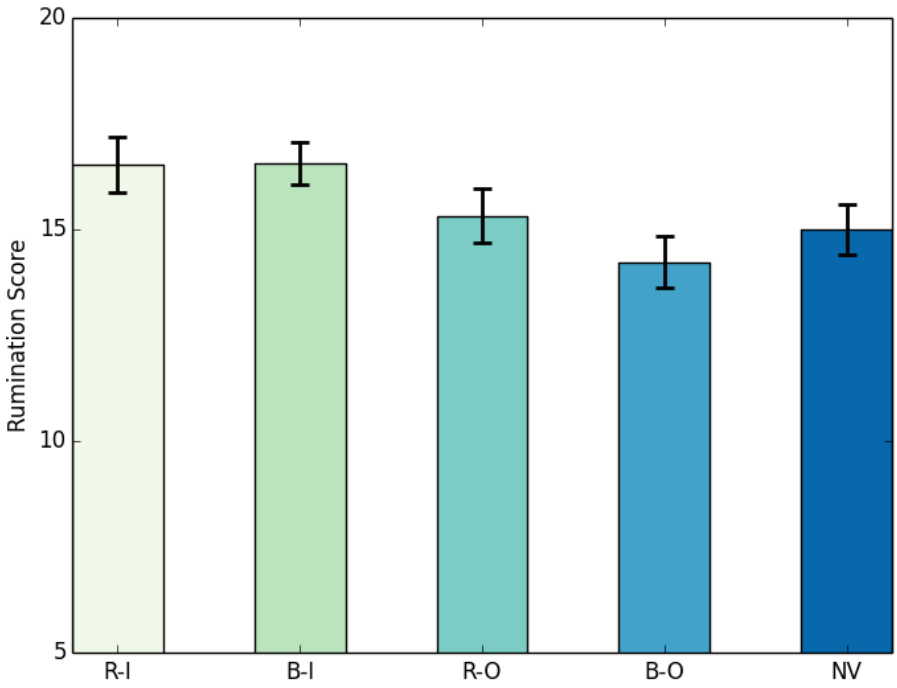


Figure 10.3: Rumination scores for the five experimental conditions.

of the colouring scheme (multicoloured, single-coloured) and shape used (radial bar chart, bar chart) on the rumination score. A two-way ANCOVA, controlling for the participants' rumination traits revealed that the colouring scheme had a significant effect on the rumination score, $F_{1,157} = 9.53$, $p < .01$. More specifically, multicoloured visualisations lead to higher scores on the rumination scale. No effect of shape used was found, nor were any interaction effects present. Figure 10.4 depicts the results showing rumination score given colouring scheme.

10.6.2 Reflection

Accordingly, we conducted a one-way ANCOVA to investigate the effect of the type of visualisation used on the reflection scale score, controlling for the participants' reflection traits. We found a significant effect, $F_{4,158} = 2.94$, $p < .05$. Post hoc test with Tukey's HSD revealed significant differences between the condition pairs NV — B–I, with $p < .05$. Figure 10.5 shows the results. A significant effect of the covariate, reflection trait scale score was present, $F_{1,158} = 7.54$, $p < .01$. As in the case of rumination, we investigated the effect of the colouring scheme (multicoloured, single-coloured) and shape used (radial bar chart, bar chart) on the reflection score. A two-way ANCOVA, controlling for the participants' reflection trait revealed that the shape used had a significant effect on the reflection score, $F_{2,158} = 5.40$, $p < .01$. More precisely, bar charts lead to higher scores on the reflection scale. No effect of colour scheme was found, nor were any interaction effects

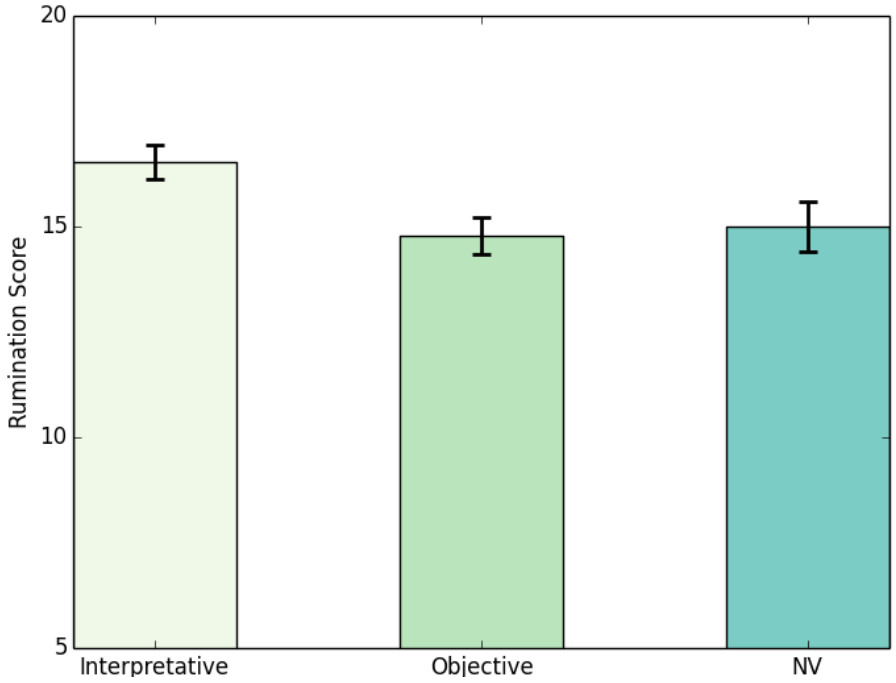


Figure 10.4: Rumination scores given the colouring schemes.

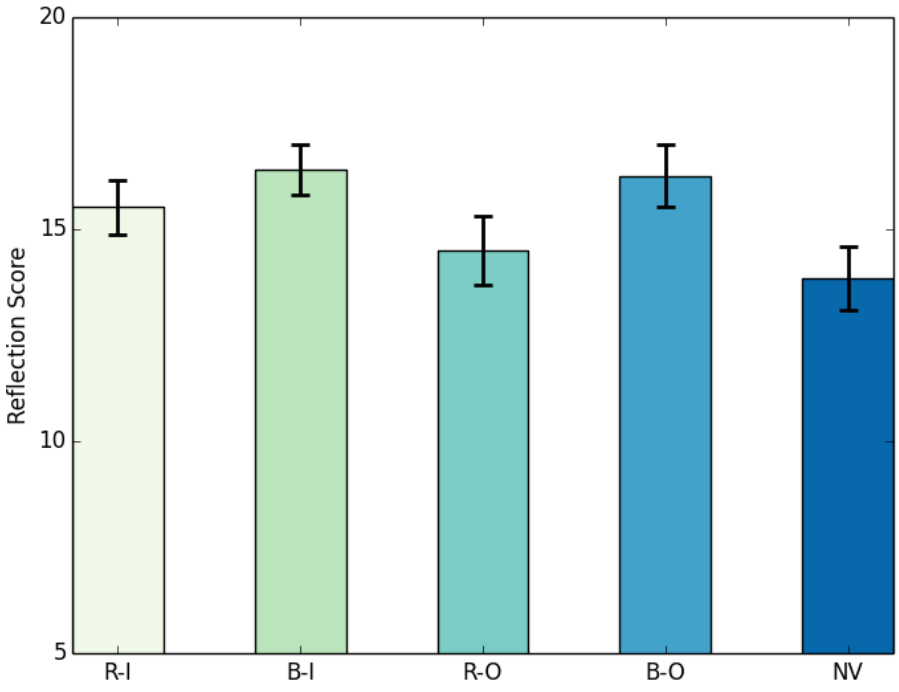


Figure 10.5: Refection scores for the five experimental conditions.

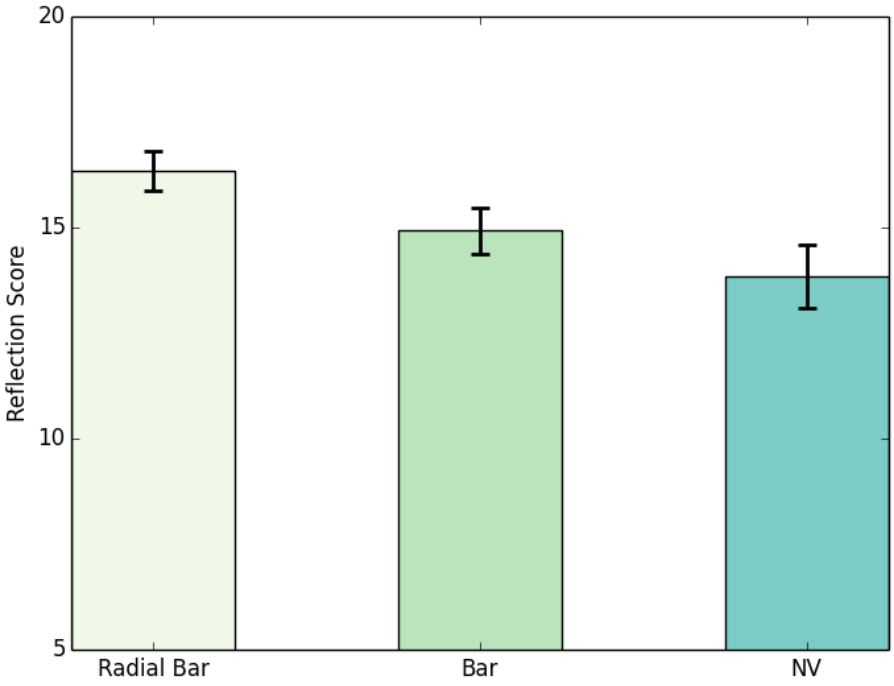


Figure 10.6: Refection scores given the shapes used.

present. Figure 10.6 depicts the results showing reflection score given shape used.

10.7 DISCUSSION

In this research, we explored possible reflection and rumination triggered by four different visualisations and a textual description of an unmet fitness tracker goal. A tangible recommendation that stems from our results is that **fitness trackers should use single-coloured visualisation styles to avoid the possibility of the users ruminating over goal failure**.

We found that the radial bar charts led to significantly more rumination **(RQ1)** and the bar graphs triggered significantly more reflection **(RQ2)**. Our results showed that the multicoloured charts triggered more rumination than the single-coloured visualisations. One possible explanation for this effect is that the unmet goals were highlighted through orange and red colouring. In line with work by Gulotta et al. (Gulotta et al., 2016), the tangible experience of failure could lead to negative affect, which in turn could trigger rumination.

Based on our results and given that users are more familiar with bar charts than with radial bar charts we hypothesise that the bar charts lead to more positive affect. In line with self-determination theory (Deci & Ryan, 2000), we argue that users strive for autonomy, feeling competent and being able to relate to their data. These needs

are potentially addressed through a visualisation that users can relate to more easily. This, in turn, potentially increases self-efficacy (Sweet, Fortier, Strachan & Blanchard, 2012). To summarise, bar graphs fostered significantly more reflection. We assume that this could be explained through users experiencing positive affect due to them feeling autonomous, competent, and being able to relate to their data (Deci & Ryan, 2000), which in turn increased their self-efficacy (Sweet et al., 2012).

10.7.1 Ways Forward

Based on our results we highlight possible ways forward in order to design engaging fitness tracker experiences in the future. In line with the *Tracker Goal Evolution Model* (Niess & Woźniak, 2018) one way to address the challenge of evolving and occasionally unmet fitness tracker goals is to shift the focus of users towards what they have already achieved; more precisely, to foster a growth-mindset(Dweck, 2006). This resonates with past work which stressed the importance of enabling users to connect their fitness tracker goals to their higher level goals (Gulotta et al., 2016).

Another way forward is the exploration of integrating mindfulness elements into the design of future fitness trackers. Previous work in Psychology explored the concept of mindfulness as a natural opponent to rumination (Kearns et al., 2016). Kabat-Zinn defines mindfulness as accepting and non-judgmental attitude and present moment awareness (Kabat-Zinn, 2003). We believe that if users are skilled in mindfulness practice they might be able to be less judgmental towards themselves and able to accept their own unmet goals in a self-compassionate way. Consequently, an emerging challenge is how to incorporate such practices in presenting fitness tacker information.

Even though we hope that our work can support the design of future fitness trackers that foster reflection and avoid triggering rumination, we are convinced that studying how to communicate failure is only one way to address this topic. We believe that future research should not only focus on how to communicate failure, but explore why 'failure' occurs in the first place. Current personal informatics systems are mainly designed for and with the white, healthy, mentally stable user in mind (Spiel et al., 2018). For instance, users who already struggle with physical or mental challenges are already prone to potentially ruminate more (Soo, Burney & Basten, 2009). Thus, in line with Spiel et al. (Spiel et al., 2018) we emphasise that building more inclusive personal informatics systems is key for engaging, meaningful, long-term tracking experiences. Consequently, future systems should develop customisation strategies to adapt more to the user and prevent failure.

10.8 LIMITATIONS

Our work constitutes a first step towards exploring ways how to communicate unmet fitness tracker goals through visualisations. Yet, we recognise that the approach used in this paper is prone to certain limitations. It has to be noted that the hues of the multicoloured bars may not be discernible by people who have a colour vision deficiency. We used MTurk to recruit the participants for our study. Even though previous research discussed advantages of that approach (Paolacci et al., 2010; Mason & Suri, 2012), we recognise that the target audience of fitness trackers most likely extends beyond the pool of participants available on MTurk. We do believe that future research could utilise longitudinal, qualitative studies to explore the 'why' behind participants' preference reactions to certain visualisations. We used hypothetical data to study the potential effects of different ways to communicate failure. Even though we believe that this was justified as we were striving for an ethically justifiable approach and high internal validity, future research should explore if our findings can be replicated when studying the visualisations with the real fitness tracker data of participants.

10.9 CONCLUSION

This paper investigated the effects of different ways to communicate unmet fitness tracker goals through visualisation on rumination and reflection. We conducted a between-subject online study with five conditions — four different prototype visualisations and a textual description of unmet fitness tracker goals. We found that bar graphs offered a significantly better potential for reflection and multicoloured charts triggered significantly more rumination. This implies that future trackers should use single-coloured visualisation as the default data view. We outlined ways the design of future fitness trackers could account for occasionally unmet fitness tracker goals and create a meaningful long-term experience.

10.10 SUMMARY

In papers III to VI, I investigate the means which self-improvement technologies can employ to offer a better match with the thinking of their users, see Figure 10.7. The work shows that there is further potential in understanding how users perceive and understand technologies for well-being and that understanding can lead to building more engaging technologies. The final group of papers in this thesis

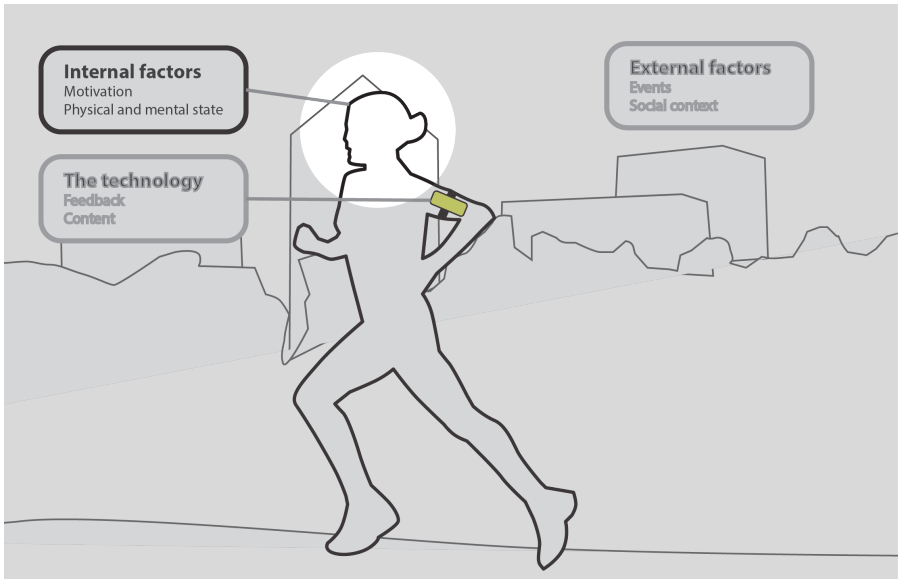


Figure 10.7: Influencing factors for designing self-improvement and well-being technologies with a focus on internal factors

described factors in designing self-improvement applications that are often beyond user control — the context.

11 PAPER VII: FITNESS TRACKING FOR DIVERSE USER GROUPS

This chapter is based on:
Niess, J., Woźniak, P. W., Abdelrahman Y., ElAgroudy, P., Abdrabou, Y., Eckerth, C., Diefenbach, S. and Knaving K. 'It's Like an Imitation Game': Understanding Fitness Tracking for Diverse User Groups. Submitted for review.

Fitness trackers have the potential for fostering sustained change and increasing well-being. However, the research community is yet to understand what design features and values need to be embodied in a fitness tracker for long-term engagement. While past work focused on fitness trackers in North America and Western Europe, this paper investigates another perspective on fitness tracking. We conducted interviews with $N = 37$ fitness tracker users in the US, Europe and Egypt to identify the similarities and differences in attitudes and practices in fitness tracking. We found that fitness tracking involved a deeper social context in Egyptian communities. Further, Arabic users focused on physiological measurement, while non-Arab users were more interested in goal achievement. We contribute design dimensions that can help build more inclusive tracker experiences. Our work highlights how future fitness trackers should support a customisable spectrum of design values to offer engaging experiences to a diverse and global audience.

11.1 INTRODUCTION

Wearable devices that enable activity tracking have become ubiquitous. With over 50 billion dollars of fitness tracker sales per year in the US, wearable activity tracking is becoming a technology with significant impact on everyday experience (Patel, Asch & Volpp, 2015). Yet clinical studies show that most users abandon their trackers, furthermore tracking has largely limited health benefits (Jakicic et al., 2016). The Human-Computer Interaction (HCI) field has attempted to address the shortcomings of current trackers by, inter alia, building models of personal informatics (D. A. Epstein et al., 2015; D. A. Epstein, Caraway et al., 2016; I. Li et al., 2010) or experimenting with feedback modal-

ities (Tang & Kay, 2017). Research work has strived to understand the current practices around tracking to learn how to design more effective interactions for activity tracking (Niess & Woźniak, 2018).

As wearable technology becomes increasingly available on the consumer market, it enters new geographical spaces. While fitness trackers were initially commonplace only in highly industrialised societies, users in other countries have recently begun to use them. Since different countries and cultures differ considerably regarding their rhythms of daily routines (Bell, Blythe, Gaver, Sengers & Wright, 2003), this creates new opportunities for research into how to build better trackers. That is why we study users beyond the US and Western Europe (in contrast to past HCI research) to gain new insights into how to build more engaging tracker experiences.

First, we aim to examine if our current understanding of fitness trackers is applicable to more geographical areas than those previously examined. Second, through comparing how users with different backgrounds use fitness trackers, we identify new elements of the tracker experience and, consequently, determine how to manipulate them to deliver more engaging fitness tracker experiences that appeal to wider groups of users. This knowledge can help build highly customisable, engaging trackers that cater to the ethnically diverse global population. For instance, past work has shown that fitness trackers offered limited benefits for individuals suffering from chronic illness (Carrington, Chang, Mentis & Hurst, 2015; Randriambelonoro, Chen & Pu, 2017). Furthermore, Spiel et al. (Spiel et al., 2018) remarked that the design of fitness trackers embraced the idea of a white, healthy, already fit and mentally stable user. Thus, designing inclusive tracking experiences emerges as a challenge for research. Our work aims to answer this need by considering users who have been mostly overlooked in the past, such as groups other than US-based and European users.

In this work, we report on a qualitative study of fitness tracker practices where we contrast the most commonly studied group (physically active participants form the US and Western Europe) with fitness tracker users that received less attention. We included participants from Europe, the US and Egypt. We interviewed 37 active fitness tracker users about their relationship with and the everyday usage of their tracker. We recorded, transcribed and analysed the interviews to build an understanding of the differences and similarities between the two user groups. Using thematic analysis, we clustered our findings into five themes: Independence, Engagement, Goal behaviour, Motivation and The Social. Based on the themes, we discuss four inclusive dimensions of the fitness tracker design space.

This paper contributes the following: (1) a qualitative description of differences and similarities in practices around wearable fitness trackers in non-Arab and Arab user groups; (2) four dimensions of the fitness tracker design space that help build more customisable

tracking experiences and (3) insights for the design of future fitness trackers that offer engaging tracking for diverse user groups.

