

Towards Happiness and Psychological Well-Being: Understanding and Designing Positive Experiences with Conversational Agents

CANDIDATE

Xi Yang

SUPERVISOR

Marco Aurisicchio

A thesis submitted in partial fulfilment of the requirements for the degree of:

Doctor of Philosophy

Imperial College London

Dyson School of Design Engineering

This page is left blank intentionally.

Declaration

I confirm that the work presented in this thesis is my own. Where information from other sources is needed, this has been indicated in the thesis.

Xi Yang

Copyright

The copyright of this thesis rests with the author. Unless otherwise indicated, its contents are licensed under a [Creative Commons Attribution-Non Commercial-No Derivatives 4.0 International Licence](#) (CC BY-NC-ND).

Under this licence, you may copy and redistribute the material in any medium or format on the condition that; you credit the author, do not use it for commercial purposes and do not distribute modified versions of the work.

When reusing or sharing this work, ensure you make the licence terms clear to others by naming the licence and linking to the licence text.

Please seek permission from the copyright holder for uses of this work that are not included in this licence or permitted under UK Copyright Law.

Abstract

Happiness is our ultimate goal and often a consequence of day-to-day experiences. These experiences are inevitably affected by the products we interact with, ranging from everyday artefacts, to interactive technologies, and increasingly, intelligent tools such as conversational agents (CAs). Design and technology greatly shape how we feel, think, and behave in those experiences, and thus influence happiness and well-being. However, when designing for happiness, what experiences to strive for, and how to achieve them are still unclear. In particular, the lack of knowledge and design support for newly emerging products such as CAs is more evident than others. Hence, this thesis aims to gain better understanding of the experiences that support well-being and provide guidance to help design such experiences.

This aim is achieved through a comprehensive literature review followed by four explorative studies. First, the scientific and design literature on happiness and well-being were reviewed, together with relevant works on CAs. This review develops the knowledge foundation for the thesis. Next, an empirical study investigated which and how everyday products contribute to well-being. The study identified seven well-being supportive experience themes and routes to creating them through products. Motivated by the recent AI development, the focus was then shifted from everyday artefacts to CAs. The next study explored users' affective experiences with CAs. The findings present four main usage scenarios, the factors influencing affective responses, and implications for designing positive ones. To provide a eudaimonic perspective on CA experiences, an interview study was conducted to explore Self-Determination Theory (SDT) in the CA context. The findings show how the needs of competence, autonomy, and relatedness could be fulfilled or undermined with CAs. Based on the findings, ten design guidelines were developed, and later evaluated through a survey study. Together, these studies offer practical design support for CAs grounded in SDT.

Acknowledgement

I would like to say thank you to everyone who has supported me throughout the course of my PhD, sincerely.

I am especially grateful to my supervisor, Marco Aurisicchio, for his tremendous help, guidance, and support on the progression of my PhD. I feel very fortunate in having Marco as my supervisor and receiving his valuable comments and advice on my research work. I would also like to thank Weston Baxter, who has been an incredible mentor and a valuable source of research advice. I am grateful to Dyson School of Design Engineering for providing a fantastic research environment that made this possible.

It would not be possible to acknowledge by name everyone who has helped me when I needed professional advice, cheered me up when I encountered challenges, and celebrated with me when I made small achievements. I am referring to my family, friends and colleagues from Imperial College and beyond. I also appreciate all the incredibly useful feedback from anonymous reviewers on my paper submissions. So, thank you all!

Finally, I would like to express my great thankfulness to Imperial College London for having offered me the President's PhD scholarship which allows me to pursue my research interests, undertake research projects, broaden my horizons, and open up the next chapter of my life.

Table of Contents

<i>Abstract</i>	<i>5</i>
<i>Acknowledgement</i>	<i>6</i>
<i>Table of Contents</i>	<i>7</i>
<i>List of Figures.....</i>	<i>11</i>
<i>List of Tables.....</i>	<i>12</i>
<i>Chapter 1 Introduction</i>	<i>13</i>
1.1 Motivation.....	13
1.2 Research Aim and Objectives	18
1.3 Research Approach	20
1.4 Contributions.....	24
1.5 Thesis Structure	27
<i>Chapter 2 Literature Review</i>	<i>29</i>
2.1 Positive Psychology: The Science of Happiness and Well-Being.....	30
2.1.1 What is well-being: the hedonic and eudaimonic views	31
2.1.2 How to improve well-being.....	40
2.1.3 Theoretical foundation.....	46
2.2 Positive Design and Technology.....	50
2.2.1 Why is ‘design for well-being’ a responsibility?	51
2.2.2 The psychological stand.....	52
2.2.3 The role of products in supporting well-being.....	53
2.2.4 How to design for well-being	55
2.2.5 Gaps and research opportunities	62
2.3 The Rise of AI and Conversational Agents (CAs).....	64
2.3.1 Conversational agents	66
2.3.2 CAs and well-being.....	69
2.3.3 Gaps and research opportunities	71
2.4 Conclusions	73