We first review related work on past models and concepts in understanding and improving the experience of fitness tracking. We also discuss past studies that looked at diverse groups in HCI that inspired our work. This is followed by details of the methodology applied in our study, specifying the two distinct user group samples. We then present the findings of our data analysis, which we later interpret to derive a set of four dimensions that can stimulate the design of inclusive fitness tracking experiences.

11.2 RELATED WORK

We first report on past work in physical activity and personal informatics that inspired the research presented in this paper. We then revisit studies of diverse user groups in HCI to showcase past works that have inspired our research and offer new perspectives through contrasting users from different cultural backgrounds.

11.2.1 Physical Activity Tracking

Building technologies that encourage physical activity is a well-established pursuit in the HCI field. Consolvo et al. (Consolvo et al., n.d.) presented guidelines for such technologies based on a pilot study of a mobile application for fitness. Their work emphasised reward systems, considering practicalities, building awareness and taking into account the social environment of the user as key success factors in technologies that foster physical activity.

Later work examined the social dimension in more detail and several works concluded that technologies could use existing social support systems to foster increased activity or improve the experience of being physically active. Wozniak et al. (Woźniak, Knaving, Björk & Fjeld, 2015) illustrate that facilitating communication during physical activity strengthened social bonds between runners and supporters. In a similar vein, Park et al. (Park, Weber, Cha & Lee, 2016) analysed fitness-related sharing on twitter. They observed that involving long-term friends in physical activity through social media promoted sustained engagement. Chen et al. (Chen, Chen, Randriambelonoro, Geissbuhler & Pu, 2017) studied the differences between chronically ill and healthy adults to investigate how to foster social support through fitness applications. They found, inter alia, that comparison and competition was effective only for some users and its effectiveness was bound by many constraints. In addition to social aspects connected to physical activity tracking the application of game principals has been explored.

One postulated idea, was to utilise game mechanics (Campbell, Ngo & Fogarty, 2008) to increase physical activity.

While many early efforts focused on developing systems for fostering physical activity, e.g. (Purpura et al., 2011), later work turned to fostering reflection (Baumer, 2015) and meaningfully analysing one's own data. The need for meaningful reflection on fitness tracking data was confirmed by studies which investigated step counting campaigns. Gorm and Shklovski (Gorm & Shklovski, 2016a, 2016b) found that such campaigns were unlikely to have a lasting impact and generated social concerns. Concurrently, Chung et al. (Chung, Gorm, Shklovski & Munson, 2017) studied a step counting campaign to conclude that it was too detached from health benefits to make a profound contribution to increase the users' well-being. Finally, both Epstein et al. (D. A. Epstein, Borning & Fogarty, 2013) and Knaving et al. (Knaving et al., 2015) found that the values that users attached to systems that support physical activity played a key role in the success of the interactive artefacts. They found that value tensions were key in the understanding of the social aspects of physical activity, most notably sharing activity data.

While a significant amount of research effort has already been devoted to understanding activity tracking, past work shows that further work is needed to build trackers that offer an engaging long-term experience. It was also shown that a deeper understanding of the social behaviours and values around fitness tracking can offer more insights (Knaving et al., 2015; D. A. Epstein et al., 2013), investigating social behaviours and values.

11.2.2 Understanding the Experience of Personal Informatics

Considerable research effort has been invested in building models of how users experience personal informatics over time. An initial effort by Li et al. (I. Li et al., 2010) identified five stages of personal tracking. They concluded that a sequence of events was required for tracking to lead to effective change. Users first need to plan and prepare for tracking, then collect data, integrate and reflect upon it to reach meaningful conclusions that can lead to action. This model was later extended by Epstein et al. (D. A. Epstein et al., 2015) in their 'lived informatics model'. This model also included lapses in tracking and emphasised understanding the motivation behind starting to track and selecting the right means of tracking. Recently, HCI research has investigated how these principles apply to areas beyond physical activity, e.g. menstrual tracking (D. A. Epstein et al., 2017).

Understanding the issue of lapsing or abandoning fitness tracking altogether emerged as another relevant research topic. Clawson et al. (Clawson et al., 2015) studied craigslist advertisements to chart the motivations for disposing of fitness trackers. They found that health,

social and technical factors influenced the decision to stop tracking. Abandoned trackers that were still in the possession of users were seen as design opportunities for further intervention (D. A. Epstein, Kang et al., 2016). Epstein et al. suggested that appropriate framing and social comparison could be used to support users resuming their tracking. Tang et al. (Tang et al., 2018) developed methods to deal with gaps in data caused by lapses. These examples show that the HCI field has built a considerable understanding of the practical, personal and social constraints that affect one's experience with personal informatics. However, all of the studies cited above used participants from the US or non-Arab Europe. Our work is inspired by past models of personal informatics and aspires to build a deeper understanding of the factors contributing to successful fitness tracking through contrasting existing findings with fitness tracking practices in non-Arab areas.

11.2.3 Studies of Diverse User Groups

Past studies that investigated similarities and differences between user groups influenced our work. In particular, we were inspired by a number of research efforts that contrasted users from different cultures. Research examined the effect of culture in the adoption and use of different social computing technologies (Kyriakoullis & Zaphiris, 2016). Several studies were conducted in order to investigate cultural differences in different context involving proxemics and personal space (Joosse, Lohse & Evers, 2014; Baldassare & Feller, 1975), disclosure of mental illness (De Choudhury, Sharma, Logar, Eekhout & Nielsen, 2017), and interface design (Kyriakoullis & Zaphiris, 2016). All of these works use cultural differences as a starting point for an inquiry that eventually results in a better understanding of user behaviours in a particular domain. Our work is inspired by these efforts and aims to shed new light on understanding fitness tracking through contrasting users with different geographical backgrounds.

More recently, members of the CHI community have been advocating for HCI research to investigate designing for users beyond the typical middle-class educated Western user. Spiel et al. (Spiel et al., 2018) showed how fitness trackers catered primarily to already fit and healthy users. Further, Carrington et al. (Carrington et al., 2015) illustrated frustrations caused by fitness trackers to users on wheelchairs. These works inspired us to study fitness tracker usage beyond previously studied groups. Past work investigated primarily US-based participants (e.g. (D. A. Epstein, Caraway et al., 2016; D. A. Epstein et al., 2015; Saksono et al., 2018; I. Li et al., 2010)) or users from the European Union (e.g. (Gorm & Shklovski, 2016a; Niess & Woźniak, 2018; Gouveia, Karapanos & Hassenzahl, 2018; Rooksby et al., 2015; Gorm & Shklovski, 2016b)). In contrast, we studied participants from Northern Africa.

These past works show that customising interactive artefacts to account for diversity can have tangible benefits for the user. This fact led us to investigate whether users from different backgrounds have different views and experiences of personal informatics. To that end, we conducted an analysis that endeavoured to identify user-specific dimensions in the design of fitness trackers that could offer a more inclusive experience.

11.3 METHOD

To understand practices around fitness tracking across cultures, we conducted a series of semi-structured interviews with active tracker users. We decided to interview two comparable samples of users in the two distinct geographical settings. Our research network enabled us to conduct face-to-face interviews in Egypt.

Our study contrasts participants living in Egypt with those residing within in the US and the European Union. Research indicates that Egypt can be seen as representative of the Arab world. Gupta et al. (Gupta, Hanges & Dorfman, 2002) collected and classified data on cultural values and beliefs. They identified 10 cultural clusters. Based on their model, Egypt was identified as part of the ***Arab Cultures***. Hofstede included Egypt in the Middle East region (Hofstede, 2003). Consequently, our work compares participants from Egypt to the rest of the study participants as a vantage point for inquiry. In the remainder of this paper, we call the two user groups *non-Arab* and *Arab*.

11.3.1 Interviews

We recruited 37 participants. Participants were asked for consent for recording before the interviews. The semi-structured interviews lasted an average of 30.96 minutes ($MIN = 18$–$MAX = 65$, $total = 629$). Each of the interviews was a one-on-one session with a single researcher. Interviews were only conducted with participants who identified as active users of fitness trackers with an experience of three months or more.

11.3.2 Participants

We used a different recruitment strategy for each group that reflected the availability of tracker technologies in the respective location. Consequently, we present the two participant groups separately. Overall, we recruited $N = 37$ participants aged from 18–62 ($M = 30.44$, $SD = 9.71$), with 24 being male and 13 female.

11.3.2.1 *Non-Arab Users*

For the non-Arab sample, $n = 18$ participants were recruited through snowball sampling starting with social media posts. The participants were aged 18–41 ($M = 26.67$, $SD = 5.42$); nine male and nine female. All participants were natives of their country of residence (with the exception of W8 — a UK-based Irishman). While the only inclusion criterion for the study was using a fitness tracker for three months or more, we found that the participants in the non-Arab group largely reflected the stereotype users as discussed by Spiel et al. (Spiel et al., 2018). This suggest that this group can be used as representative of the fitness tracker user studies in past research and offer a meaningful comparison to the Arab group. Table 11.1 provides an overview of the participants.

11.3.2.2 *Arab Users*

Our Egyptian sample consisted of $n = 19$ participants, recruited through directly contacting a local running group and distributing a call for participants through a university mailing list. All participants were natives of their country of residence and identified as ethnically and culturally Egyptian. The participants were aged 20–62 ($M = 33.32$, $SD = 11.75$). As shown in Table 11.2, the sample included 4 female participants.

11.3.3 Interview Protocol

In the interview, we first obtained demographic data and information about the participants' daily usage of the tracker and the goals set. We then inquired if the way they used their tracker may have been connected to a history of lapses (which significantly affects one's tracker experience as shown by Epstein et al. (D. A. Epstein, Caraway et al., 2016)). In the next part of the interview, we investigated if and how users looked at and reflected upon their tracker data. Next, we explored whether users were sharing their data. The final part of the interview addressed the social dynamics of fitness tracking and the users' perception of privacy with regard to tracker measurements.

11.3.4 Analysis

All audio recordings were translated to English when necessary, transcribed and imported into the Atlas.ti analysis software. We hired a single expert to perform the translation to ensure uniform translation, as the Egyptian participants used code switching (Bassiouney, 2006) between English and Arabic language. We use thematic analysis with open coding (Blandford et al., 2016). This approach allowed us to look for commonalities and contrasts in the data. Two researchers open

Table 11.1: An overview of the interview participants in the non-Arab group. All participants were active tracker users. The duration reported is the time since the participants started tracking and, in some cases, includes lapses. Participant IDs are used throughout the paper to indicate interview quotes. Participants resided in the USA, United Kingdom, Poland, Denmark; France and Germany. We label this group W.

ID	Age	Sex	Profession	Tracking Time	Primary goal	Device used	Country
W1	29	M	IT specialist	2 yrs.	Steps	Fitbit	Poland
W2	30	F	Teacher	2 yrs.	Steps	Fitbit	Poland
W3	21	M	Student	3 m.	Steps	Xiaomi	Germany
W4	18	M	Student	2 yrs.	Steps	Polar	Germany
W5	29	F	Researcher	2 yrs.	Body mass	Xiaomi	Germany
W6	22	M	Engineer	8 m.	Active hrs.	Garmin	Poland
W7	29	F	Researcher	1 yr.	Steps	Xiaomi	USA
W8	26	M	Engineer	5 yrs.	Steps	Fitbit	UK
W9	29	M	Programmer	6 m.	Exercise sessions	Apple Watch	Germany
W10	35	F	Researcher	2 yrs.	Calories	Apple Watch	France
W11	28	M	Unemployed	9 m.	Exercise sessions	Apple Watch	USA
W12	27	F	IT specialist	1 yr.	Steps	Xiaomi	Germany
W13	29	F	Data specialist	6 yrs.	Steps	Fitbit	Poland
W14	32	M	Car mechanic	1 yr.	Exercise sessions	Pebble	USA
W15	41	F	Researcher	6 m.	Steps	Fitbit	Denmark
W16	20	M	Student	2 yrs.	Steps	Xiaomi	Germany
W17	27	F	Unemployed	4 yrs.	Steps	Fitbit	USA
W18	26	F	Student	6 yrs.	Steps	Fitbit	USA

Table 11.2: An overview of the interview participants in the Arab group. We label this group A. All participants were living in Egypt at the time of the study.

ID	Age	Sex	Profession	Tracking Time	Primary goal	Device used
A1	36	M	Lecturer	2 yrs.	No goal	Samsung Gear
A2	25	M	Manager	6 m.	Steps	Fitbit
A3	21	M	Student	2.5 yrs.	Body mass	Razor
A4	22	M	Student	6 m.	No goal	Xiaomi
A5	32	F	Trainer	6 m.	Calories	TomTom
A6	55	F	Engineer	1.5 yrs.	Steps	Samsung Gear
A7	25	M	Teacher	3 yrs.	Steps	Fitbit
A8	35	M	Engineer	3 m.	Exercise sessions	Garmin
A9	20	M	Student	1 yr.	Calories	Nike
A10	21	M	Student	1 yr.	No goal	Samsung Gear
A11	30	M	Engineer	4 yrs.	Exercise sessions	TomTom
A12	25	M	Accountant	4 m.	Calories	Fitbit
A13	62	F	Professor	6 yrs.	Calories	Apple Watch
A14	25	M	Researcher	2 yrs.	Steps	Fitbit
A15	35	M	Engineer	4 yrs.	Exercise sessions	Garmin
A16	25	F	Medical Rep.	5 yrs.	Calories	Apple Watch
A17	50	M	Engineer	6 m.	Steps	Xiaomi
A18	35	M	Engineer	4 yrs.	Body mass	Garmin
A19	45	M	Engineer	4 m.	Steps	Xiaomi

coded a representative sample of 15% of the material. Next, a coding tree was established through iterative discussion. The remaining transcripts were split between the two researchers and coded individually. A final discussion session was conducted to finalise the coding tree after the material was coded. The two researchers then identified emerging themes in the material: Independence, Engagement, Goal behaviour, Motivation and The social.

11.4 FINDINGS

Here, we provide a detailed description of the themes and illustrate them with excerpts from the interview data.

11.4.1 Independence

The first theme that emerged in the coding process is independence.

The importance of being independent and self-reliant throughout their tracking experience was mainly underlined by the Arabic user group. However, some non-Arab users described the phenomenon as well. A participant of the non-Arab user group emphasized the personal, motivational process to prove something to herself and not to anyone else:

> *And then the numbers are (...) self pushing. I think it is a personal thing. I don't get pushed if someone said 'let's do this'. And no one sees it, I don't want to prove anything to anyone, I just want to prove it to myself, that I can actually do it. (W5)*

The importance of staying independent and self-reliant in the decision making process is also highlighted by this statement by an Egyptian participant:

> *I only complete the suggestions or recommendations from the application if it suits my day and life. I am the one in control. (A13)*

The conscious decision to interact with the tracker when it is compatible with one's schedule was mentioned by many Arab tracker users. Another participant from the Arab sample described a similar phenomenon, where the tracker was forgotten or not reviewed regularly in busy times:

> *When (...) there is not a lot going on at college, then I am focused on the tracker. But at times when I am busy with projects, I may forget to wear it on a day, or don't check it out as often. So this really depends on the mood and how my day is going. (A9)*

Further, participants in the Arab group often emphasized that they ignored the notifications they received from their device. They needed to be in control and maintaining their autonomy was frequently men-

tioned in this context. One non-Arab user reflected about finding a way to relax and be less stressed:

> *During my master exams I was stressed and I didn't know what to do with myself and I wondered what could I do to just relieve myself from the surroundings and (...) I just started walking with my dog. It was then that I had a slower pace so I could chill out and think about different things. (W16)*

The importance of cultivating one's own ideas and abilities was further represented as being aware of one's pursuit for happiness and well-being:

> *It is about getting a feeling for what is healthy for oneself. You should figure out what makes you happy and what makes you good. (W17)*

Reviewing data and planning one's activities was a recurrent topic. The reflection process, usually conducted in the evening, encouraged planning future activities. One participant attributed particular importance to the evening review:

> *Probably my evening review is the most common, I just summarize the things from the whole day, thinking of the next one, take a peek at my activities from time to time. It also happens when I plan a new activity to schedule, for example the day when I do not regularly do sports or I want to exchange one activity to another. For example in spring I do more outdoor activities, in winter I am more eager to go play squash. (W4)*

11.4.2 Engagement

This theme describes the excitement, novelty and challenge connected with fitness tracking as perceived by the participants in our study. The Egyptian user group as well as the non-Arab participants mentioned engagement as an important aspect of their tracking experience. However, the theme was more predominant in the data of the non-Arab user group.

Many non-Arab users expressed excitement about their tracker device. They showed interest in the functionalities and, more specifically, wondered how the device conducted measurements. One non-Arab user expressed surprise at the accuracy of the sleep tracking feature:

> *I had to tap the device to put it to sleep. But this one recognises it. I don't know how it does it. (...) probably because I don't move when I sleep. But I think it does kind of a good job. (W17)*

In contrast, one Egyptian participant was fascinated by the accurate calculation of calorie intake. They were also proud to own an accurate fitness tracker:

> *It's an art and science, and how you calculate your intake of calories, and these calories are composed of protein and so on. It's*

> *quite sophisticated. Especially that I got it from abroad, so it is not very common in Egypt. I enjoy when someone asks me about the tracker. (A9)*

Further, non-Arab participants reflected that it was fun to interact with and explore a new technology. The joy of discovering what a new tool can do and, on the other hand, the need to possess something fashionable was evident in non-Arab tracker users:

> *I really like playing around with technology and I also wanted to get a little more active. And I knew that the Flex or the Fuel reminded me to go on my run. (W13)*

Some of the non-Arab users identified fitness trackers as fashionable gadgets. One participant openly declared that their initial interest in a fitness tracker was a result of a fashion trend:

> *I think it was the hipster level. I think it was just having these smart gadgets. (...) Because I wasn't doing sports in 2012. That was probably the main reason. Also, because I started doing real software development, I wanted to see if I could somehow extract data from it, but I never did this. It was only for being hipster. (W8)*

11.4.3 Goal Behaviour

This theme describes the ways users choose, set and relate to fitness goals in their tracking experience. In general, users in the non-Arab group commented more extensively about goal setting and achievement. One participant remarked that goal setting lay at the core of their tracking practice:

> *When I do engage in some kind of sports activity, I do plan my goals. For example, I use a training plan for running. I sign up for races, the goal has a different form but it is also present. I plan my goals so that they are possible to scale reliably. (W7)*

Daily goals also had a more profound impact on fitness behaviours for non-Arab users. The desire to complete goals and challenges was discussed extensively and present throughout the tracking experiences. Many users reported that they made practical decisions every day that enabled them to organise their activities in a way that would result in better performance in terms of a tracker goals. This was illustrated by one participant reflecting on his dog-walking routine:

> *Before I got (the tracker), I didn't measure steps. So, I was walking my dog just for 5 minutes and then coming back. Now when the tracker tells me, for example, that I have 8k steps and I need 2k more to reach my goal, I am going for a long walk with my dog. (...) It changed my typical day a bit. (W8)*

Further, choosing new goals and planning for new goals was addressed solely by participants in the non-Arab group. These partici-

pants not only thought about reaching their current goals, but they also considered a wider perspective of future goals. Non-Arab tracker users were not only goal-driven, but they also saw fitness goals as steps in gradual and constant progress. One participant commented on the perceived sequential nature of goals:

> *I think that, probably, when I accomplish it (tracker goal), I feel it is not only a feeling of comfort and accomplishment, but I also feel that I am able to move on to the next goal. (W13)*

In contrast, participants in the Arab group were using fitness goals infrequently. The majority of them were not using the goal actively and some did not even set a goal, see Table 11.2. When asked about the reasons for not using a goal, participants responded that their days often differed, with different levels of activity. Thus, there were reluctant to apply a uniform goal to differently organised days. Participants expressed the opinion that goals may have been mismatched to some days:

> *I don't need a goal to remind me. I know very well on which days I'm active and on which days I'm not active and I'm not denying that (laughter). (A5)*

Yet some of the Arab users did set a goal. Their usage of the goal feature differed from the non-Arab group as the users would change the goal more often. All Arab users who used a fitness goal reported on tweaking the goal settings. A constant goal was perceived as a sign of an established fitness routine and a desired ultimate circumstance:

> *Initially, my target setting was not constant; I used to change it whenever I find my progress has become constant. Now since I have a training program, it will be constant. (A14)*

A general trend that emerged from the data was that Arab participants perceived the fitness tracker more as a monitoring or measurement device. The non-Arab group desired a tracker that would facilitate motivation and provide challenges. In other words, trackers were perceived more as tools that require active usage and skill in the Arab world. In contrast, non-Arab users wanted the tracker to be proactive and serve as a companion for daily activities and contextualised advice. The following statement illustrates the Arab mindset towards trackers as monitoring tools, where the user comments on actively obtaining measurements, interpreting them and acting based on data:

> *It is more about monitoring the behaviour. For instance, if I know that my weight increased because I haven't eaten properly on a day, then I try to compensate it the next day. If I find that I have high blood pressure, then I wouldn't drink coffee that day. If there's an exercise that helps me with burning calories (...) and I have fun doing it, then I continue doing it. (A11)*

11.4.4 Motivation

Another recurrent theme in the collected data described the dynamics and sources of motivation connected to fitness tracking. Participants reported on a diverse set of motivational strategies and how their fitness tracking supported those practices. The more goal-driven non-Arab group often identified the sole fact of completing a goal as a source of motivation. They also appreciated intermediate feedback on daily progress towards a goal. The goal completion notification was a source of joy and satisfaction:

> *I have to admit that the vibration after achieving it is very motivational for the next days and when I couldn't reach 10k I got upset so I changed the goal to 8k to not feel that bad. (W3)*

The Arab group, however, exhibited a preference towards not receiving goal feedback as this created a feeling of being more in control. Thus, the feeling of being in charge of one's physical activity and the state of one's body was a source of motivation. One participant reflected that motivational messages from a tracker application had no effect on them:

> *My new phone has an application that does that (provide motivational notifications). It keeps telling me 'You are almost there', 'Try to move around', for example. I do not act on these. I feel that I want to be more in control. (A4)*

A similar difference was evident with regard to how participants used the quantitative aspect of data to motivate themselves to increase physical activity. We observed that non-Arab participants used numbers prominently, often increasing activity levels by the smallest of margins to build a sense of achievement:

> *I scroll and I see that I didn't want to jump to 15 (thousand steps) so I set it to 12.5. But then, when I reached 13, I would be like 'okay 13, so let's push it to 15'. (...) And I can actually do it. (W12)*

In contrast, Arab users most often expressed disinterest in objective numbers as they struggled to relate the numbers to their health and well-being. Consequently, increases in quantitative measures were ineffective in fostering motivation for them. For instance, step counts were perceived to offer little meaning.

> *The steps are easy to me, but it's not really the metric for measuring if I am healthier or not. (A8)*

Some users even de-emphasised the role of the measures provided by the tracker altogether in motivation. One user attributed an increased will to progress in fitness to the mere presence of a fitness-oriented digital artefact:

> *It is easier to not follow the diet when I don't have it on, but it is very encouraging when I have it on. (A2)*

Another participant designed their tracker experience to be only about dedicated fitness-related activity. She would remove the tracker during parts of the day when she did not exercise to not track other daily routines. This way, using the tracker became an explicit expression of willingness to be physically active and the possibility of using the tracker in the household was a source of motivation.

> *When I was doing these activities without the tracker, I didn't understand or measure it. (...) I originally used to calculate it by multiplying the number of laps by the length of the walking track in the club. (...) This possibility of measurement makes me motivated. I take it off at home to not collect measurements which are not truthful to reflect the actual (dedicated) walking activities. (A15)*

Similar remarks were also present in the non-Arab group. While all the non-Arab participants wore the tracker almost all day, the tracker still functioned as a physical artefact that signalled the importance of physical activity. The tracker's continuous presence provided motivation in the form of a reminder about one's well-being:

> *It is a reminder to always remain active, since I like to be active. It is like a tattoo around your wrist reminding you of what you thought you wanted to stick to (W11)*

11.4.5 The Social

The last theme in our findings describes the social practices around fitness tracking in the two user groups. Participants in the non-Arab group were mostly uninterested in sharing fitness tracker measurements on social media. Excessive sharing was perceived as a possible concern:

> *I'm not this kind of person who would share this like 'Oh! I took x number of steps', but when I tell it to myself like 'Okay I did 10 km and now I can do 15 km without even feeling tired.', I feel like 'Huh, bravo me'. (W5)*

The need to effectively manage privacy and select audiences across multiple social networks was also perceived as a deterrent from engaging with fitness tracker data on a social level. One non-Arab participant found himself in a state of 'social media saturation' and thus preferred to keep fitness data private:

> *I track my own data and nobody else can see it. I don't use it as social factor, like Facebook for example, where you have an account, you socialise with people. (...) I'm not using this (fitness data sharing), because the problem is that I have 10,000 social networks and that's making things complicated. (W5)*

Comparing data with others was not a common practice among non-Arab users. They preferred to focus on one's training goals and the

goals provided by the tracker. Some participants felt that sharing with other users would mean relying on their knowledge about training which may have been insufficient:

> *I don't compare. Sometimes, I talk about the experience (...) we compare the devices, but I don't think we discuss our performance in daily activities. (...) We do not have enough knowledge and experience to properly analyse the activity because of how measure something using the tracker. We can't say 'Hey, change your lifestyle!'. (W11)*

Attitudes towards the social elements of fitness tracking in the Arab group were strikingly different than those in the non-Arab group. For many participants, the decision to consider acquiring a tracker was motivated by social circumstances. Family members would often introduce each other to tracking:

> *I sort of relied on my brother's opinion and judgement in this matter. I saw it with him and liked it. So, I decided to get it. (A9)*

All Arab participants mentioned sharing data and most shared with other tracker owners. They often spoke of small groups that would develop informal practices around fitness tracking to support their members. Similarly to non-Arab participants they were reluctant to share fitness information on social media:

> *I have my own group of people, I share it with them, and I don't share it on social media, so I have no privacy concerns. (A5)*

Some Arab users shared their data with small groups, other participants from the Arab sample focused on one person to discuss and compare their tracker data with. One participant reflected about sharing and comparing tracker data with a friend. The user described how the comparison offered a point of orientation for his own endeavour to maintain a healthy lifestyle:

> *He is a person who is capable of maintaining a busy lifestyle, while being healthy. So, I check what he is doing and compare our life styles, it is like an imitation game. (A1)*

One participant reported how their initial friendship with another tracker user developed into a deeper relationship. This resulted developing a certain emotional attachment to the tracker and embedding the tracking deeply in its social context. As a consequence, the participant was also concerned about the physical state of the device and its parts:

> *After we became more than friends, it became both fitness and social goals, especially that it's a gift. It means a lot to me. But I read about it, and found that this torn part was the most likely to be torn. (A3)*

Family also played an important role in the fitness tracking experience in the Arab sample. Many participants reported discussing data with their families and receiving social support from family members. One

participant developed a daily fitness support relationship with her mother:

> *It is more of encouragement. And Apple sends me notifications saying '(Participant's mother's name) finished her rings, congratulate her', so I send her an applause, an emoji, or 'Way to go!' and she does the same. It's fun! And we're cute! (A16)*

The findings in the last two themes are perhaps best described by an unsolicited comment from one of the participants who explicitly reflected on how Arab users of fitness trackers were less interested in the qualitative aspect on tracking and preferred to focus on the social opportunities afforded by fitness trackers:

> *Maybe Europeans and Americans are more concerned with the steps and mileage. Egyptians would be more into following their fitness idols, taking pictures, posting them on Facebook and Instagram, and how many calories were burnt. They'd be more interested in the social aspect of fitness tracking rather than the actual fitness aspect. (A14)*

11.5 DISCUSSION

In our qualitative interview study, we found an array of differences and similarities in fitness tracker usage between the Arab and the non-Arab user groups. The findings show that the Arab user group put more emphasis on their independence from the tracking device than the non-Arab user group. This is, inter alia, highlighted through statements in the theme INDEPENDENCE, where Egyptian users stressed that they did not necessarily follow the recommendations of their device, because it was important for them to retain control while interacting with the tracker. This may suggest that Arab users may be more receptive to technologies that support reflection rather than providing prescriptive measures such as those discussed by Gulotta et al. (Gulotta et al., 2016).

In contrast, the non-Arab user group focused more on goal setting and goal pursuit, which was reflected in the theme GOAL BEHAVIOUR. Differences were also evident in the various MOTIVATIONS for tracking. Arab users enjoyed keeping track of their data and showed a tendency to use the fitness tracker more as a monitoring device, whereas non-Arab users mainly discussed goal-oriented behaviour. This multitude of approaches and motivations to track reflects past findings by Epstein et al. (D. A. Epstein et al., 2015). Our analysis shows that some of the variability in motivations can be explained by cultural factors. Further, the entire experience of long-term personal informatics may be significantly shaped by one's cultural background.

We also observed a strong emphasis on SOCIAL features of a tracker in the Arab user group and a strong interest in stimulating features in

the non-Arab user group. We hypothesise that these findings are connected and are an expression of the same underlying need — the need for engagement. Hassenzahl et al. (Hassenzahl, Wiklund-Engblom, Bengs, Hägglund & Diefenbach, 2015) previously identified engagement as a basic psychological need that is also relevant for the design of interactive systems. Our work shows that, in terms of fitness trackers, engagement can either be satisfied through stimulating features within the individual tracker or through social interactions included in tracking practices. Consequently, future trackers should support both ways of providing engagement and enable the users to choose their own strategies in that respect. This resonates with past findings on sharing in the context of physical activity which highlighted a need for fine-tuning social preferences and audiences (Wozniak et al., 2017).

The two user groups prioritised two different metrics. Statements in GOAL BEHAVIOUR outline the primary focus on steps and step goals in the non-Arab user group. This contrasted with prioritising calorie intake or alternative metrics such as race performance in the Arab user group. These findings imply that future trackers should consider a wider array of metrics spanning different time periods to offer engaging experiences to more users.

Combined, the differences and similarities that we observed in our study show that there is an emergent design space for fitness trackers that better fit the particular user in terms of practices that vary across users and locations. We hope that we managed to use the geographically diverse composition of the two groups to identify different aspects of what fitness tracker experiences can constitute for an individual. However, the contrasts we highlighted here are just a means to further investigate how users experience trackers. In a globalised world, many users have mixed background and it is highly likely that a personalised tracker style preferred by one of the participants from our Arab user group would also be required in Western Europe. Consequently, our results should be interpreted with caution. Further investigation is needed to determine if it is possible and meaningful to attribute certain desired qualities of a tracker experience to cultures or location. Instead, we suggest that future trackers should offer a greater degree of flexibility to offer a more inclusive experience. In order to stimulate developing and help in designing such devices, we identified four dimensions of tracking based on our findings.

11.5.1 Inclusive Dimensions of Tracking

Here, we propose four dimensions that help navigate the design space of fitness tracking experiences (see Fig. 11.1). These dimensions take the diversity of users into account and strive to offer support in designing more engaging trackers that offer flexibility to the users.

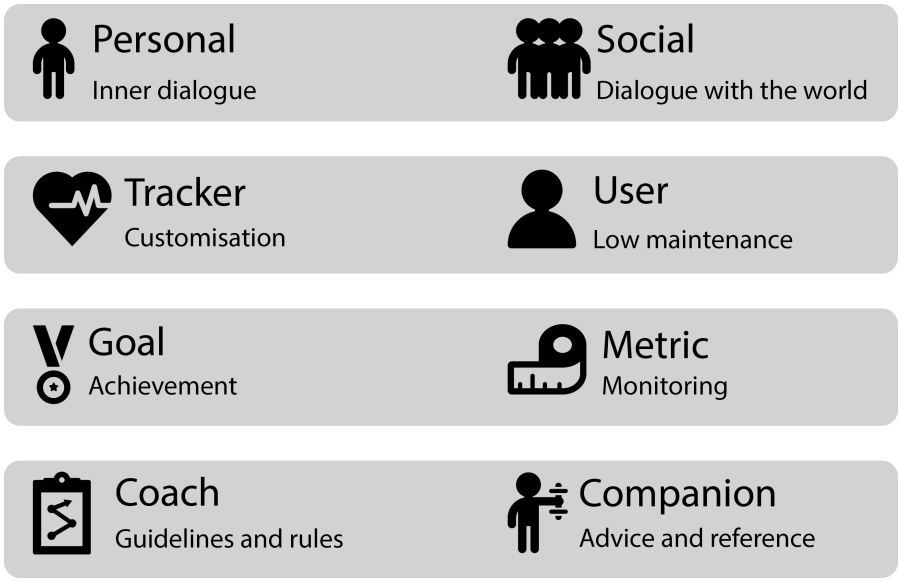


Figure 11.1: A summary of the four dimensions of fitness tracking evoked by the differences between users identified in our study. The dimensions serve as conceptual means to inspire designing more customisable tracker experiences.

They help shape the aspects of one's personal informatics that may be user background-dependent.

Our work indicates that trackers should be flexible and adapt to the user along these dimensions. The aim of these dimensions is not to underline differences between or show how these differences are manifested in attitudes towards fitness tracking. Instead, we postulate that future trackers should be highly customisable along these dimensions and offer an experience that considers different diverse approaches to how trackers are appropriated. We hope that the dimensions can aid in designing inclusive fitness tracking experiences that answer to the needs of a diverse population, as described by Spiel et al. (Spiel et al., 2018).

11.5.1.1 *Personal — Social*

Offering the opportunity to shape the tracking experience as a personal or a SOCIAL experience can support meaningful fitness tracker interactions. Users should be empowered to make conscious decisions on how social they want to make their tracking experience from its beginning. Our work shows that users prefer different levels of social influence in fitness tracking: Some found meaning and pleasure in the social aspects; others through the moments and activities which they only shared with their tracker. Thus, a successful fitness tracking experience should enable finding one's balance between an 'inner dialogue' and a 'dialogue with the world'. This stance poses a challenge for interaction design for trackers and calls for enhancing and

building new sharing features that enable users to customise content and audiences dynamically.

11.5.1.2 *Tracker — User*

Our work showcased how different users developed different material relationships with their trackers. Our participants included users who found joy, MOTIVATION and ENGAGEMENT in experimenting with tracking technology or making the tracker aesthetically pleasing. In contrast, others treated the tracker as a necessity to acquire activity metrics. This implies that future trackers should allow users to choose a preferred level of maintenance and/or customisation. Consequently, future fitness trackers should enable users to interactively customise notification levels and maintenance required to suit their personal profile. Designing effective ways of controlling those features remains an open research challenge.

11.5.1.3 *Goal — Metric*

GOAL BEHAVIOUR showed varying preferences in terms of engaging with the tracker in everyday life. Our work shows that there is a continuum between focusing on goal achievement and monitoring metrics. However, both ends of this spectrum are logically intertwined. The design of future trackers should enable the user to consciously and transparently put more emphasis on one of the two dimensions in order to create a satisfying interaction with it. In other words, users should be able to make a choice on how deeply to engage with tracker goals and this choice needs to be complemented with rich and transparent metrics. As a consequence, fitness tracking experiences should empower the user to feel in full control of their metrics and decide how visible their goals should be. This is in stark contrast with current trackers, which are predominantly goal-focused (Niess & Woźniak, 2018). Thus, future interaction design should explore alternative designs for displaying metrics throughout a personal informatics experience.

11.5.1.4 *Coach — Companion*

Our study showed that users exhibited different attitudes towards notifications and suggestions provided by fitness trackers. This was strongly linked to different levels of INDEPENDENCE in thought and action. There is variety among users in terms of how they perceived prescriptive measures provided by a fitness tracker. Consequently, a differentiation between the tracker as a companion and the tracker as a coach is needed. The tracker as a companion supports its users through offering advice and a frame of reference. In contrast, the tracker as a coach provides rules, recommendations and guidelines for improvement. Building devices that support navigating the coach —

companion spectrum will empower users to find their desired level of independence in fitness tracking. An emerging challenge for the HCI field is modelling how the dialogue of the system with the user can look like to embody different qualities along the coach — companion spectrum.

11.5.2 Limitations

While we aimed to make a contribution towards designing inclusive, meaningful tracking experiences, we can identify some limitations in our work. Firstly, we recognise that this kind of research is affected by the values of the researchers conducting the studies, which is reflected in the topics and the questions we selected (De Mooij, 2013). While we used a culturally diverse author team, our personal social background and geographical origin may still have affected the study.

Moreover, we decided to focus our inquiry on the comparison between an Arab user group and a group that we considered as representative of the users primarily studied in past work. Through applying this lens, we have been able to identify dimensions alongside which tracker designs can be customised to enable an inclusive, positive tracking experience for global users. However, our sample is prone to some limitations. The non-Arab sample consisted of participants from four different countries and the Arab user group consisted of participants from one country. A gender imbalance in the Arab group should also be noted. We believe the discrepancy may be representative of the user pool in Egypt (as fitness tracker users are predominantly male in most countries (gfk, 2018)), but studies answering these questions are currently missing.

Finally, we see possible theoretical developments from our study data that we decided to omit in favour of focusing on the design space for inclusive fitness trackers. For instance, a deeper analysis using cultural theories (Schwartz, 2006; Hofstede, 2003) could help identify which differences the usage of a fitness tracker were potentially explained by cultural differences. In this work, however, we focused on inspiring the design of inclusive trackers that give users the freedom of choice rather than culturally profiling them.

11.6 CONCLUSION

This paper investigated differences in practices around fitness tracking between the US, Western Europe and Egypt. We conducted semi-structured interviews with 37 active fitness tracker users. Through thematic analysis, we found five themes: INDEPENDENCE, ENGAGEMENT, GOAL BEHAVIOUR, MOTIVATION and SOCIAL. We observed that users in the two groups differed in their desired level of independence,

preference for social interactions around tracking and how they related to goal and metrics. Furthermore, our work highlighted a need for future trackers offer more customisable experiences that take the diversity of users into account. To aid in that process, we proposed four design dimensions for fitness trackers that stem from our analysis: Personal — Social, Tracker — User, Goal — Metric and Coach — Companion.

Our work sheds new light on the research community's understanding of fitness tracking and aims to stimulate further studies in personal informatics. We wonder if and how the findings presented in this paper can be applied to areas in personal informatics beyond fitness tracking. Future work should investigate the importance of user background in shaping non-fitness tracking experiences. We hope that our results will help design inclusive tracker experiences that offer long-term engagement.

12 | PAPER VIII: DIGITAL COMPANIONS

This chapter is based on:
Niess, J., & Diefenbach, S., & Platz, A. (2018). Moving beyond assistance: psychological qualities of digital companions. In Proceedings of the 10th Nordic Conference on Human-Computer Interaction (pp. 916–921). ACM.

Digital assistant technologies are becoming increasingly common at home. These technologies also hold high potential through supporting individuals at work. However, it remains a challenge for research to understand which psychological features should be embodied by digital assistant technologies so that they can become meaningful everyday companions and contribute to user's well-being. In this work, we conducted a focus group, a survey and an expert workshop to investigate user perceptions of digital assistants and explore how interactive technologies can be perceived as companions. We found that the design space of digital companions can be described as a spectrum between passive and active assistance. Further, users reported that assistant technologies can assume different roles (e.g. friend, advisor) connected to the task performed. Our findings contribute initial insights regarding psychological qualities of digital companions and highlight a number of important questions for future research.

12.1 INTRODUCTION

Digital assistant technologies are already widespread assisting people in daily tasks (e.g. Amazon Alexa[1]). Furthermore, digital assistants become increasingly popular in the working domain, supporting manual labour (e.g., industry robots) and cognitive tasks, such as in the domain of software development. The latter reflects a typical field of application for assistant technologies in the era of information society. As knowledge workers have to deal with an increasing amount of information every day, there is an emerging need to build technologies that reduce information overload and aid in sensemaking (Goyal & Fussell, 2016). Assistant technologies can improve how employees obtain information and thus can contribute to users' efficiency and well-being.

1 alexa.amazon.com

This way, systems can become cooperative partners (Grudin, 2017) that interact with the human knowledge worker to deal with the increasing complexity in organizational and administrative regards (e.g. constant availability (Mazmanian & Erickson, 2014)). However, to enfold its full potential and support users in the best way possible, such technology needs to be designed in a way that users are open to engage with it and integrate it into their daily work routine. In other words, a critical question is how technology can go beyond assistance and be perceived as a trustworthy (digital) companion.