Chapter 3 Understanding Products and Experiences That Support Well-Being	75
3.1 Motivation	75
3.2 Related Works	77
3.3 Methods	80
3.3.1 Data collection.....	80
3.3.2 Data analysis	82
3.4 Findings	84
3.4.1 What products support well-being.....	84
3.4.2 How do products support well-being	85
3.4.3 Role of products in creating well-being supportive experiences.....	93
3.5 Discussion	95
3.5.1 Well-being supportive products	95
3.5.2 Well-being supportive experiences	95
3.5.3 Design implications	97
3.5.4 Limitations	97
3.6 Conclusions	98
Chapter 4 Understanding Affective Experiences with Conversational Agents	99
4.1 Motivation	99
4.2 Related Works	101
4.3 Methods	103
4.3.1 Data collection.....	103
4.3.2 Data analysis	106
4.4 Findings	108
4.4.1 CA user experiences: scenarios and contexts of use	108
4.4.2 Affective responses	112
4.4.3 Correlation between product qualities and affect	114
4.4.4 Factors underlying pragmatic qualities	115
4.4.5 Factors underlying hedonic qualities	117
4.5 Discussion and Design Implications	118
4.5.1 CA user experiences	119
4.5.2 Affective responses	120
4.5.3 Factors influencing affective responses	122

4.5.4 Limitations	123
4.6 Conclusions	124
<i>Chapter 5 Designing Positive Experiences with Conversational Agents.....</i>	<i>125</i>
5.1 Motivation	125
5.2 Related Works	128
5.2.1 Self-determination theory (SDT) and its implications for design	128
5.2.2 Designing CAs.....	130
5.2.3 Research gaps.....	133
5.3 Phase 1: Applying SDT to Inform the CA Design.....	134
5.3.1 Method	134
5.3.2 Competence in the CA and implications for its design.....	136
5.3.3 Autonomy in the CA and implications for its design.....	142
5.3.4 Relatedness in the CA and implications for its design	147
5.4 Phase 2: Deriving Design Guidelines	152
5.4.1 Method	152
5.4.2 Design guidelines for CAs	153
5.5 Phase 3: Evaluating Guidelines.....	161
5.5.1 Method	161
5.5.2 Perceived importance of guidelines	163
5.5.3 Guideline application/violation and relation to user satisfaction.....	165
5.6 Discussion	168
5.6.1 Competence and autonomy in CAs	169
5.6.2 Relatedness in CAs	170
5.6.3 Design guidelines.....	172
5.6.4 Limitations and future work	177
5.7 Conclusions	177
<i>Chapter 6 General Discussion and Conclusions.....</i>	<i>179</i>
6.1 Summary of Research Findings	179
6.2 Discussion	186
6.2.1 A model for well-being design	186
6.2.2 Well-being supportive experience themes	188
6.2.3 Affective CA experiences and how to design positive ones	189

6.2.4 Design for competence with CAs	191
6.2.5 Design for autonomy with CAs	192
6.2.6 Design for relatedness with CAs	193
6.3 Limitations	194
6.4 Future Work.....	197
6.5 Conclusions	198
<i>References</i>	<i>200</i>