As already discussed in the nineties, when stepping into the role of a social actor (Nass et al., 1994), technology evokes particular psychological reactions and expectations in its users. These findings can also be relevant in the field of assistant technologies. In order to successfully transform an interactive assistant into a technology that people can perceive as a supportive companion, technical functionalities need to be augmented. The assistant should embody certain psychological qualities (e.g. use a particular 'communication style' (Beun et al., 2017)). Consequently, building a profound understanding of the subtleties of companion technologies from a psychological perspective emerges as a challenge for HCI. We aim to fill this gap by conducting an inquiry with a focus on the following questions: What are the central characteristics, which allow people to consider technology or artifacts as a 'companion'? What are the psychological qualities involved in designing digital assistant technologies to transform them into true digital companions? What are the differences in needs and expectations of digital companions between different applications areas? Aiming for a broader perspective on the required psychological qualities of digital companions, we present initial insights from the specific domain of software architecture with more general inquiries into user needs and expectations of technology or artifacts as companions. More specifically, we investigate (1) user perceptions of digital assistant technologies and (2) critical prerequisites of interactive technologies to become digital companions. We conducted a focus group with software–architects to explore a specific application area of assistant technology, the work environment, in more depth. We also conducted an online survey and an expert workshop to explore the psychological benefits and features of future digital companions in general. This paper contributes the following: (1) empirical results on current and future roles of digital assistant technologies from a variety of data sources: a focus group, an online survey and an expert workshop and (2) preliminary insights about the requirements and constraints involved in designing digital companions.

Figure 12.1: Focus group participants using the needs inventory.

12.2 METHOD

Our work explores how users relate to companions in different contexts, i.e. work and private life. To that end we combined three methodological approaches: a focus group, an online survey and an expert workshop. In order to get as much insight as possible the term 'companion' was not explained in more detail. Instead we invited the participants to freely express what they associated with the term. We did however specify that we ask about objects as companions and if our questions are about digital, non-digital or both types of companions.

12.2.1 Focus Group

With the aim of inquiring about the views on companions in work settings, we conducted a focus group (2 hours) with $n = 6$ software architects in a big corporation (4 male, 2 female, work experience 1–14 years). We chose software architects, because they were a good representation of a user in a knowledge-based economy. Furthermore, an increasing number of people are going to pursue this profession in the future.

The focus group started with a general reflection on (digital and non-digital) objects that could be companions in everyday life. Psychological functions and related needs were discussed (see Figure 12.1)

with the help of the needs card set [2]. With the aim to gain in-depth insights in current practices and attitudes towards objects as companions we did not restrict the reflection task to digital or non-digital companions. Afterwards, the discussion focused on specific requirements and expectations from a digital companion in the participants' professional context, i.e., software architecture. Besides appropriate functions to be supported by the companion, a point of discussion was also the appropriate form of interaction and communication between the user and the companion. Participants demonstrated their individual views and ideas by building collages of drawings and photos.

12.2.2 Online Survey

In order to explore the perception of companions among users, we conducted an online survey with $n = 156$ (117 male, 39 female, $M_{age} = 24.28$, $SD_{age} = 6.17$). In the survey, we asked about typical features of a good companion (digital and non-digital). Further, we queried users if they had already had companions and what shape the companions assumed. We explored various roles of companions, what needs they could have fulfilled and potential ways for companions to interact and communicate with the user. We decided to inquire digital and non-digital companions in order to gain as much insight as possible regarding the variety of perceptions towards objects as companions. Answers were collected over two weeks in August 2017 and the survey took an average of 15 minutes. Participants were recruited via mailing lists and social media platforms. As an incentive, participants were able to take part in a raffle for Amazon vouchers (1× EUR 50, 2× EUR 20, 5× EUR 10).

12.2.3 Expert Workshop

In addition, we conducted an expert workshop with experts from software development, psychology and design $n = 4$ (3 female, 1 male). The participants were active in research and practice and held a Master's Degree or higher (1 MSc, 3 PhD). The workshop participants explored and analysed how users could interact with digital companions at home and at a workplace. Based on the preliminary results from the online study, we explored interaction patterns for various roles of digital companions. Further, connections between interaction patterns and experiential qualities were explored and discussed using the interaction vocabulary by Diefenbach et al. (Diefenbach, Lenz & Hassenzahl, 2013). The interaction vocabulary is a set of qualities to describe interactions. The attributes are descriptive, non-judgmental and abstract (e.g. gentle – powerful). The vocabulary can be used

2 adapted from https://hassenzahl.wordpress.com/experience-design-tools/

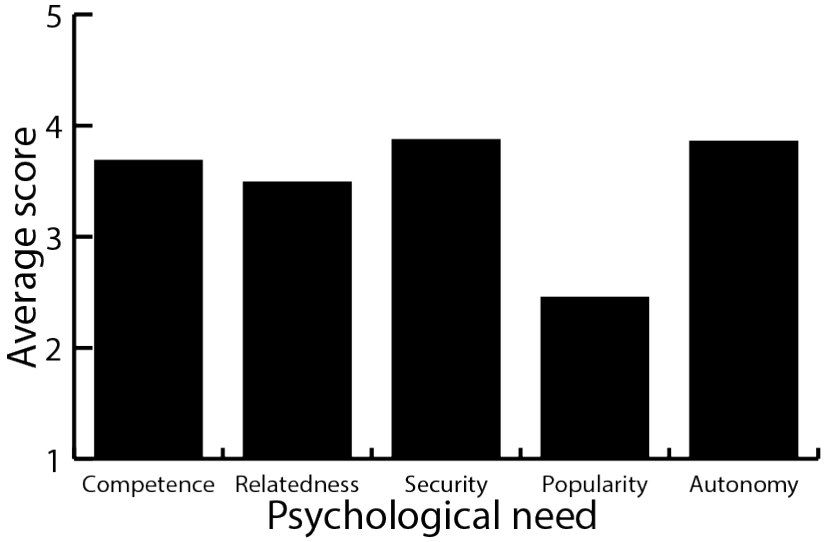


Figure 12.2: The psychological needs potentially addressed by a companion, rated on a 5-point Likert scale.

to inspire potential ways to design interactions and as a means to support systematic discussions about how interactions feel.

12.3 FINDINGS

A central finding was the identification of two basic types of companions — active and passive. The examples of digital and non-digital companions in everyday life provided by the participants of the focus group and the online survey (e.g. notebook, pen, smartphone, laptop) covered a wide variety of products. However, independent of the product category, the way participants of the focus group talked about that product and their relation to it was affected by whether the product played a more active role, actively initiating a 'conversation with its user', or a more passive role, waiting to be 'called for assistance'. The former, for example, could be a calendar app that actively reminded its users of appointments and tasks that need to be accomplished. While the users believed their companions had their best interest at heart, the active companion could also be perceived as annoying. An example of a passive companion described by one participant of the focus group was a (non digital) notebook. As a reliable companion, the notebook was always there to record all the things that 'would take too much space in her head', and produced the information when requested. Focus group participants also assigned different character traits to passive and active companions. An active companion was typically characterized as innovative, dominant, proactive and independent.

Some participants also reported a feeling of being under surveillance and having limited autonomy. For example, one participant explained that

> *When I make a mistake, he corrects me immediately and this [correction] is obligatory.*

A passive companion, in contrast, was characterized as caring, empathetic, cautious and subdominant, only acting on explicit request. This is, for example, reflected in the following statement of a participant of the focus group.

> *He gives me the space I need, but, as soon as I need him, he is there.*

We asked what kind of companion (active or passive) participants would prefer in general and in different contexts. There was no general preference for one of the two companion types, 52 % of the participants chose passive. However, the specific questions for both leisure and work/study contexts revealed a slight preference for the active companion (leisure: 58 %; work/study: 58 %). In sum, the survey findings imply that both companion types, active and passive, are relevant for assistant technologies (Figure 3).

12.3.1 Psychological Benefits of Companions

Both focus group discussion and online survey revealed competence, security and autonomy as most important psychological needs fulfilled by companions (Figure 12.2) In the online study, the perceived need fulfilment was assessed with the needs questionnaire (Hassenzahl et al., 2015) on a five-point scale. Focus group participants discussed the dominance of needs in the context of their companions with the help of a needs card set, representing different psychological needs by pictures and associated feelings and statements. While need fulfilment of stimulation, relatedness, and popularity was only apparent in single participants' statements, competence, autonomy, and security were unanimously mentioned by all participants. For example, relating to autonomy, one participant described his laptop as a 'universal weapon', providing support in a variety of situations, another referred to her smartphone helping her 'find her way'.

12.3.2 Companion Roles

Moreover, beyond the active–passive distinction, the focus group and online survey also revealed a variety of possible roles and associated character traits behind the broad image of a companion. For example, a (digital) companion may take the role of a friend, an advisor, a teacher, or a coach. Each of these roles comes with different expectations towards the product, and, in the case of interactive products,

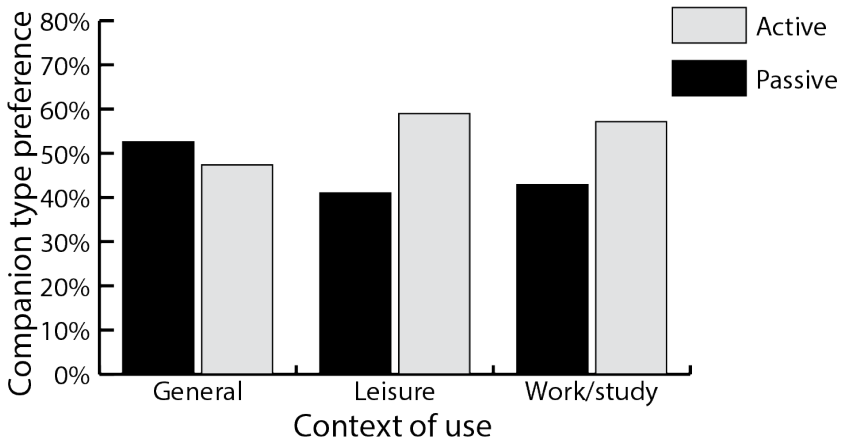


Figure 12.3: User preference for active or passive companions depending on different contexts.

also different requirements of interaction qualities. We explored such patterns of interaction qualities related to different companion roles with the help of the interaction vocabulary (Diefenbach et al., 2013). As a result of the expert workshop, Figure 12.4 shows the specified ideal interaction profiles for two different companion roles, *friend* and *advisor*. For example, the requirement of instant interaction for the companion as advisor (Figure 12.4) reflects the expectation that an advisor should provide instant feedback. Moreover, instant interaction was perceived as an expression of definite advice, as expected from a good advisor. The need for clear advice was also related to powerful interaction; the need for stepwise interaction was explained in parallel to a structured dialogue. In a similar manner, each interaction attribute was related to a particular character trait or role. Compared to this, seeing the companion as a friend, brought up different expectations of interaction attributes. For example, a more gentle and fluent interaction was seen as appropriate. In sum, companions that assume different roles were thus connected with different interaction profiles and the way the companion is experienced can be shaped through a deliberate design of interaction attributes.

12.4 DISCUSSION AND FUTURE WORK

Our preliminary results reveal several interesting starting points for the deliberate design of digital companion technologies such as the active–passive distinction or interaction qualities as a way to shape a desired companion role and character. But these questions need to take the specific context into account. While in the working domain, a companion might shall take on the role of an advisor, for a technology

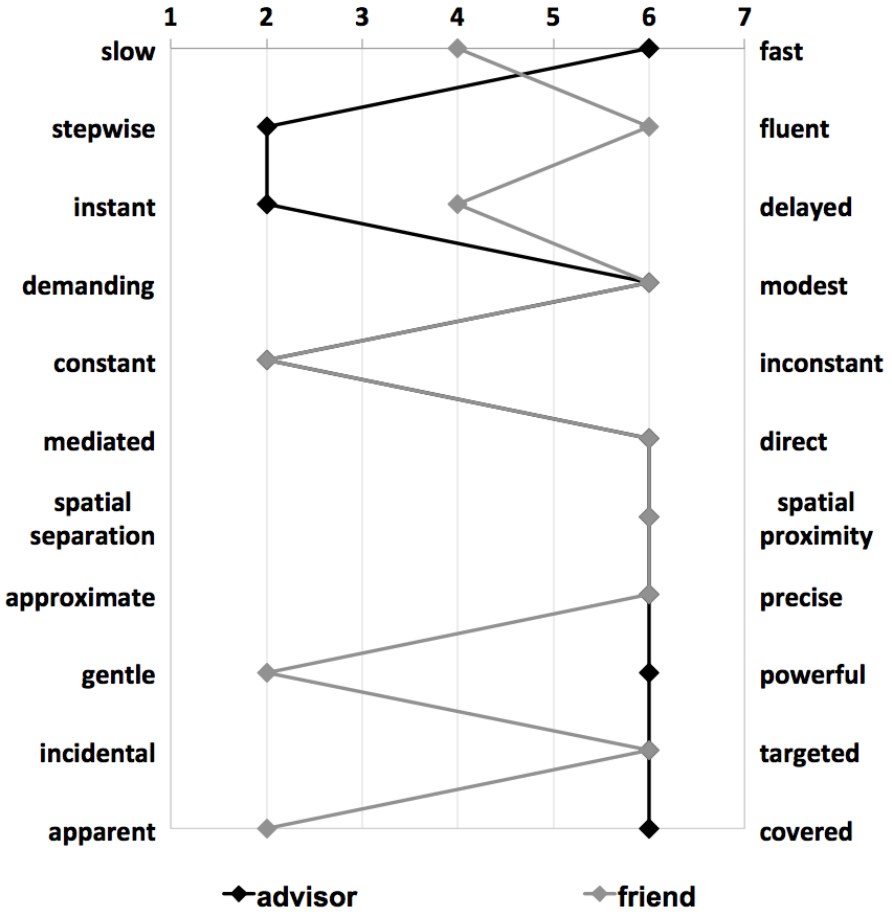


Figure 12.4: Interaction profiles for two companion roles — friend and advisor.

used in one's free time, other requirements may arise. Thus, the question of context and resulting requirements is also a central one in the field of companion technologies. The conscious decision for a fit between context and role of the companion comes with the consideration of specific interaction qualities, such as the way the technology communicates with the user (Beun et al., 2017), interaction patterns (Diefenbach et al., 2013) and the difference between active and passive companion qualities. Moreover, we see parallels to other HCI concepts. For example, the active-passive qualities of interactive technologies relates to the work of Weiser et al. seminal work on reactive and proactive systems, which operate in the periphery (Weiser & Brown, 1997).

In future work, we aim to study relevance and adequacy of various digital companion roles in specific contexts. Therefore, we will also explore possible ways to operationalise different contexts. We strive to explore the connection between roles of digital companions and specific interaction qualities. Furthermore, we plan to conduct a study in a specific context of use, looking closely at software development practice. We aim to do in-depth user research in order to get a profound understanding of the daily work routine of the participants and the accompanying chances and challenges of their work. We plan to develop prototypes of digital companions that assume different roles. We will explore how these different companion roles are perceived in this specific work context. We hope to determine psychological qualities of companions connected to their specific roles and investigate the companion's influence on the work atmosphere and efficiency.

12.5 CONCLUSION

In this paper, we explored the psychological qualities of artefacts and technologies that may become users' companions. We explored differences in perceptions of assistant technologies in work and private contexts and psychological factors for designing digital companions. To this end, we conducted a focus group, an online survey and an expert workshop. Our initial results show that companion objects are already present in a variety of domains, including leisure activities and the work environment. This suggests a string potential for developing companion technologies that embody desirable psychological qualities for both domestic and work settings. We found that companions can assume different roles and the preferred role may depend on the context of use. There were two types of companions (active and passive), which are a continuum rather than a dichotomous variable. However, the results also revealed the complexity of the user experience of companion technologies. Users reported that merely providing assistance did not necessarily form a desirable digital companion. Our work

constitutes a first attempt at envisioning future companion technologies. We hope that our initial insights will inspire further research into how digital assistant technologies can become meaningful everyday companions and contribute to user's well-being.

Acknowledgements

We thank Eva Lenz, Daniel Ullrich, Marietta Herzog and Kim Bormann for their valuable contributions to this work.

13 PAPER IX: THE WHEEL OF EVERYDAY INTERACTION

This chapter is based on:
Niess, J., and Woźniak, P. W. The Wheel of Everyday Interactions: A Tool for Temporal Mapping. Submitted for review.

Designing for everyday interactions becomes increasingly complex as ubiquitously connected users engage in an ever-increasing number of activities. As designers strive to build better interaction technologies for both collocated and remote communication, we need more efficient means to build interactive artefacts that fit the users' daily routines. In this paper, we introduce the Wheel of Everyday Interactions (WEI); a tool for temporal mapping of everyday interactions for multiple users. Our tool enables designers to better empathise with users and understand the temporal dimension of their daily lives. Based on knowledge from Psychology, it allows for investigating how time is spent to fulfil basic needs. We evaluated the WEI in three workshops with interaction design students and found that it produced a positive response in the participants and enabled them to empathise well with users. We contribute the WEI to the public to help in designing better artefacts for everyday interaction.

13.1 INTRODUCTION

Users are constantly confronted with a variety of stimuli. Notifications from a multitude of mobile applications are permanently asking for our attention. The coming age of automation in the Internet of Things offers many comforts, but it also comes at the cost of managing and keeping track of a multitude of sensors and devices. However, as constant availability (Mazmanian & Erickson, 2014) is expected, finding time for engaging social interaction is becoming a challenge for users. Consequently, some users find it difficult to deal with all the remote communication challenges or even choose to sacrifice face-to-face interactions in order to process all their messages. As a consequence, building systems that value the users' time and put

Figure 13.1: Impressions from the WEI evaluation workshops. Top: Completed time mapping wheel for two users. Note that the workshop participants applied the same time scale to differently sized rings. Bottom: Generating insights on post-it notes using the common time slot selector and a clear overlay.

meaningful use of time in focus emerges as a challenge for Human-Computer Interaction (HCI).

In order to address this challenges in HCI it is important to empathize with users and understand their everyday lives. Tools such as personas, journey mapping or concept maps help understand the context of a design activity and make the insights from user research more tangible. However, engaging with the temporality of users every day is challenging and complex. We offer an extension to existing tools that intends to support the HCI research community and practitioners in designing social interactions for the everyday and engage with temporal complexities of users' lives.

This paper introduces our toolkit that aims to provide an increased understanding of the temporarily of interacting. The Wheel of Everyday Interactions (WEI) enables engaging with the time aspect of the users' lives and relating time to basic psychological needs. We contribute the following: (1) The Wheel of Everyday Interactions toolkit, available to the community as a download, and (2) the evaluation of the toolkit in three interaction design workshops with n=27 participants.

We first discuss related research and tools that inspired our work, then provide a description of the WEI and report on its evaluation. Finally, we discuss our findings and show insights for designing better interactions that consider temporality.

13.2 RELATED WORK

We developed the WEI as a repose to work that called for a better understanding of temporality while designing interactive systems.

Huang and Stolterman (C.-C. Huang & Stolterman, 2011) called for carefully managing the temporal experience of using systems and its consequences for attention management. In further work, they advocated understanding how interactive artefacts age over time when becoming part of the everyday (C.-C. Huang & Stolterman, 2012) (later echoed in work by Odom (Odom, 2015)) and discussed interfaces for retrospection (C.-C. Huang & Stolterman, 2014). Ferreira et al. (Ferreira, McGregor & Lampinen, 2015) studied how users devoted their time to maintaining infrastructure. Lundgren (Lundgren, 2013) showed how applying Temporal Themes to existing designs can lead to new design ideas. Velt et al (Velt, Benford & Reeves, 2017) underlined how temporal trajectories constitute an important lens in understanding interactive systems. These findings show that enhanced design tools that focus on temporality are needed in the HCI community.

A different strain of work explored the importance of identifying the right time for interaction with technology through the users' days. The drift table (W. W. Gaver et al., 2004) explored ludic interactions that offer pleasurably spent free time of varying length. Past work pointed out that identifying the right moments for interaction may facilitate reflection (Knaving & Woźniak, 2016; Fleck & Fitzpatrick, 2010) and learning (Dingler et al., 2017). As a consequence, identifying opportune moments is a key consideration for designing many systems. While the HCI field explored technical means to detect opportune moments (e.g. (Iqbal & Bailey, 2005; J. E. Fischer, Greenhalgh & Benford, 2011; Pielot et al., 2017)), we postulate addressing opportune moments at the design stage through gaining a deeper understanding of the user's everyday routines.