List of Figures

Figure 1. Research phases and objectives	20
Figure 2. Design Research Methodology (DRM) framework (Blessing and Chakrabarti, 2009)	20
Figure 3. Applying DRM to address the objectives of the thesis	21
Figure 4. Venn diagram of where this thesis sits compared to relevant literature	30
Figure 5. Finding flow (Csikszentmihalyi, 1997)	36
Figure 6. The PERMA well-being theory (Seligman, 2012)	38
Figure 7. Positive interventions improve well-being by creating positive experiences	41
Figure 8. The sustainable happiness model (Lyubomirsky et al., 2005b)	45
Figure 9. Well-being design model	46
Figure 10. The positive design framework (Desmet and Pohlmeier, 2013)	57
Figure 11. A three-layer experience design model. From why to what and how (Hassenzahl, 2011)	59
Figure 12. Designing pleasurable and meaningful experiences (Hassenzahl et al., 2013)	60
Figure 13. The relationship between experience and experiencing (Ortiz Nicolas, 2013)	78
Figure 14. Data collection on products and experiences that contribute to well-being	81
Figure 15. Products that contribute to participants' well-being	85
Figure 16. Everyday products support well-being via seven themes of experiences	87
Figure 17. Description of the relaxing experience theme	88
Figure 18. Description of the entertaining experience theme	89
Figure 19. Description of the connecting to loved ones experience theme	90
Figure 20. Description of the developing self-image experience theme	91
Figure 21. Description of the mastering an activity experience theme	91
Figure 22. Description of the learning new knowledge experience theme	92
Figure 23. Description of the doing things freely experience theme	93
Figure 24. Products play two roles in creating well-being supportive experiences	93
Figure 25. Contexts of use across four scenarios	112
Figure 26. Affective responses in the four scenarios	114
Figure 27. Examples of G1 to G3	155
Figure 28. Examples of G4 to G6	157
Figure 29. Examples of G7	159
Figure 30. Examples of G8 to G10	160
Figure 31. Participants' evaluations of the importance of the guidelines	164
Figure 32. Application (or violation) of the guidelines in existing CAs	167
Figure 33. Summary of research findings	180

List of Tables

<i>Table 1. How happiness is defined in the hedonic literature</i>	<i>32</i>
<i>Table 2. Six aspects of psychological well-being (Ryff and Keyes, 1995)</i>	<i>34</i>
<i>Table 3. Aspects of well-being</i>	<i>48</i>
<i>Table 4. A set of needs suitable for experience design (Hassenzahl et al., 2013, 2010; Sheldon et al., 2001)</i>	<i>49</i>
<i>Table 5. Examples of the two product roles.....</i>	<i>94</i>
<i>Table 6. Participants' information</i>	<i>107</i>
<i>Table 7. Overall evaluation of affective experience.....</i>	<i>113</i>
<i>Table 8. Correlation between product qualities and affect</i>	<i>115</i>
<i>Table 9. Participants' information</i>	<i>135</i>
<i>Table 10. Design Guidelines for CAs</i>	<i>154</i>
<i>Table 11. Participants' Information.....</i>	<i>163</i>
<i>Table 12. Correlation between guideline application and overall user satisfaction with CAs</i>	<i>167</i>
<i>Table 13. Comparing CA guidelines to AI and UI guidelines</i>	<i>175</i>

Chapter 1 Introduction

1.1 Motivation

There is no doubt that happiness is important. In fact, the pursuit of happiness has long been the primary goal of individuals worldwide (Diener, 2000; King and Napa, 1998). This is largely due to the many positive outcomes brought by happiness including, but not limited to, improved physical health and life expectancy (Ryff and Singer, 1998), as well as improvement in other life domains, such as education, career and social relationships (Lyubomirsky et al., 2005a). Beyond individuals, the pursuit of happiness has also become a national goal. The World Happiness Report¹ has made happiness one of the indicators of a nation's success.

However, the world is not yet as happy a place as much as it could be. According to the latest happiness report (Helliwell et al., 2020), there has been a rapid increase in negative affect globally from the year 2010 to 2019. In contrast, there has been no significant change in positive affect over the last decade. Mental and mood disorders have become one of the major threats to one's overall health and well-being. The latest available data (till 2017) from the Global Burden of Disease (GBD) Study estimated that approximately 10.7% of the global population

¹ <https://worldhappiness.report/>

live with a mental disorder, such as depression, anxiety, eating disorders and others (Ritchie and Roser, 2018).

Importantly, it is incorrect to assume that individuals who do not suffer from mental disorders are happy. Many individuals may not have met the criteria for a diagnosis of mental disorder, but they still do not consider themselves happy. This is because authentic happiness is much more than the absence of illness and requires additional positive virtues and strengths, such as persistence, open-mindedness, kindness and gratitude (Peterson and Seligman, 2004; Seligman and Csikszentmihalyi, 2000). Despite not exhibiting or only exhibiting subthreshold symptoms, these individuals may struggle with developing the positive character that contributes to happiness. They also have the risk of developing major depression in the future (Cuijpers and Smit, 2004). Unfortunately, this phenomenon is not uncommon (Parks et al., 2013), and the World Health Organisation has estimated that over 300 million individuals suffer from depression and other mental disorders globally (World Health Organisation, 2017).

The rise of positive psychology

This situation calls for our society to not only focus on fixing illness, but also on the positives of human experience. In other words, the focus should be shifted to help normal individuals foster human flourishing and improve their quality of life. Consequently, positive psychology (Seligman and Csikszentmihalyi, 2000) has emerged out of this need. It investigates the constructs of happiness and psychological well-being, as well as the obstacles and approaches to fostering human flourishing. The ultimate goal is to help individuals move from the *acceptable* to the *positive* side of their psychological well-being spectrum.

Positive experiences are the key to happiness. According to the research in positive psychology, happiness is often achieved through the collection of positive experiences. Prior research illustrated that 40% of individual happiness was determined by how we think and act in daily experiences, compared to 50% by genes and 10% by life circumstances, such as marriage, money, location or others (Lyubomirsky et al., 2005b). Given that daily engagement in positive experiences can lead to sustainable happiness, how can we achieve this in our lives? One approach to achieve positive experiences is through intentional activities (also known as positive interventions), such as writing gratitude letters or imagining best possible selves

(Lyubomirsky, 2007). However, despite the short-term effectiveness of these positive interventions, it is often a challenge to practice them in the long-term. This is because they usually require extra time and effort from individuals, and it is not easy to incorporate them well within our busy modern life. This suggests another approach, which consists of enhancing existing daily experiences to make them *positive experiences*. For example, a daily commute could be turned into an opportunity for self-improvement (such as, listening to a podcast, discovering new music, or practicing meditation); cooking could become an opportunity to relax and relieve stress (such as, concentrating on the aroma and the making of good food, or trying out new recipes). It is interesting to see that many of these changes can benefit from intentional design and technology.

The role of design and technology

Considerable progress has been made on supporting happiness and well-being through positive design and technologies. This can be seen in the development of design theories and frameworks, for example, Norman's Emotional Design (Norman, 2005), Jordan's description on the four pleasures that can be designed into a product or experience (Jordan, 2002), Desmet and Pohlmeier's Positive Design framework (Desmet and Pohlmeier, 2013), Hassenzahl's Experience Design model (Hassenzahl, 2010), and Calvo and Peters' Positive Computing framework (Calvo and Peters, 2014). Key learnings from this body of literature include that: i) design work can benefit from a solid theoretical foundation (e.g. positive psychology theories) to derive useful insights and borrow evaluation metrics, and ii) design should start with exploring the resulting experiences that we want to achieve before defining product functionality (Hassenzahl, 2010). As happiness is achieved through collective positive experiences, understanding and designing positive experiences is central to the design of happiness. With everyday products, and in particular interactive technologies, becoming more ubiquitous, they are creating an increasing impact on our lives. This indicates great potential and opportunities for them to play a role in supporting happiness and well-being.

Despite the progress made so far, advancement in product design and technology has not brought improved happiness. In fact, technology is a double-edged sword. According to the World Happiness Report 2019 (Helliwell et al., 2019), there has even been a decline in happiness with the rise of digital media and smartphone technology. This has been due to less

time being spent on: physical interactions with each other, reading books, attending religious services, sleeping and many others. More importantly, it is apparent that well-being has not yet been effectively and systematically considered in the design cycle of products. A strategic approach is vital to guarantee that designed products and technologies are to generate more positive than negative impacts on well-being. Two main gaps have been identified that may prevent this from happening.

First, despite acknowledging the importance of a theoretical foundation, it is difficult for designers to quickly acquire the relevant knowledge and apply it in design. It would be relatively impractical for designers to conduct a thorough review of the well-being literature due to limited time and other resources. To overcome this, a concise (yet not oversimplified) synthesis of well-being science and its relevant insights is required. Second, despite the increasing intention of designing for positive experiences, understanding the practical ways of achieving this is lacking. For example, what are the characteristics of well-being supportive products? Among everyday artefacts, which ones are more likely to help people improve well-being, and why? What experiences do they create, and how? This indicates a requirement for more in-depth understanding of the product-mediated positive experience.

The rise of Conversational AI

In the last five years, there has been a rapid development of Artificial Intelligence (AI) and AI-infused products, in particular Conversational Agents (CAs)² such as, Alexa, Google Assistant and Siri. It has become evident that the rise of CAs can potentially influence every aspect of our lives (Klopfenstein et al., 2017; Zamora, 2017). This indicates an urgent need to understand how these new technologies may affect our experiences and well-being, and how to design them to promote positive effects and mitigate negative ones. Prior work has studied this topic following two main themes. The first theme explored the utilisation of CAs to support e-healthcare systems, for example, assisting with after-hospital treatment (Fadhil, 2018), or

² Broadly speaking, CAs could refer to different types such as ‘personal assistants’ and ‘chatbots’. This thesis mainly focuses on ‘personal assistants’ due to their ubiquity and diversity of use in our daily lives. More details are discussed in Chapter 2.

providing healthcare consultancy (Fadhil and Gabrielli, 2017). The second theme explored how CAs can support positive interventions and behaviour changing activities, for example, fitness training (Kocielnik et al., 2018), nutrition (Graf et al., 2015), meditation (Shamekhi and Bickmore, 2015) and reminiscing (Nikitina et al., 2018).