Moreover, this paper aims to further explore the interplay between how technology can shape the experience of time and how time shapes the way technology needs to be designed. Lindley (Lindley, 2015) highlighted how interaction designers can build artefacts that support temporal patterns and infrastructures. She further showcased how successful interactive artefacts navigate the inherent temporal constraints of their design. Thus, an understanding of time tailored to the design case is an important success factor in the interaction design process. These considerations are reflected in work in various domains. For instance, Reddy et al. (Reddy, Dourish & Pratt, 2006) studied temporal patterns in clinical work. They provided an extensive example of the importance of temporal patterns in everyday work and how it should impact the design of digital solutions for patient care in hospitals. Our work aims to empower designers to understand the users' perception of time better and enable a rapid, practical approach to designing for temporality. As postulated by Lindley (Lindley, 2015), our tool can help build artefacts that help shape time organisation, encourage reflection, and consider the time dimension beyond the individual.

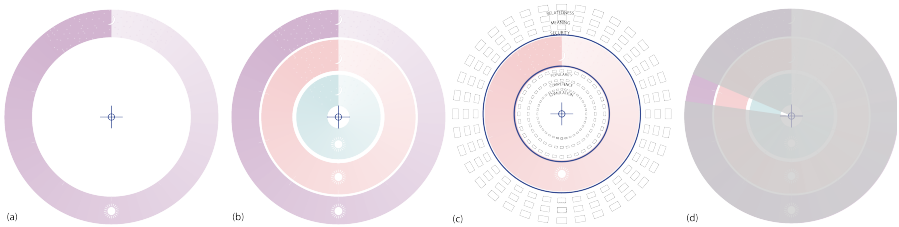


Figure 13.2: The basic elements of the WEI. (a) The time mapping wheel for user one with space to draw actions over a period of time. (b) Combined time mapping wheels for three users. (c) Needs overlay over user two's mapped time. (d) Common time selector overlaying three users.

Finally, the development of the WEI was inspired by other tools that now serve the HCI community. Our work aspires to complement the well-established personas (Pruitt & Grudin, 2003) which show that intermediate design artefacts that synthesise user research can be useful in the entire design process. We also build on the potential of toolkits to spark creativity in HCI, which was previously successfully achieved by both technical (Dietz, Reyes & Kim, 2014) and conceptual (Lundgren, Fischer, Reeves & Torgersson, 2015) contributions. The WEI also builds on the ease of use and applicability of paper-based tools such as the Moving Context Kit (O'Leary et al., 2017), Tango cards (Deng, Antle & Neustaedter, 2014) or inspiration cards (Halskov & Dalsgård, 2006). Similarly, our toolkit also aims to capitalise on the versatility and tangibility of the paper form.

13.3 WHEEL OF EVERYDAY INTERACTIONS

The Wheel of Everyday Interactions is a tool that helps design interactive artefacts and services that embrace temporal relationships in users' lives. The WEI consists of three components with multiple pieces and additional material. The three basic components are: *the time mapping wheel*, *the needs overlay* and *the common time slot selector*. The WEI is freely available as a PDF download[1] and free to use for researchers, educators and practitioners. Producing the toolkit requires A3 and A4 (alternatively letter and tabloid) paper and OHP film. Wheels can be cut with scissors or a laser cutter using the stencils provided. An alignment symbol is placed in the centre of each page to be printed in order to facilitate centering the wheel elements and using the different overlays as concentric rings.

1 Public link available in camera-ready version; please consult the auxiliary files in PCS.

13.3.1 Time Mapping Wheel

The time mapping wheel (see Figure 13.2a and 13.2b) consists of three differently coloured concentric rings. Each ring represents a user's actions over an agreed-upon period of time. The colour on each ring gradually changes from a lighter to a darker shade, to emphasize the beginning and the end of a timespan defined by the designer (e.g. a day, an hour, a week). Designers can map the activities within the defined timespan on the wheel with drawings and textual annotations. This supports the designers in engaging with the temporal aspects of the user's everyday life. Each ring can be used independently or combined with the other rings. This way, the WEI enables designing for both individual and collective action. If used together, the concentric composition of the rings invites the designer to discover opportune moments for potential interaction between the two or three users. This is also supported through the common time slot selector (see section below and Figure 13.2d).

13.3.2 Needs Overlay

In order to help identify opportunities for design interventions, we added the needs overlay to the WEI. Once the user's actions over a timespan have been mapped, the WEI enables mapping of which basic psychological needs of the user are satisfied and when. The needs map is inspired by research in the psychology of interaction. We extracted six needs applicable to temporal mapping from the work of Hassenzahl et al. (Hassenzahl et al., 2015), which has proven to inspire design in past research. The selected needs were: relatedness, meaning, security, popularity, competence and stimulation. The WEI invites designers to reflect about opportunities in addressing psychological needs through interaction in the everyday life of the user.

13.3.3 Common Time Slot Selector

The WEI also features a tool to identify opportune moments for interaction, which can be used for individual and collective interactions. Past work (Dingler et al., 2017) has shown that identifying these instances of time can help build engaging everyday experiences. The common time slot selector kit consists of three pieces; the small, medium and large time slot selectors. It is a grey, slightly transparent wheel overlay with a completely transparent, triangular slot. The slot stretches over all the time mapping wheels currently in use, and can be rotated to facilitate finding opportune moments in time to design interactions between users. The common time slot selector makes the detection of opportune moments for interactions easier by temporarily decontextualizing individual actions and forcing looking at small instances of

time. This way, the designer can identify transition periods between activities, transport times, etc. It allows designers to assume new perspectives and quickly switch between views to facilitate serendipitous idea generation.

13.3.4 Additional Material

The WEI contains optional material that simplifies the usage of the wheel and helps designers engage with the toolkit. The list of additional materials presented here is not exhaustive and we invite future users to add materials they consider useful or inspiring. To simplify the usage of the WEI, we also include clear wheel-shaped overlays in the toolkit. We also recommend using cork underlays with pushpins fixed on them to enable rotating the different pieces of the toolkit, as well as OH pens with erasers in multiple colours and sticky notes to affix their insights, additional information and possible design ideas. Since the WEI emphasises the importance of the temporal aspects of the users' everyday lives, this is also inherently reflected in the design of the toolkit. Time is perceived as a relative flow (*Panta rhei* (Lundgren, 2013)) and so we encourage designers to make changes to the WEI. The erasers of the OH pens enable reacting dynamically to new developments.

13.3.5 Using the Wheel

The WEI can be used in two different ways; in a workshop setting or as an extension of a persona. During a workshop, the tool supports the participants in engaging with the results of user research and gaining a deeper understanding of user routines and needs throughout a timespan defined by the designers. This understanding can empower designers to create insights regarding possibilities for potential interactions, which in turn can be used to inspire ideas for a design solution. There is no specific workshop structure in which to use the WEI; we believe that one of its strengths is its versatility to be used in various settings and contexts. The tool is also adaptable to a specific design context when required.

The other way to use the WEI is as a companion for a persona. The insights created through the means of the wheel can add more depth to the story of the persona, and a deeper understanding of user needs. Attaching a completed WEI to a persona can serve as a reminder for designers to keep temporality in mind when designing everyday interactions. We envision that completed time mapping wheels can accompany designers through the entirety of the design process together with the respective personas.

Table 13.1: Participant overview for the evaluation workshops.

Group	Participants	Programme	Age	Gender
1	7	PhD and Master in HCI	24–37, $M \approx 27.6$	4 M, 3 F
2	10	Master in IxD	24–31, $M \approx 26.3$	5 M, 5 F
3	10	Master and Bachelor in CS	19–22, $M \approx 20.6$	6 M, 3 F[2]

13.4 EVALUATION

In order to explore the possibilities offered by the WEI and verify if it performs well in practice, we conducted three evaluation workshops where we used the WEI to engage in the temporal aspects of interaction. We decided to conduct and analyse multiple workshops as they have been successfully used to evaluate HCI tools before (Ledo et al., 2018). Further, workshops offered the opportunity to examine in detail how users perceived and used different parts of the WEI.

13.4.1 Participants

Altogether, 27 students at different educational levels participated in the study. The participants were recruited through contacting external universities which offered programmes that taught students who could be potential users of the WEI. All the participants were external to the authors' institutions, and the authors had no prior acquaintance to the participants. As an incentive for their participation, they received access to the toolkit as PDFs. Snacks and drinks were also provided throughout the workshop. Additionally, workshop two was conducted on the opening day of a conference and participation enabled entering the opening reception. Participants were asked to work in groups of three to five. Table 13.1 provides basic information about the participants.

13.4.2 Workshop Procedure

In order to evaluate the Wheel of Everyday Interactions, we engaged participants in WEI workshops. The workshops were to emulate a design scenario where designers would need to create solutions for users for whom temporality is particularly important. To that end, we created a hypothetical design case where an airline wanted to increase employee satisfaction and contracted designers to design systems for air crews. The description distributed to the workshop participants read:

2 One participant decided to not disclose their gender.

> *AirBenin has been struggling with cost efficiency for quite a while. To combat this, they decided to limit plane turnaround times and introduced a more competitive schedule. This, however, affected the working hours of the pilots and put more pressure on them. As a consequence, pilots began to report that the new schedule put a strain on their family lives as it was difficult to coordinate their availability.*
>
> *While the new schedule cannot be changed for business reasons, AirBenin is determined to improve the work experience for the pilots. The airline wants to design a new tool that will help pilots stay in touch with their friends and family. This is where you step in.*

The choice of case was motivated by the fact that past research identified that airline personnel were often heavily concerned with time pressure and the work organisation made it hard to maintain well-being (Yoon, Pohlmeyer & Desmet, 2014). Participants were free to choose particular details of the case such as the type of employee to focus on or specific information about schedules. Given that workshops needed to be limited in time, we informed the participants that they should assume they would have completed extensive user research prior to the workshop. As all participants had interaction design experience, such an approach enabled us to explore if the WEI was suited to be integrated in a dynamic design process.

All three workshops followed the same structure. We began with a short introduction (5 minutes) and continued with a warm-up exercise, a picture association task that encouraged introductions and gave every participant an opportunity to speak to the workshop participants (5 minutes). This was followed by a short explanation of what the workshop was about and the introduction to the design case on which the participants would focus throughout the workshop (10 minutes). Afterwards, we asked the participants to create two personas based on the design case presented (20 minutes). The participants then mapped the days of the two personas with the WEI (20 minutes, shown in Figure 13.1, left). Subsequently, the needs overlay was used to map the psychological needs of the two personas. Copies of the need descriptions in the work by Hassenzahl et al. (Hassenzahl et al., 2015) were available for reference (10 minutes).

This task was followed by a 15 minute break. The first task after the break was a combined analysis of the two time mapping wheels of the two personas (10 minutes, shown in Figure 13.1, right). The aim was to shift the focus from the individual level to the collective level and to gain insights regarding opportune moments for communication for the specific design case. The common time slot selector was used to support the workshop participants with this task. The combined analysis of the two personas (the two time mapping wheels) was followed by an open-ended *insight combination* (Kolko, 2011) exercise

(minimum 10 minutes). Finally, the workshop was concluded with a short wrap-up and an open reflection round. This way, in two hours, the workshop offered a simplified journey from early user research to initial design ideas. At the end of the workshops participants were asked to complete evaluation sheets.

13.4.3 Measures

Using evaluation sheets, we administered the Positive and Negative Affect Scale (PANAS) (Watson et al., 1988) to evaluate the affect of the workshop participants towards the WEI. We chose to use the PANAS as it offered a rapid evaluation of the participants' initial reactions to the WEI (Nass & Brave, 2007) on a scale from 10 to 50. This, in turn, offered the opportunity to perform an initial check of whether the WEI and the accompanying instructions were provided in an approachable and clear form that produced a positive impression. The PANAS scale offered an objective assessment of whether the first impression of the tool was positive enough to offer the potantial of being integrated in a design process. Furthermore, we asked the participants to briefly note their answers to open questions regarding the experience with the WEI; if the WEI enabled them to effectively map the activities of the users and helped them to engage with user needs. In addition, one researcher made notes while the second researcher moderated the open reflection round.

13.4.4 Qualitative Analysis

We used thematic analysis (Blandford et al., 2016) to understand the qualitative data gathered during the workshops. All answers to the open questions as well as the notes from the open reflection round were transcribed verbatim and imported into the Atlas.ti analysis software. The two authors coded a representative sample of 15% of the material using open coding. Next, a coding tree was established through iterative discussion. The remaining transcripts were coded in parallel by the two authors. The interrater agreement was satisfying (Cohen's $\kappa = .87$). In a final discussion session we grouped codes and revisited parts of the material to discuss commonalities in codes. We then identified emerging themes that describe the participants' experience of the workshops and their opinions of the WEI.

13.4.5 Results

In this section, we present the results of the evaluation of the WEI. First, we report general impressions of the tool, both in terms of PANAS scores and qualitative remarks. We then discuss details of how

users experienced working with the WEI by presenting the findings of the qualitative analysis.

13.4.5.1 *PANAS Scores*

Average PANAS scores indicated that the workshop participants reported high positive affect ($M = 35.48$,$SD = 13.52$) and low negative affect ($M = 4.45$,$SD = 4.18$). Next, we investigated if there was any difference in the affect connected to the three workshops. Two one-way ANOVAs revealed no significant effects of which workshop the participants were assigned to on positive ($F(1, 25) = 0.003$, $p > .05$) or negative ($F(1, 25) = 2.459$, $p > .05$) affect.

13.4.5.2 *General Qualitative Feedback*

Participants reported that they found the WEI approachable and easy to use. The majority of the tool feedback regarding the overall experience with the WEI was positive. The participants commented that the visual features of the WEI enabled efficient mapping of activities throughout the day. One participant remarked about the colour coding of the rings:

> *The tool is interesting and fun to use. I really liked the visual aspect of the WEI. It manages the information in a way that is easy to understand and clear, so it doesn't even have to be explained to others. (WS2, F25)*

Further, participants reported that the approach using multiple rings and overlays introduced structure to the design process and provoked reflection. After using multiple rings to try different time divisions, one workshop participants commented:

> *(The WEI is) interesting, useful... gives structure to think what happens throughout a day with (user) needs in mind. (WS1, F27)*

13.4.5.3 *Themes*

Thematic analysis revealed four themes that describe the participants' usage of the WEI: Temporality, User needs, Social interactions and Suggestions for improvement.

TEMPORALITY Participants commented on how the WEI enabled them build a comprehensive temporal map of the users' day. The rings were perceived as allowing flexibility in mapping:

> *We could divide the whole day on our own, we could choose our scale and decide how 'long' the day should be. (WS3, F21)*

Further, we observed how participants used the wheel to spot opportune moments efficiently. They used the visual presentation form

provided by the WEI to discover unexpected insights or reveal temporal patterns that they did not anticipate:

> *It was interesting to see when and during what time of day people's availability overlaps. (The WEI) unveils the everyday behavioral patterns and allows an extended analysis of these. (WS1, F27-2)*

Finally, participants saw the WEI as a way of externalising their understanding of the users' perspective of time and thus avoiding the bias of their own perception of temporality:

> *(The WEI was) very helpful to tap into different perspectives, because the researcher is often influenced by his/her own personality and life style. (WS2, F31)*

USER NEEDS A key design goal of the WEI was to empower designers to effectively empathise with users from a temporal perspective. Participants reflected that performing the activities associated with the WEI enabled them to build an in-depth understanding of the user needs in a temporal perspective:

> *I had a clear overview on the day of the user and I could easily understand what needs were met and which were not and to what extent they were. (WS3, M20)*

We further observed participants connect the different psychological needs to events in time and thus appreciating a temporal perspective of how a user's needs were fulfilled:

> *Mapping needs to different times of the day and, in turn, to different parts of an activity provides useful insights into how activities and needs change over time. (WS2, M27)*

Participants also remarked that the explicit marking of user needs required by the WEI facilitated discussion within the design team. One participant commented on how the wheel facilitated sharing ideas with the other members of their group:

> *The wheel enables thinking about the different steps involved in a day and visualising the related needs. It was easy and enabled me to discuss the steps and thoughts with the others (in the design team). (WS1, F37)*

SOCIAL INTERACTIONS Another theme that emerged in our analysis describes the way participants used the WEI to better understand and generate ideas about the interactions between the multiple users for whom they were designing. One participant reported that the WEI provided an overview of opportune moments for interaction:

> *It helped me get an overview of the connections between the two persons. (WS2, M26)*

The WEI enabled users to find overlapping time slots for potentially fostering interactions between users:

Overlapping time slots can be identified easily. (WS1, M25)

The participants also appreciated how the time selectors and the visual alignment of the rings in the WEI enabled them to better navigate simultaneous activities between multiple users:

Doing it using the overlapping circles gives nice insights into the activities of both users at the same time. (WS3, M22)

As the WEI presents the actions of multiple users in parallel, it enabled participants to get a better overview of how activities intertwine and relate to each other.

SUGGESTIONS FOR IMPROVEMENT Workshop participants also shared suggestions on how to improve the WEI. Firstly, some WEI workshop attendees asked for more structure and direction to map the activities of the user. This contrasted with other participants appreciating the freedom of choosing a time flow suitable to the task at hand, as seen in the TEMPORALITY theme. One participant remarked:

It was helpful. But having marked time-slots could be good. Like 9–10, 10–11, etc. (WS1, F27-3)

Concurrently, the circular form of the WEI drew a strong analogy to a 12-hour clock for some participants and it was difficult for them to not think about time in a structured manner:

I think it would be easier if it were a clock. If the moon were illustrating midnight, so that the mapping between persons would be easier. (WS1, F27-2)

Finally, participants remarked that the psychological needs used in the model were complex at times and it may have been difficult to adopt the user's perspective in some situations:

Sometimes his needs are hard to get, it's more guessing if he needs, maybe, more sleep but we don't know that! (WS2, M27-2)

13.5 DISCUSSION

Our results show that the WEI performed well in an interaction design education setting. PANAS scores have shown a generally positive response, which indicates that the WEI is approachable and it can be effectively explained to students in a two-hour workshop. However, the limitations of the PANAS instrument, the novelty of the tool and the designerly enthusiasm of the students need to be acknowledged. The better-than-average result on the PANAS scale shows that the WEI offers visual appeal and it is approachable. Based on the PANAS scores and the general qualitative feedback, we believe that the WEI can be rapidly introduced to design teams and offers an easy learning curve.

Our thematic analysis showed how the workshop participants were able to use the WEI. We observed students actively engaging with USER NEEDS and considering the details of TEMPORALITY in everyday interactions. Qualitative data indicated that the participants appreciated the clearly marked and named needs, however some users found the concepts overly complex. Thus, data in the USER NEEDS theme indicates that using the WEI effectively may require engaging with psychological knowledge in detail. This, in turn, implies that design teams using the WEI may need to decide on what needs to focus prior to using the tool in the design process. Further, design teams may consider alternative needs models.

We also observed workshop participants exploring the interplay between time, needs and different users. Feedback gathered in the TEMPORALITY and SOCIAL INTERACTION themes illustrates how the WEI was an effective tool in unpacking the complexity of everyday interaction. In a way, the WEI helped to 'atomise' time into units of different size and offer multiple perspectives on the same set of activities. Shared actions and communication between the users for whom the participants were designing were made explicit. Consequently, the WEI offers opportunities to effectively identify time points for possible design interventions that enrich social interactions. We see potential for using the WEI to design systems that facilitate collocated interaction (Jarusriboonchai et al., 2014; J. Fischer et al., 2016) or help maintain social bonds (O'Hara, Massimi, Harper, Rubens & Morris, 2014).

Interestingly, workshop participants were split on whether or not the WEI should include an explicit time scale, as observed in the TEMPORALITY and SUGGESTIONS FOR IMPROVEMENT themes. We believe that this presents both a threat and an opportunity for designers. The WEI could be augmented with a specific precise (e.g. minutes, hours or days) time scale to be applied to very specific tasks. For example, one could use it to design for workplace interaction in factories where work time is strictly controlled. Further, as some users remarked, a time scale would provide reference and help align the wheels for multiple users. On the other hand, a specified time scale may limit creativity and impose a linear perception of time.

In the light of Lundgren's (Lundgren, 2013) work, such a focus on linear time flow could significantly limit the perceived design space and eventually lead to fewer ideas. Consequently, we encourage the users of the WEI to experiment with time scales and use time mapping wheels with their custom scales. Our printout template contains notches on the wheels that provide general guidance, but they are light enough not to impose a scale. We wonder how designing with the WEI can benefit from applying Lundgren's (Lundgren, 2013) Temporal Themes. For example, the WEI can support sequencing events of designing for branched versions of time. One idea to extend the

WEI would be to provide different versions of the tool that use different time scales or even discrete segments that could be repositioned like puzzle pieces. Finally, we see an opportunity for rings to be augmented to promote thinking about time in different ways as suggested by Lindley (Lindley, 2015).

While we believe that our work shows that the WEI is a tool that is likely to contribute to the design process, we recognise that this work is prone to certain limitations and possible changes as indicated in SUGGESTIONS FOR IMPROVEMENT. We chose to evaluate the WEI in an academic setting. Consequently, we are unsure how it can affect longer design processes. In future work, we would like to investigate how practitioners can use the WEI effectively. Further, we recognise that our current graphic design of the toolkit is limited to three users and needs sourced from Hassenzahl et al. (Hassenzahl et al., 2015). In the future, we plan to explore if the WEI can be applicable to bigger user groups and incorporate mapping other concepts, e.g. hedonic and eudaimonic well-being (Deci & Ryan, 2008). This, in turn, raises the question of how the WEI would perform in different application domains. In future work, we plan to explore possible domain-specific extensions to the wheel, e.g. its applications to personal informatics or computer-mediated communication, where it can be used to identify when users interact with personal trackers or communication tools. Finally, we recognise that possible alterations to our workshop methodology could affect the results of the presented evaluation. We chose gathering written feedback to encourage objectivity, but interviews would have given us the opportunity to ask more specific questions about the WEI.

13.6 CONCLUSION

In this paper, we introduce the Wheel of Everyday Interactions; a design tool that helps with engaging with users' everyday interactions. The WEI is available as a downloadable toolkit. To use the WEI, designers map the user's actions onto coloured rings, map how basic psychological needs are fulfilled using needs overlays and identify opportune moments for interaction using the common time slot selectors. The wheel supports a deep engagement with the temporality of everyday interactions. Our tool is designed as a method for synthesizing user research during design sprints. It can also be used as a temporal companion to a persona. This paper reported on three evaluation workshops for the WEI. We found that workshop participants perceived the WEI positively and reported that it was easy to understand and enabled them to engage with the temporality of interactions.

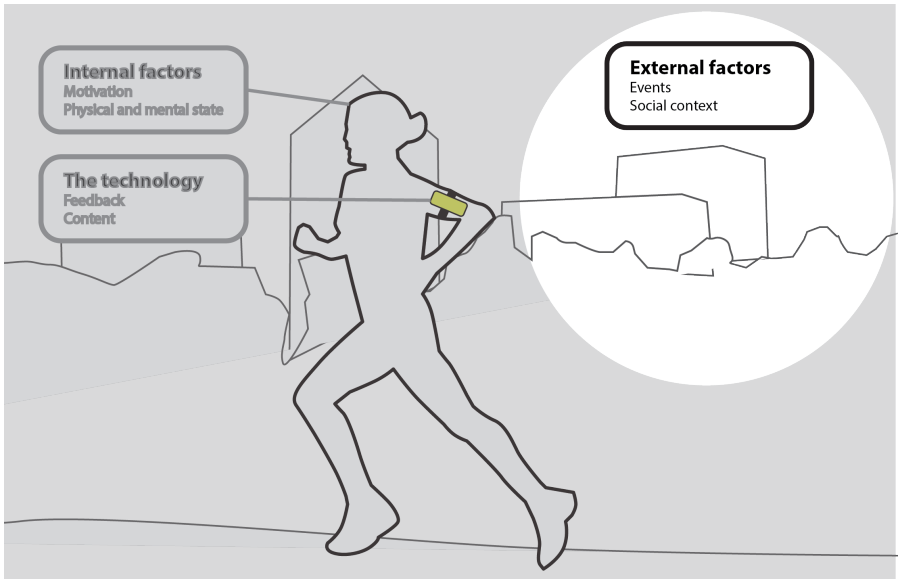


Figure 13.3: Influencing factors for designing self-improvement and well-being technologies with a focus on external factors

It is our hope that researchers and practitioners will be able to use the WEI to better understand their users and, consequently, design systems that fit well in the users' lives. We also hope that the WEI can be used in interaction design and computer science teaching to help students learn to embrace the user perspective while building new systems.

13.7 SUMMARY

The context of interacting with self-improvement technologies was the focus of papers VII to IX, see Figure 13.3. I believe the work presented here shows the complexity of embedding technologies for well-being in everyday life. On the other hand, the works above indicate that studying the social, temporal and cultural context of technologies is a key success factor when technologies for well-being are to be engaging.

Part III

DISCUSSION

14 DISCUSSION

This thesis is situated at the cross-section of psychology and Human-Computer Interaction. In the first part of this thesis, I set the scene for the subsequent inquiry. I showcased that technologies became ubiquitous in everyday life and can potentially provide the means to support their users in their everyday and beyond (Schmidt et al., 2012). Furthermore, I remarked that the digital revolution that the global society is witnessing today comes with chances and challenges that may change life for the better on a global scale (Sellen, Rogers, Harper & Rodden, 2009). However, if we want to study how people interact with computers, interactive technologies are the study object and, at the same time, they are needed as a means to study these interactions. In other words, they are the interlocutor as well as the tool to study Human-Computer Interaction. Consequently, an in-depth understanding of the intricacies of human attitudes, perceptions and behaviour towards these tools and the processes while interacting with technology is needed for sensible, meaningful and ethically justifiable technology design decisions and sound research inquiries.

Hence, the superordinate objective of the present thesis was to acquire knowledge about the psychological factors that come into effect when humans interact with self-improvement and well-being technologies and to extrapolate ways how these insights can be utilised to enrich such interactions to foster long-term engagement.

14.1 DISCUSSION OF THE RESEARCH QUESTIONS

More precisely, the aim of the present thesis was threefold. The first step of our investigation focuses on the exploration of the communication style of interactive technologies for self-improvement. We inquire if the communication style of interactive technologies for self-improvement can be perceived by users and how variations of the communication style affect psychological outcomes, such as affective response (**RQ 1–3**). The second research objective focuses on investigating ways to design psychologically-founded feedback and ways to account for evolving goals and to communicate goal attainment or failure. For instance, we explore if the principles of the Construal Level Theory can be utilised to formulate meaningful feedback of self-improvement tools (**RQ 4–7**). The third aim was to inquire how feedback can be adapted to a specific context of use in meaningful

ways. This aim is more application-oriented than the other two aims of the present thesis (**RQ 8–9**).

14.1.1 Psychological Consequences of the Communication Style of Interactive Technologies for Well-Being and Self-Improvement

The first element in our inquiry focused on the communication between the interactive technology for well-being and self-improvement and its user. Our results show that users are perceiving the interaction with their technology as a form of communication (**RQ1**) (Niess & Diefenbach, 2016). Furthermore, we found that users are able to differentiate between different communication styles of their interactive well-being and self-improvement tool (**RQ2**) (Niess & Diefenbach, 2016). The varying communication styles seem to be connected to distinct emotional and motivational consequences, such as a more positive evaluation of experiences when interacting with a device that utilised the friendly communication style (see paper I, III), a significant difference regarding the number of training sessions participants reported (participants in the friendly communication style condition reported a higher number of training sessions, (see paper II) or higher goal commitment, when interacting with a device that utilised the friendly communication style (see paper III).

To summarise, our findings demonstrated that users are able to differentiate between different communication styles of technologies for well-being and self-improvement and that these communication styles seem to be connected to motivational and behavioural concepts. As a consequence, the communication style of an app that supports self-improvement is a necessary factor to be considered in designing future technologies.

A potential starting point for further research is to explore the applicability of our findings to other facets of the communication of well-being technologies. Since our research was mainly based on models with a focus on the communication between two human interlocutors, such as exploring if these theories and findings can be adapted to human-technology communication in a meaningful way, one could argue that another possible starting point for future research could be a more technology or media oriented focus. A more technology-inspired approach could be utilised to support envisioning what is possible and use these visions as a means to generate ideas (Fjeld, Woźniak, Cowls & Nardi, 2015). One viable angle could be to imagine what well-being technology could do in the future. Another viable angle could look into previous work that investigated the characteristics of communication media and how these characteristics might influence interaction. One of the oldest and best known theories that explored the characteristics of communication is Media Richness

Theory (Daft, Lengel & Trevino, 1987; Daft & Lengel, 1986). Based on Media Richness Theory, media can be differentiated based on their richness (Daft & Lengel, 1986; Daft et al., 1987). Richness is referring to the ability of the medium to foster mutual understanding between the communication partners. The theory further explains that, if there are various possibilities of interpretation, a richer medium is needed than if, for instance, the task is solely to pass on simple information. The richness of the medium is assessed based on the following criteria: feedback, multiple cues, language variety and personal focus. Instant feedback allows for direct interaction and instant communication. Multiple cues refer to stimuli a message can include, such as gestures or symbols. Language variety is the meaning communicated through language symbols (e.g., the meaning of numbers is usually more precise than natural language). Personal focus is referring to the adaption of a message while considering the needs and the current situation of the receiver.

If we apply the insights of Media Richness Theory to the dialogue between interactive technologies for well-being and self-improvement the medium simultaneously transforms into the interlocutor and the transfer medium. In other words, the medium and the interlocutor merge to one entity. Consequently, the technology eventually would have humanoid qualities or the interactive coach would have technological characteristics. The possibility to transform an interactive technology into a coach or advisor with humanoid qualities is supported through our research and previous work in the field of HCI (Niess & Diefenbach, 2016; Diefenbach et al., 2016; Fogg, 2002; Nass et al., 1994). Our research touched on the dimensions feedback, language variety and personal focus. However, combining the insights with Media Richness Theory would lead to a variety of further research questions. For instance, future research could investigate the effect of language symbols on psychological reactions in the context of well-being technologies. One can investigate if it is possible to craft the communication style of interactive technologies based on language symbols and visualisations and which psychological consequences this entails.

Initially, the Media Richness Theory aimed to explain the effectiveness of communication media. This leads to the question: how effective communication can be defined? One could say that good communication is when it supports cooperation. But this, in turn, leads to the question of autonomy in the process of behaviour change. This could refer to the cooperation towards the technology. Consequently, one would assume that the technology knows what the user needs. But the question remains if the user wants the technology to make him- or herself feel good, to support him or her to make healthy life decisions, to help the user pursuing the goal they have set for themselves, even when it might be unhealthy, or to satisfy the need

for empathy, comparable to a therapist or a sympathetic coach. Since empathy is communicated in more than one channel (Haase & Tepper, 1972) future research can investigate if a variation within the dimensions based on the Media Richness Theory (Daft & Lengel, 1986; Daft et al., 1987) affects how the interaction is perceived by the user.

14.1.2 Crafting psychologically founded feedback content

Paper III focused on utilising psychological knowledge to build an understanding of the ways of communicating goal attainment, failure and general fitness advice. Our results show that Construal Level Theory (Trope & Liberman, 2010) can be adapted to communicate feedback in positive situations, such as goal attainment (**RQ 4**). In these situations, a more abstract level of construal increased goal commitment and a more positive affective response. More precisely, we found that fitness feedback that was formulated in more abstract terms (e.g., reaching your fitness goal of taking more steps) compared to feedback formulated in more concrete terms (e.g., reaching your fitness goal of taking 8000 steps) led to increased goal commitment and more positive affect.

Regarding negative situations, our results were partly contradictory to previous work and our assumptions. In line with our assumption, we found that the friendly communication style led to a more positive affective response in the negative situation of failure. In the negative situation of failure, the friendly communication style had no significant effect on goal commitment. Interestingly, our results show that a more concrete construal significantly increased goal commitment in negative situations of failure.

Furthermore we found that not surprisingly, failure to achieve a goal was correlated with a decrease in positive affective response and decreased goal commitment, compared to a positive situation, such as goal attainment (**RQ 5**). Moreover, our results indicate that, due to the varying emotional cost of negative and positive experiences (Weiner, 1985), goal achievement and failure should be communicated in different ways. However, since we mainly conducted qualitative research and explored hypothetical goals in empirical settings, future research is needed to derive more specific implications.

On another note, in addition to the need to communicate goal achievement and failure in different ways, we found explaining how a fitness goal was computed can also have a positive effect on outcomes relevant for technology-supported behavioural change, such as goal commitment. Hence, based on our results, we would argue to consider disclosing how a suggested tracker goal was computed. This resulted in significantly increased goal commitment and perceived transparency of the system (see paper V, **RQ 6**). Further, based on our results, we would suggest clear visualisations, when communicating

unmet goals (**RQ 6**). Uncertainty, which can be connected to more abstract construal, can have negative effects (Greis, Ohler, Henze & Schmidt, 2015) and is therefore not recommended in situations of failure. Uncertainty can, for instance, be caused by radial bar charts (see paper VI).

Regarding the connection between hedonic and eudaimonic well-being goals we found that users have a need for the self-improvement tool supporting them in relating their eudaimonic goals (such as feeling energetic and healthy) to their hedonic goals (such as eating tasty ice cream) in a meaningful way. For instance, the technology could support the user to balance their need for momentary pleasure (e.g., taking a relaxing bath instead of working out) and eudaimonic fulfilment (living an active, healthy life) through displaying the momentary benefits of both actions and connecting them to superordinate goals, such as being less stressed or being more active. Furthermore, since current technologies mainly focus on quantitative, numeric goals, there is an emergent need to support users on their way to enhanced well-being through enabling them to see the bigger picture (e.g., eudaimonic well-being goals). These findings can be connected to Construal Level Theory. Eudaimonic well-being goals show similarities to superordinate, high level goals (Trope & Liberman, 2010), which can enable people to see the forest instead of focusing on the trees, or in other words, why they should not eat more ice cream (i.e., hedonic goal) when their superordinate well-being goal is to make healthier nutrition choices (**RQ 7**).

Even though our results indicate that communicating failure in the context of self-improvement technologies in ambiguous ways might trigger rumination, we assume that there is merit in designing ambiguous information or feedback for behavioural change (Baumer, 2015). When designing ambiguous feedback for well-being and self-improvement, we suggest to differentiate between the temporal and physical context of the reflection process and what one is reflecting upon.

Another potential way of fostering engagement in well-being and self-improvement technologies might be ludic design (W. W. Gaver et al., 2004). The majority of current well-being and self-improvement technologies operate within an achievement frame. Such technologies have a defined meaning. In contrast, ludic design should de-emphasise the pursuit of external goals and maintain openness and ambiguity, while promoting curiosity, exploration and reflection. Consequently, ludic design emphasises playful exploration. Hence, one could assume that the ludic and the rationale behind self-improvement technologies (i.e., goal-oriented and focused) contradict each other. The question remains, however, if it is possible to successfully implement ludic elements in the design of self-improvement technologies. This in turn can be seen as a misuse of the original intention of Gaver when he

introduced the concept of ludic design. However, if we draw on lessons for ludic design discussed in the Drift Table (e.g., 'Allow the ludic to be interleaved with everyday utilitarian activities') it is the next step, since game, playfulness and uncertainty can support learning (Piaget, 2013).

At a first glance, the rationale of ludic design to offer multiple meanings (Sengers & Gaver, 2006) contradicts the rationale of well-being and self-improvement technologies. Users of technologies for self-improvement usually pursue one specific target (e.g., losing weight). Hence, one could explore offering the user multiple ways to pursue a specific goal (e.g., losing weight) and how these multiple options to pursue the goal might affect user engagement.

Another potential question for future research is to explore how unpredictable or ambiguously designed technologies might affect the perception of psychological qualities of these technologies. Short and colleagues explored how humans perceive cheating robots and found that ambiguous behaviour motivated people to make sense of the technology and that it lead to humanise the robot more (Short, Hart, Vu & Scassellati, 2010). Since experiencing the transience of human behaviour is a very human experience in itself it might is not a possibility but a necessity to integrate planned inconsistencies into the design of technologies for behaviour change. Acquiring self-knowledge might can only be achieved through tacit knowledge accumulated through years of uncertainty.

14.1.3 Adapting feedback to context

Paper VII, VIII and IX of our inquiry focused on ways to build an understanding of temporal and contextual factors of the usage of well-being and self-improvement technologies. We observed different contexts of use and developed a tool that could support engaging with users everyday interactions (**RQ8**). Our exploration of assistant technologies in work and private contexts showed that there are two types of digital companions (active and passive). These two types of digital companions are equally important and form a continuum rather than a dichotomous variable. People ascribe specific characteristics two these companions types and these characteristics are connected to psychological need fulfilment (**RQ 9)**. Furthermore, digital companions can assume different roles and the preferred role may depend on the context of use. Hence, making a design decision regarding the appropriate companion type for a specific situation and designing the role of the digital companion (e.g., supervisor) in a consistent way can lead to need fulfilment and a more positive experience with the technology.

Our inquiries emphasise the need to choose an appropriate method for the specific inquiry. This is a general research paradigm, but all the

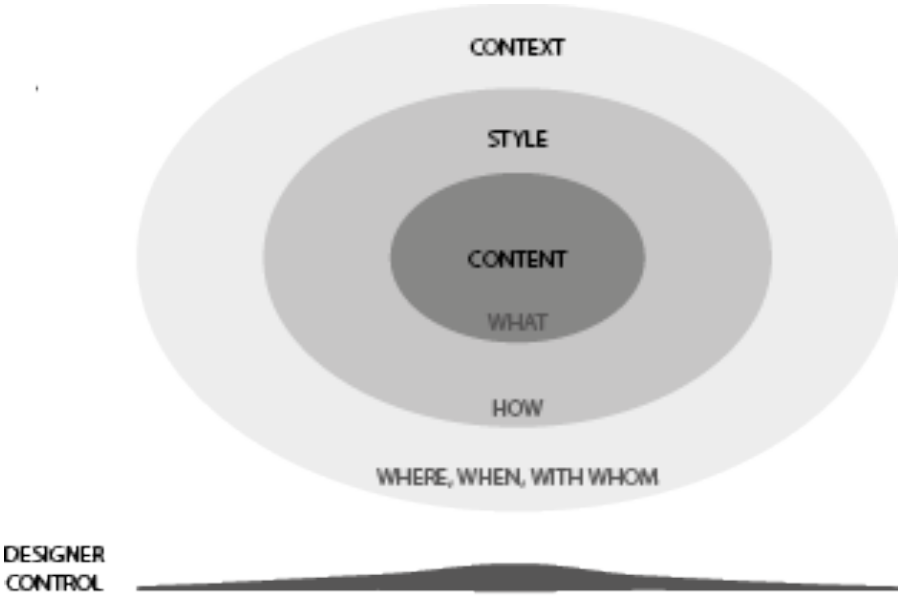


Figure 14.1: The three dimensions for designing meaningful feedback for well-being and self-improvement technologies

more important if one strives to acquire meaningful insights regarding a specific context of use. If an inappropriate study design or methodological approach is chosen, it can potentially lead to questionable results regarding their validity or difficulties with the data collection arise (see paper VII, different sampling methods). If a method is chosen for a specific context of use, this can mean that these results are not generalisable and difficult to interpret. We feel that this weakness can be utilised as a strength. Instead of striving for generalisability of these results one could derive lessons learned for context-sensitive inquiries that can be applied to similar studies in the future (Foucault, Russell & Bell, 2004).

Technologies have a social as well as a cultural meaning (Bell et al., 2003). Humans define themselves through the objects they make and use. Homo faber, the maker and user of objects shapes the objects he or she uses and the objects shape him or her in return (Csikszentmihalyi & Halton, 1981). Consequently, an object might assume a new meaning when utilised by another user. This, in turn, means that the context is always a factor.

14.2 GENERAL INSIGHTS

In this section, I will summarise and discuss the main insights of the present thesis (see figure 14.1). These findings can provide meaningful starting points for further research in psychology and HCI and support the design of sensible, inclusive self-improvement and well-being technologies. Note however, as discussed in the introduction, the

interpretation of these results should be made cautiously. Behavioural change is a complex, long-term process and it was beyond the scope of this thesis to account for this factor. Nevertheless, our exploration provides initial insights on how psychological theory can potentially enrich the understanding of well-being technologies.

Communication style is a concept based in psychological theory that can be applied to design feedback in technologies for well-being and self-improvement. We found that different styles a technology uses to communicate goal attainment, failure or general feedback can be differentiated by users.

Since communication style can be seen as an umbrella term that combines insights of related concepts and theories, such as affective tone and feedback (Fishbach & Finkelstein, 2012), we hypothesise that the communication style of interactive technologies for well-being and self-improvement could potentially be utilised as an actionable concept for future research and practice. Especially at the intersection of different disciplines, clear and intuitive terms can facilitate cross-disciplinary dialogue, support cooperation and collaboration and lead to better long-term results (Shneiderman, 2016).

Moreover, we found that the mechanisms of Construal Level Theory (Trope & Liberman, 2010) can partly be transferred to fitness scenarios. Furthermore, they can be utilised to design ways to communicate goal attainment and failure. In line with previous findings, our results showed that a more abstract construal fostered a more positive affective response and supported goal commitment, in positive scenarios (see paper III). This can be connected to the findings of the Tracker Goal Evolution Model (see paper IV) that showcased that numeric goals don't seem to be sufficient to foster long-term engagement. A connection to qualitative, superordinate goals, similar to goals phrased in a more abstract construal seem to be essential for long-term engagement.

The understanding of how a fitness technology works can potentially foster goal commitment and perceived transparency of the device. This in turn may foster trust in the device. A potential question for future research would be to explore the role of initial trust in technology. We found indications that general trust in technology might positively influence the subsequent interaction process. One could draw parallels between this, admittedly valid, assumption and findings from other areas of research. For instance, in the extended slippery slope framework of tax compliance, Gangl and colleagues showcased the relation between trust and legitimate power and how these concepts might lead to cooperation (Gangl, Hofmann, Pollai & Kirchler, 2012). If we adapt these insights to our findings, one could hypothesise that novel users start the interaction with a leap of faith (implicit trust), but this foundation of trust has to be maintained over time (reason-based trust). Simultaneously, trust is connected to legitimate power (in our

case the power and autonomy we allow the device) and the interplay of power and trust might lead to cooperation in the well-being or the self-improvement context.

Furthermore, our results indicate that uncertainty or ambiguity does not necessarily foster reflection. More precisely, our study showed that interpretative visualisations of unmet fitness goals can trigger rumination. Future research can investigate to communicate feedback in ambiguous ways in different situations, such as positive situations (e.g., goal attainment), negative situations (e.g., failure) or neutral situations (e.g., no achievement focus).

Interacting with tools shapes the tools and the users alike (Csikszentmihalyi & Halton, 1981). Technological artefacts can embody our needs, our goals and have the ability to shape our personality. Hence, in order to understand technology usage one has to build an understanding of the specific context of use.

Building an understanding of how the technology is situated within the context is key for long-term engagement. I hypothesise, that it is feasible to build an understanding of the user, the tool and the specific context. I emphasise however, that, comparable to an iterative design process, researchers should critically reflect if the methods they applied are the right ones for the context of use they are investigating.

I believe that the lessons learnt from these 'failures' (for the lack of a better word) are already providing valuable knowledge about the researched context.

In conjunction with the previously discussed findings, we found that assistive technologies can turn into a companion technologies through embodying psychological qualities and sensible, context-aware design decisions. Future research can investigate psychological consequences of designing ambiguous or somewhat confusing companion technologies. Based on previous work (W. W. Gaver et al., 2003; Greis et al., 2015), this might lead to uncertainty and dissatisfaction or to positive outcomes such as sensemaking or critical reflection (Baumer, 2015).

14.3 UNANSWERED QUESTIONS

The studies within this thesis are prone to certain limitations and leave certain questions unanswered.

14.3.1 Mixed-Method Design

We conducted a mixed-method inquiry focusing on qualitative explorations in the field, longitudinal studies and online-experiments in more controlled settings. However, one could have also chosen another approach, such as focusing on one of these types of inquiry instead, utilising a pure qualitative or a pure quantitative approach.

We recognise that this, in turn, could have led to different results. In line with Patton (Patton, 2005), we believe, that subjectivity, when conducting qualitative research, is to some extent inevitable and can be transformed to a strength in order to generate an understanding of experiences.

14.3.2 Sampling

While we did try to acquire balanced samples in terms of age and gender, a question that remains is how our results would have looked like if we had recruited different samples. Questions regarding the samples of our studies that could be addressed in future research concern experience of our participants; more precisely the experience with well-being and self-improvement tools as well as their self-improvement experience, such as fitness level. Another question for future research related to our participant groups is about the user group we would desire to learn more about. We think that there is merit in the approach we chose, namely investigating classic groups of participants (Spiel et al., 2018), utilising convenience samples and recruiting specific groups of participants. Since we are aiming for multifaceted starting points for further inquiry in research and practice we think that our approach allows for broad, insightful exploration and inspiration. But we acknowledge that a more controlled and uniform approach to recruiting makes for a valid investigation for future research.

14.3.3 Measures

The quantitative inquiries within this thesis focused on psychological measures such as reflection, rumination and goal commitment. They explored behavioural outcomes such as self-reported training sessions or the length of training sessions. In psychological research and HCI, scholars are confronted with a large variety of available scales and measures. We selected our measures and scales based on psychological theory and previous empirical findings. However, we do recognise that our selection is, due to the limited scope of this thesis, limited. One could argue that we could have also investigated other dependent variables, such as self-determination or motivation. Studying our findings and adding additional measures to the study design is an interesting question for future research.

14.3.4 Persuasion

Research in psychology and HCI has discussed a variety of criticisms related to behavioural change and persuasive technology (Yetim, 2013). One of the main challenges in this research area is the need to inves-

tigate long-term adoption and change, in order to be able to make statements with high ecological validity. However, due to the available resources (or the lack thereof) and the resulting nature of the majority of studies in this area, investigating long-term change proves to be difficult. With some notable exceptions (such as (Fritz, Huang, Murphy & Zimmermann, 2014)), the field mainly utilises cross-sectional studies or short term explorations. Nevertheless, we can observe critical reflection within the field about these challenges (Mutsuddi & Connelly, 2012; Truong, Kientz, Banerjee, Brush & Mahajan, 2015). Thus, we believe that the challenge here is not to motivate scholars to conduct longitudinal studies but to provide the means and the incentives to do so.

14.3.5 Generalisability

In this thesis we started with a very broad exploration of a variety of different self-improvement and well-being technologies. As a next step we limited our scope to mobile fitness applications and fitness trackers. Subsequently, in paper VII, VIII and IX we broadened our focus again to investigate contextual factors of well-being and self-improvement tools. As we have already addressed at the beginning of this thesis, our aim was not to provide broad, generalisable results that can be sold as the solution to the challenges technologies for behavioural change are facing in research and practice. Instead we endeavoured to provide a variety of puzzle pieces in order to explore the applicability of integrating psychological concepts in the design of well-being technologies in an actionable way. Moreover, we hope that we succeeded in providing inspiring starting points for designing betters systems and future academic investigations.

14.4 CONCLUSION

When we talk about behaviour change supported through technology people often assume that the technology must know. Know what is good for us, know what we need in terms of communicating feedback and know how to keep its users engaged in the long run. Hence, the tool turns into a social actor, exercising different types of power. When we talk to people in the user modelling community[1] or read their work it does not appear to be that simple after all. The almighty technology that supports us in changing our behaviour and enhances our well-being does not seem to be here yet.

Hence, we have to get active ourselves (Rogers, 2006), we are the experts of what we need and striving for (Bamberger, 2011). Tech-

1 User modelling is the process of building a conceptual understanding of the user, in order to be able to adapt technology to the user's specific needs.

nology can provide support to help us to achieve our superordinate goals (Calvo & Peters, 2014). Nevertheless, technology is not yet a legitimate authority figure, and the question remains, if we want to allow it to become one. To date, some of the means in which technology can provide to support us in our endeavours towards enhanced well-being and behavioural change are reflection, autonomy support and critical thinking (Rogers, 2006; Baumer et al., 2014; Baumer, 2015).

Furthermore, human behaviour still remains messy and unpredictable. In social interactions, such as conversations or coaching processes, the ability of the technology to learn over time seems to be essential in order to create engaging experiences (Weir, 2018).

We have high expectations towards humans and technologies. One can observe, however, that we tend to give technologies (man made devices) less opportunity to prove themselves to us. When the novelty effect of the technology decreases, the tool is often placed in the drawer (D. A. Epstein, Kang et al., 2016). Sometimes, it is placed there together with the well-intentioned well-being or health goal. In contrast, we evaluate if one training method or one trainer works for what we want to achieve and, if not, we start looking for another trainer instead of stopping to pursue our goal. Hence, the inquiries of the present thesis provide psychological starting points to inspire further research and meaningful system design. This, in turn, may lead to happier, healthier people, who are more than just more productive (Calvo & Peters, 2014). We aim to inspire the inclusive design of well-being technologies that support users to determine what they need and supporting them in their endeavour, instead of prescribing a normative ontology to become fitter, healthier and more productive as an end in itself (Spiel et al., 2018).

The multifaceted presence of technology in our everyday lives leads to the need for various different approaches to explore all the research questions that may arise due to this development. Collaborations between psychology and HCI and beyond can lead to new insights, inspire ideas and facilitate the testing of these ideas, with a variety of methods. HCI has already successfully adapted psychological theory for its work and psychology has started to acknowledge the importance of tangible, applicable knowledge about technical artefacts.

The next challenge is, however, how we can make these insights and the generative power of cross-disciplinary collaborations actionable in a meaningful and ethically justifiable way.

> *The essential source of value right now is coming less from master strategy than from broad experimentation, because no one has a complete grasp, or even a very good one, about what the next great idea will look like. (Shirky, 2010, p. 186)*

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A | APPENDIX

A.1 PAPER II

A.1.1 Pre-study questionnaire

Liebe Teilnehmerin, lieber Teilnehmer, es freut uns, dass du IMove2Improve ausprobieren möchtest. Die App ist zur Unterstützung sportlicher Aktivitäten gedacht und wurde im Rahmen eines Lehrforschungsprojekts am Department Psychologie der Ludwig-Maximilians-Universität München in Kooperation mit der Universität Stuttgart entwickelt. Deine Teilnahme ist freiwillig, du gehst dadurch keine Verpflichtungen ein. Wir versichern dir, dass alle deine Angaben vollkommen vertraulich und anonym behandelt werden und lediglich wissenschaftlichen Zwecken dienen. Eine Identifizierung von Personen ist nicht möglich. Bevor es losgeht, stellen wir dir einige Fragen zu deinen aktuellen sportlichen Aktivitäten und deinem Verhalten in sozialen Situationen. Es gibt kein Richtig oder Falsch – antworte bitte einfach spontan aus dem Bauch heraus und beachte, dass du alle Fragen vollständig beantwortest. Solltest du Fragen oder Anmerkungen haben, kannst du dich gerne unter folgender E-Mailadresse an uns wenden: move2improve@gmx.de

Vielen herzlichen Dank im Voraus für deine Unterstützung!

- Machst du gerne Sport? (5 point Likert Scale)
- Wie motiviert bist du momentan Sport zu machen? (5 point Likert Scale)
- Welche Sportarten betreibst du bisher? (Open Text Field)
- Wie häufig machst du aktuell Sport? (Open Text Field plus specification 'per month', 'per week)
- Geschlecht? (weiblich, männlich, keine Angabe)
- Alter? (Open Text Field)
- Aktuelle berufliche Beschäftigung? (SchülerIn, StudentIn, Vollzeit-Anstellung, Teilzeit-Anstellung, Selbstständig, Hausfrau-/mann, MinijobberIn, RenterIn, Derzeit ohne Beschäftigung, Sonstiges)
- Falls du an der Verlosung der Amazon-Gutscheine teilnehmen möchtest, benötigen wir noch deine E-Mail-Adresse. Diese wird unabhängig von deinen übrigen Daten gespeichert. (Open Text Field)

- Für Psychologie-Studentinnen der Ludwig-Maximilians-Universität München gibt es auch die Möglichkeit Versuchspersonenstunden zu sammeln. Dafür benötigen wir noch deine E-Mail-Adresse. Diese wird unabhängig von deinen übrigen Daten gespeichert. (Open Text Field)

Vielen herzlichen Dank für deine Unterstützung und viel Spaß mit IMove2Improve

A.1.2 Post-study questionnaire

Liebe Teilnehmerin, lieber Teilnehmer, zunächst einmal vielen herzlichen Dank fürs Mitmachen! Toll, dass du durchgehalten hast! Nachdem du IMove2Improve nun 5 Wochen lang ausprobiert hast, möchten wir dir abschließend einige Fragen zu deinen jetzigen sportlichen Aktivitäten und deinen Erfahrungen mit der App stellen. Antworte bitte spontan und beachte, dass du alle Fragen vollständig beantwortest.

- Wie häufig machst du aktuell Sport?? (Open Text Field plus specification 'per month', 'per week)
- Wie hast du die Kommunikation der App wahrgenommen? Bitte gib uns eine kurze Beschreibung. (Open Text Field)
- Haben die Push Benachrichtigungen dich dazu motiviert, mehr Sport zu machen? (5 point Likert Scale)
- Wodurch haben die Push Benachrichtigungen dich (nicht) motiviert? Bitte gibt uns eine kurze Beschreibung. (Open Text Field)
- Hat die Rückmeldung der App nach dem Eintragen deiner Sporteinheit dich dazu motiviert, mehr Sport zu machen? (5 point Likert Scale)
- Wodurch haben die Rückmeldungen dich (nicht) motiviert? Bitte gibt uns eine kurze Beschreibung. (Open Text Field)
- Wodurch haben die Rückmeldungen der App dein Wohlbefinden (nicht) gesteigert? Bitte gibt uns eine kurze Beschreibung. (Open Text Field)
- Hast du in den letzten Wochen ein kurzfristiges oder langfristiges Ziel im sportlichen Bereich verfolgt? (kurzfristiges Ziel, langfristiges Ziel, keines von beidem)
- Bitte beschreibe dein(e) Ziel(e) kurz. (Open Text Field)
- Hast du dich durch die App provoziert gefühlt? (5 point Likert Scale)

- Wodurch genau hast du dich (nicht) provoziert gefühlt? (Open Text Field)
- Hast du regelmäßig Push Benachrichtigungen erhalten? (Ja, Nein)
- Hast du die Push Benachrichtigungen gelesen? (Ja, Nein)
- Gab es während deiner Teilnahme an der Studie Zeiten, zu denen du die App nicht nutzen konntest/wolltest (z.B. Urlaub, Krankheit, Verletzung)? (Ja, Nein)
- Wenn Nutzungspause gemacht wurde: In welchem Zeitraum konntest du die App nicht nutzen (z.B. Woche 3 und 4)? (Open Text Field)
- Wie lange dauerte eine durchschnittliche Sporteinheit bei dir, bevor du die App IMove2Improve genutzt hast? (Open Text Field)
- Abschließend würden wir uns sehr freuen, wenn du deine Erfahrungen mit unserer App IMove2Improve mit uns teilst. Hier ist Platz für deine Anregungen, Lob und Kritik. (Open Text Field)
- Sammelst du VP-Stunden? Eine Bestätigung über die im Rahmen der Teilnahme erworbenen Versuchspersonenstunden kannst du im Sekretariat des Lehrstuhls für Wirtschafts- und Organisationspsychologie abholen. Bitte beachte bei der Abholung die Öffnungszeiten: Mo-Do, 10-12 Uhr, Leopoldstr. 13, Raum 3202. Bitte notiere dir folgende Infos, die du zur Abholung der VP-Stunden benötigst: Name der Studie: IMove2Improve Code: M2I Außerdem benötigst du deine E-Mail-Adresse, die du im Anfangsfragebogen angegeben hast.
- Wollen Sie in Zukunft über aktuelle Studien des Lehrstuhls für Wirtschafts- und Organisationspsychologie informiert werden? Dann geben Sie bitte hier Ihre E-Mail-Adresse an. (Die Adresse wird nur für diesen Zweck verwendet, streng vertraulich behandelt und nicht an Dritte weitergegeben. Sie können sich auch jeder Zeit wieder aus dem Verteiler austragen lassen, indem Sie uns auf eine unserer E-Mails antworten.)

Vielen herzlichen Dank für deine Unterstützung und weiterhin viel Spaß und Erfolg beim Sport machen! Deine Antworten wurden gespeichert, du kannst das Browser-Fenster nun schließen und die App deinstallieren. Team IMove2Improve, Ludwig-Maximilians-Universität München – 2016

A.1.3 Push notifications and feedback

Original used german phrases (push notifications and feedback) for the two communication styles friendly and dominant

A.1.3.1 *Dominant push-notifications*

- Faulheit ist keine Hilfe auf deinem Weg zum Ziel, beweg dich! ($M = 1,69$, $SD = 0,99$)
- Beweg deinen Hintern – ab zum Sport! ($M = 1,83$, $SD = 1,15$)
- Schluss mit Rumhängen – pack deine Sporttasche! ($M = 2,07$, $SD = 1,26$)
- 'Nicht jetzt' wird schnell zum 'nie'. Ab zum Sport! ($M = 2,10$, $SD = 0,92$)
- Ausreden zählen nicht, eine Sporteinheit muss immer gehen! ($M = 2,14$, $SD = 1,07$)
- Raus aus den Federn – beweg dich! ($M = 2,17$, $SD = 1,05$)
- Hoch mit dir du Faulpelz – rein in die Sportklamotten! ($M = 2,24$, $SD = 1,10$)
- Nichtstun ist keine Option, auf zum Sport! ($M = 2,38$, $SD = 1,16$)

A.1.3.2 *Friendly push-notifications*

- Heute ist ein guter Tag zum Sport machen! ($M = 4,28$, $SD = 0,69$)
- Sport ist gesund und macht Spaß – hast du Lust? ($M = 4,14$, $SD = 1,01$)
- Lust dich heute zu bewegen? ($M = 4,10$, $SD = 0,84$)
- Wer nicht aufgibt hat nie verloren. Weiter so. ($M = 3,86$, $SD = 1,07$)
- Der Anfang ist schon die Hälfte des Weges. Auf zum Sport! ($M = 3,83$, $SD = 0,91$)
- Na, wie wäre es mit einer Sporteinheit? ($M = 3,76$, $SD = 1,07$)
- Ich würde dir vorschlagen heute Sport zu machen. Was hältst du davon? ($M = 3,72$, $SD = 1,34$)
- Wie wäre es heute mit ein bisschen Sport? ($M = 3,69$, $SD = 1,21$)

A.1.3.3 *Dominant feedback*

- War das schon alles? Das muss noch besser gehen! ($M = 1,59$, $SD = 0,72$)
- Es muss noch besser gehen! Streng dich weiterhin an! ($M = 2,00$, $SD = 0,87$)
- Du musst dich noch weiter steigern! Auf geht's! ($M = 2,21$, $SD = 0,71$)
- Ruh dich nicht auf deiner Leistung aus, es geht noch besser! ($M = 2,45$, $SD = 1,04$)
- Das war nur ein Schritt auf dem Weg zum Ziel. Weiter, weiter, weiter! ($M = 2,48$, $SD = 1,07$)
- Keine Zeit für Pausen. Weiter geht's! ($M = 2,45$, $SD = 1,07$)

A.1.3.4 *Friendly feedback*

- Ich glaube an deinen Fortschritt, du schaffst das! ($M = 4,38$, $SD = 0,76$)
- Es geht voran! Du wirst merken, es wird von nun an immer leichter gehen! ($M = 4,34$, $SD = 0,76$)
- Wieder eine Sporteinheit geschafft! Jetzt hast du dir aber eine Pause verdient und kannst beim nächsten Mal wieder durchstarten! ($M = 4,31$, $SD = 0,83$)
- Du bist schon auf dem richtigen Weg und dein Ziel ist heute wieder ein Stück näher gerückt! ($M = 4,14$, $SD = 0,94$)
- Bleib am Ball! Ich glaube daran, dass du dein Ziel erreichen kannst! ($M = 4,14$, $SD = 1,14$)
- Jetzt kannst du dich erst einmal ausruhen. Beim nächsten Mal geht es noch leichter. ($M = 3,93$, $SD = 0,74$)

A.1.3.5 *Smiley Scale*

A.2 PAPER III

A.2.1 Vignette Intro

Imagine that you have recently downloaded a fitness app, in order to become more active. You used it all week and recently you have increased your goal to walk 8000 steps per day. You wake up in the morning and the fitness app presents you with the following feedback, which you study carefully.

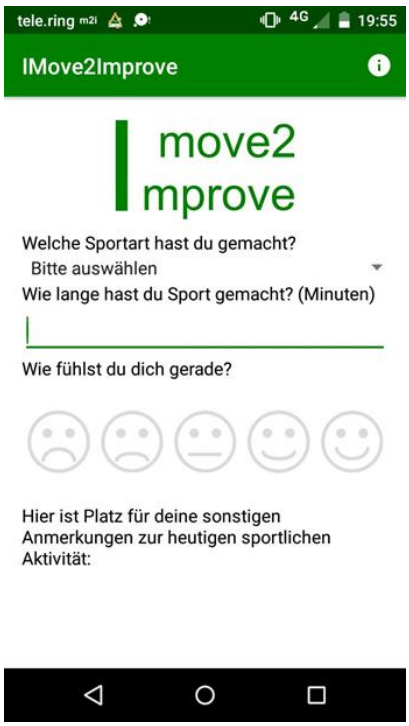


Figure A.1: Smiley Scale

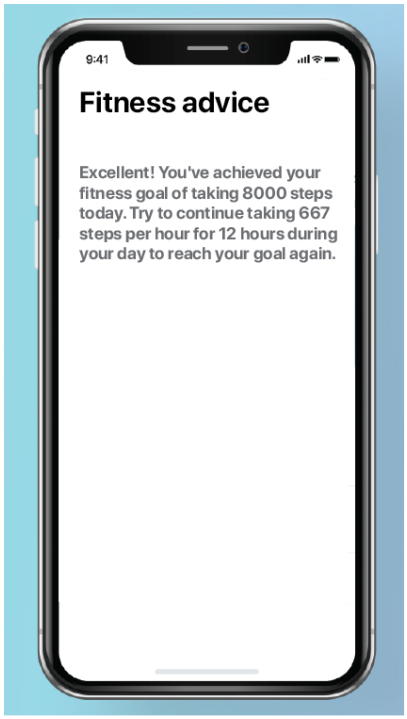


Figure A.2: Example screen: Goal attainment, friendly communication style, low construal level

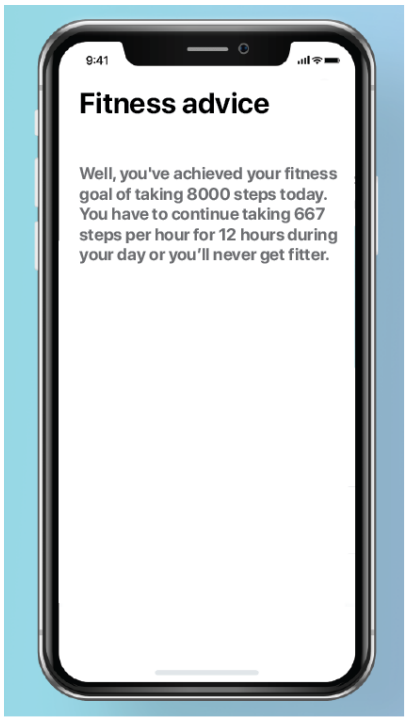


Figure A.3: Example screen: Goal attainment, dominant communication style, low construal level

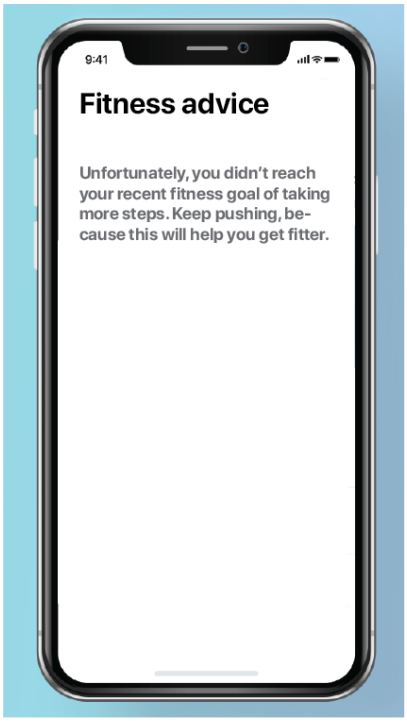


Figure A.4: Example screen: Failure, friendly communication style, high construal level

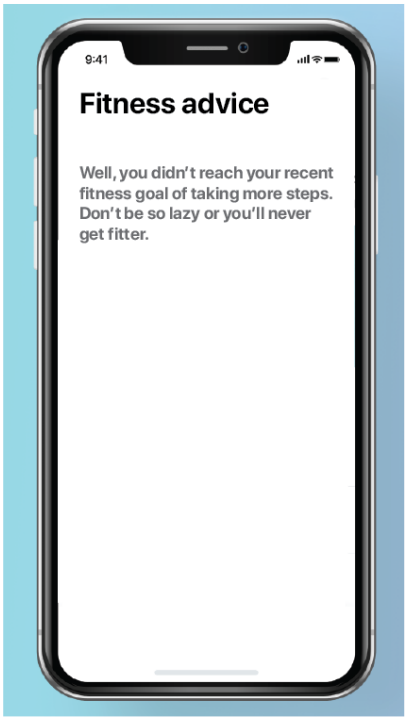


Figure A.5: Example screen: Failure, dominant communication style, high construal level

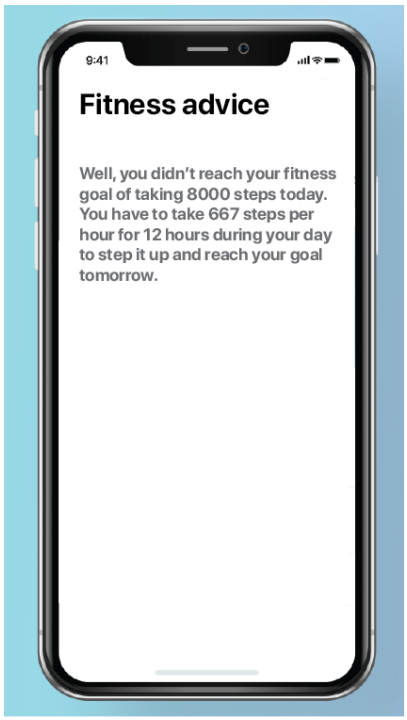


Figure A.6: Example screen: Failure, dominant communication style, low construal level

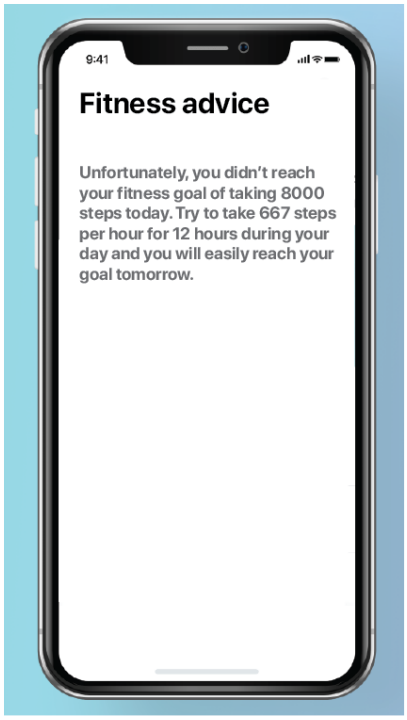


Figure A.7: Example screen: Failure, friendly communication style, low construal level

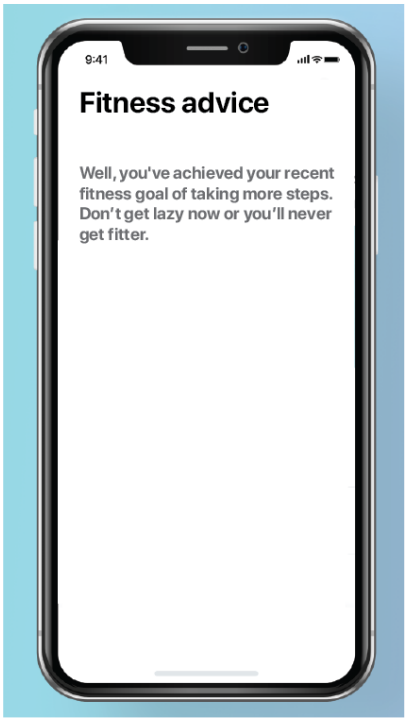


Figure A.8: Example screen: Goal attainment, dominant communication style, high construal level

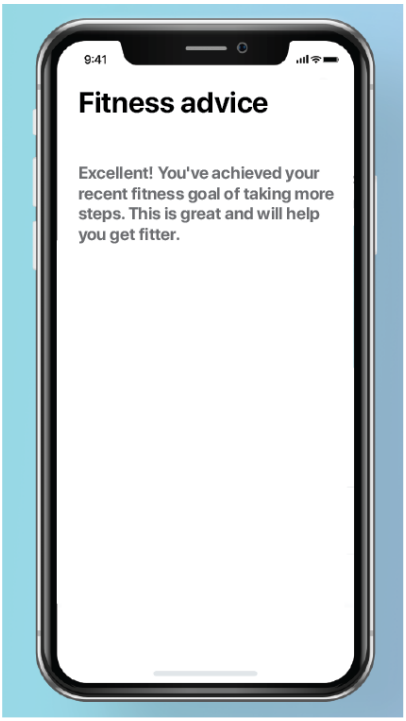


Figure A.9: Example screen: Goal attainment, friendly communication style, high construal level

A.2.2 Affective Response

This scale is based on the work from Williams and colleagues (Williams et al., 2013).

Please indicate now how the presented feedback makes you feel. Again, please try to think like the person in the situation described above would think. Please indicate your level of agreement with the following sentences and check the box that is most applicable for you. (The participants indicated their responses on a 7 point Likert Scale)

- The feedback felt pleasant.
- The feedback felt desirable.
- The feedback felt painful.
- The feedback felt unpleasant.

A.2.3 Goal Commitment Scale

This scale is based on the work from Hollenbeck and colleagues (Hollenbeck et al., 1989). The following statements refer to the person you are imagining to be right now. Please try to recall their situation in detail again. Now please rate how much you agree with the following sentences, when you try to see the world through their eyes. (The participants indicated their responses on a 5 point Likert Scale)

- It's hard to take this goal seriously.
- It's unrealistic for me to expect to reach this goal.
- It is quite likely that this goal may need to be revised, depending on how things go.
- Quite frankly, I don't care if I achieve this goal or not.
- I am strongly committed to pursuing this goal.
- It wouldn't take much to make me abandon this goal.
- I think this is a good goal to shoot for.
- I am willing to put forth a great deal of effort beyond what I'd normally do to achieve this goal.
- There is not much to be gained by trying to achieve this goal.

A.3 PAPER VIII

A.3.1 Online questionnaire

Vielen Dank, dass Sie sich die Zeit nehmen an unserer Studie teilzunehmen. In dieser Studie interessieren wir uns unter anderem dafür, was für Sie im Alltag einen „guten Begleiter" ausmacht. Der Fragebogen dauert ca. 20 Minuten. Die Teilnahme an dieser Studie ist freiwillig. Die Umfrage ist anonym und Ihre Daten werden vertraulich behandelt. Sie haben außerdem die Möglichkeit Amazon-Gutscheine zu gewinnen. Wir verlosen: 1x 50 EUR Amazon Gutschein, 2x 20 EUR Amazon Gutschein, 6x 10 EUR Amazon Gutschein Wenn Sie an der Verlosung der Amazon-Gutscheine teilnehmen wollen, geben Sie hierfür am Ende des Fragebogens bitte Ihre E-Mail-Adresse an. Diese wird ausschließlich für die Verlosung der Gutscheine genutzt und nicht mit Ihren Daten in Verbindung gebracht.

- Nennen Sie bitte ganz spontan 3 Charaktereigenschaften, die Sie mit einem guten Begleiter in Verbindung bringen (Open Text Field]

Manchmal können auch Gegenstände Begleiter im Alltag sein (z.B. ein Tagebuch, ein Kompass, ein MP3-Player, eine Thermoskanne). Denken Sie nun bitte an einen Gegenstand, der für Sie persönlich einen Begleiter symbolisiert.

- Um was für einen Gegenstand handelt es sich? (Open Text Field)
- Was macht diesen Gegenstand zu einem guten Begleiter für Sie? (Open Text Field]

- Nennen Sie bitte 3 wichtige Eigenschaften, die diesen 'Begleiter' ausmachen (z.B. treu, zuverlässig, immer verfügbar, bringt mich zum Lachen...) (Open Text Field)

Welche Bedürfnisse erfüllt dieser Begleiter für Sie im Alltag? Mein Begleiter vermittelt mir ein Gefühl von... (The participants indicated their responses on a 5 point Likert Scale)

- Kompetenz (meine Aufgaben und Ziele erfolgreich zu erreichen)
- Verbundenheit (anderen Menschen nah und verbunden zu sein)
- Bedeutsamkeit (einer tieferen Bedeutsamkeit im Leben)
- Stimulation (etwas Neues und Unterhaltsames zu erleben)
- Sicherheit (sicher vor Ungewissheit und Unheil zu sein)
- Popularität (für andere Menschen wichtig zu sein und Anerkennung zu bekommen)
- Autonomie (die Dinge so machen zu können, wie ich es für gut halte)

Vielen Dank für Ihre bisherigen Antworten. Im nächsten Abschnitt haben wir ein paar Fragen dazu wie Sie sich Ihren idealtypischen Begleiter vorstellen. Jetzt mal unabhängig von Ihrem konkreten Gegenstand. Bitte beschreiben Sie Ihre Vorstellung eines idealen Begleiters anhand der folgenden Adjektive! Welche Eigenschaften sehen Sie ganz allgemein als besonders wünschenswert für einen guten Begleiter? (The participants indicated their responses on a 5 point Likert Scale)

- Klein
- angepasst
- Kompakt
- unaufdringlich
- Zweckdienlich
- Diskret
- elegant
- zuverlässig
- Multifunktional
- Praktisch
- Visuell
- verfügbar

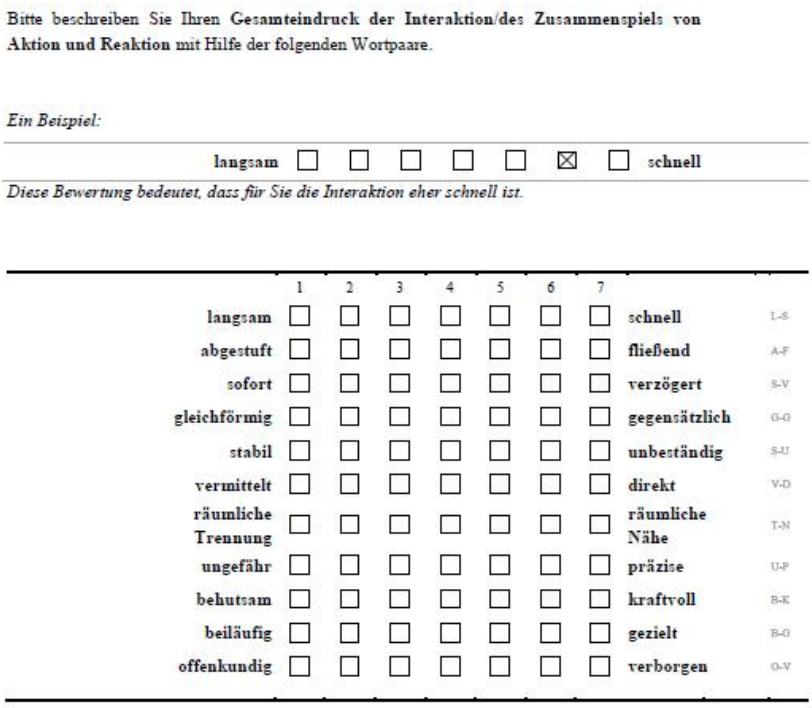
- Mobil
- einfühlsam
- Intuitiv
- witzig
- (Open Text Field)

In welcher Rolle sehen Sie einen Gegenstand als Begleiter in Ihrem Alltag idealerweise? (Mehrfachnennungen möglich)

- Begleiter
- Ordner
- Helfer
- Bestimmer
- Unterstützer
- Coach
- Gedächtnisstütze
- Überwacher
- Ratgeber
- Aufpasser
- Freund
- Aufseher
- Kamerad
- Kontrolleur
- Komplize
- Kritiker
- Vermittler
- Revisor
- Lehrer
- (Open Text Field)

The following scale is based on the work from Diefenbach and colleagues (Diefenbach, Hassenzahl, Klöckner, Nass & Maier, 2010).

Wenn Sie an Ihren idealen Begleiter denken – wie äußert sich das in der Interaktion? Wie sollte sich die Interaktion mit dem Begleiter anfühlen?



Bitte beschreiben Sie Ihren Gesamteindruck der Interaktion/des Zusammenspiels von Aktion und Reaktion mit Hilfe der folgenden Wortpaare.

Ein Beispiel:

langsam ☐ ☐ ☐ ☐ ☐ ☒ ☐ schnell

Diese Bewertung bedeutet, dass für Sie die Interaktion eher schnell ist.

	1	2	3	4	5	6	7		
langsam	☐	☐	☐	☐	☐	☐	☐	schnell	L-S
abgestuft	☐	☐	☐	☐	☐	☐	☐	fließend	A-F
sofort	☐	☐	☐	☐	☐	☐	☐	verzögert	S-V
gleichförmig	☐	☐	☐	☐	☐	☐	☐	gegensätzlich	G-G
stabil	☐	☐	☐	☐	☐	☐	☐	unbeständig	S-U
vermittelt	☐	☐	☐	☐	☐	☐	☐	direkt	V-D
räumliche Trennung	☐	☐	☐	☐	☐	☐	☐	räumliche Nähe	T-N
ungefähr	☐	☐	☐	☐	☐	☐	☐	präzise	U-P
behutsam	☐	☐	☐	☐	☐	☐	☐	kraftvoll	B-K
beiläufig	☐	☐	☐	☐	☐	☐	☐	gezielt	B-G
offenkundig	☐	☐	☐	☐	☐	☐	☐	verborgen	O-V

Figure A.10: Interaction vocabulary

- Analog – Digital

Vielen Dank für Ihre bisherigen Antworten und Angaben zu Ihrem persönlichen idealen Begleiter. Wir interessieren uns nun noch für Ihre Einschätzung zu zwei spezifischen Typen von Begleitern.

Stellen Sie sich nun bitte einen eher passiven Begleiter vor, der sich im Hintergrund hält. Er ist zurückhaltend, fürsorglich, empathisch, bedacht und tut nur das, was man von ihm verlangt.

- Wie sollte sich die Interaktion mit einem solchen eher passiven, zurückhaltenden Begleiter anfühlen?

(see FigureA.10) and the following item.

- Analog – Digital

Stellen Sie sich nun bitte einen eher aktiven Begleiter vor, der sich in den Vordergrund stellt. Er ist eigenständig, dominant, proaktiv und kommt manchmal auf Ideen, auf die man selbst vermutlich nie gekommen wäre.

- Wie sollte sich die Interaktion mit einem solchen eher passiven, zurückhaltenden Begleiter anfühlen?

(see FigureA.10) and the following item.

- Analog – Digital

Alles in allem — welchen der eben vorgestellten Begleiter — den aktiven oder den passiven — hätten Sie lieber an Ihrer Seite?

- Ein passiver Begleiter der sich im Hintergrund hält. Er ist zurückhaltend, fürsorglich, empathisch, bedacht und tut nur das, was man von ihm verlangt.
- Ein aktiver Begleiter der sich in den Vordergrund stellt. Er ist eigenständig, dominant, proaktiv und kommt manchmal auf Ideen, auf die man selbst vermutlich nie gekommen wäre.

Welchen der eben vorgestellten Begleiter – den aktiven oder den passiven - hätten Sie im Arbeits-/ Studiumskontext lieber an Ihrer Seite?

- Ein passiver Begleiter der sich im Hintergrund hält. Er ist zurückhaltend, fürsorglich, empathisch, bedacht und tut nur das, was man von ihm verlangt.
- Ein aktiver Begleiter der sich in den Vordergrund stellt. Er ist eigenständig, dominant, proaktiv und kommt manchmal auf Ideen, auf die man selbst vermutlich nie gekommen wäre.

Welchen der eben vorgestellten Begleiter – den aktiven oder den passiven – hätten Sie im Freizeitkontext lieber an Ihrer Seite?

- Ein passiver Begleiter der sich im Hintergrund hält. Er ist zurückhaltend, fürsorglich, empathisch, bedacht und tut nur das, was man von ihm verlangt.
- Ein aktiver Begleiter der sich in den Vordergrund stellt. Er ist eigenständig, dominant, proaktiv und kommt manchmal auf Ideen, auf die man selbst vermutlich nie gekommen wäre.

VIELEN DANK FÜR IHRE TEILNAHME! WENN SIE AN DER VERLOSUNG DER AMAZON-GUTSCHEINE TEILNEHMEN WOLLEN; HINTERLASSEN SIE BITTE HIER IHRE E-MAIL-ADRESSe.
(Open Text Field)

Die Angabe der E-Mail-Adresse dient nur zum Zweck der Verlosung und wird getrennt von Ihren sonstigen Angaben gespeichert. Bei Fragen oder Anmerkungen zu dieser Studie nehmen Sie bitte mit Jasmin.Niess@psy.lmu.de Kontakt auf.