However, these two themes are limited as they overlook the large proportion (the majority) of CA applications that are not dedicated to providing health-related services. In other words, these two themes have not been concerned with the notion of ‘positive CA design’, that is, actively considering well-being supported designs regardless of the primary purpose and functionality. In particular, current understanding of positive (or negative) CA experiences is limited. For example, what are the contributing factors to a positive experience? How to design positive experiences and eliminate negative ones? In addition, our understanding of eudaimonic CA experiences is incomplete. For example, how are people’s psychological needs (e.g. competence, autonomy and relatedness) reflected in CA experiences? And how to support such needs fulfilment through design?

Furthermore, even though in today’s environment, design support is in high demand for CA designers, it remains inadequate. This may be due to these reasons: the development of CAs is still in its infancy, thus lacking timely and sufficient support; and CA interactions are centred around conversations instead of traditional graphical interfaces. The novelty of the interaction brings additional technical and design challenges. Additionally, the distinctive characteristics of conversational AI technologies make previous design guidance [e.g. UI heuristics (Nielsen, 1995) and AI guidelines (Amershi et al., 2019)] partially inapplicable to CAs. Design guidance in the form of guidelines is particularly needed. This is because recommendations from design research, although useful and necessary, are often insufficient to match the industry’s needs; as Upton and Yates said, ‘in most cases the results of design research are not directly applicable’ (2001). Therefore, there is a need for the effective and efficient realisation of recommendations. Design guidelines, developed through rigorous research approaches, can provide successful implementation of results into practice (Blessing and Chakrabarti, 2009).

This is not only evident in academia; industry has also witnessed a rising demand for CA design support. Over the course of my PhD, I have been fortunate to take two UX internships working

on relevant CA projects; one on Google Assistant³ at Google (in 2018), and another on the Bot Framework⁴ at Microsoft (in 2019). Google Assistant is one of the commercial CA products on the market. The Microsoft Bot Framework, on the other hand, is a platform for building enterprise-level conversational AI products. These two industrial experiences have allowed me to closely examine how CAs are built in the real world outside of laboratory settings, and also demonstrated what knowledge and support could be useful for design practice. Being part of the design team has assisted me in realising the significance of equipping designers with sufficient conversational design knowledge. I have also noticed a huge gap in such knowledge. Although companies are progressing rapidly to provide designers with best practices, evidence-based research insights and guidelines are highly valued and expected from industries. Together, the fast-evolving AI field and the two industrial internships have influenced and motivated my research objectives presented below.

1.2 Research Aim and Objectives

As mentioned above, and discussed in more detail in Chapter 2, more knowledge and design support are needed to facilitate the design of positive experiences particularly with Conversational Agents (CAs). This leads to the following aim of the thesis:

To develop new understanding of the positive experiences with products, particularly with CAs, and to provide actionable design support (in the form of design implications and guidelines) to help practitioners apply this understanding into practice.

To achieve this aim, the following five objectives will be addressed in the thesis.

Objective A. Undertake a critical review of the state of the art on well-being science and associated design and technology practice, as well as conversational AI developments.

- What are the key takeaways from positive psychology that can build the foundation for well-being-oriented design research?

³ <https://assistant.google.com>

⁴ <https://dev.botframework.com>

- What design approaches and frameworks have been proposed to support positive design and technology? What are the gaps?
- What are the opportunities for CAs to support individual well-being?

Objective B. Investigate whether and how products support well-being in everyday life.

- What products could contribute to well-being, and why?
- What experiences do these products create, and how?

Objective C. Investigate the affective experiences mediated by CAs and how to design positive experiences.

- What experiences do users have with CAs?
- What are users' affective responses to these experiences?
- What product qualities influence affective experiences and how?
- What are the implications for the design of positive CA experiences?

Objective D. Explore how to support the fulfilment of people's psychological needs (i.e. competence, autonomy and relatedness) with CAs.

- What are CA users' perceptions and expectations around competence, autonomy and relatedness?
- What are the aspects of CAs that support or hinder these needs?
- What are the implications for the design of competence, autonomy and relatedness?

Objective E. Develop design guidelines to provide practical support for CA designers.

- What are the actionable guidelines translated from design implications from Objective D?
- What is the perceived importance of the design guidelines to improve the overall user experience?

The above objectives fall into three primary phases for the PhD research, as illustrated in Figure 1. The first phase builds the knowledge foundation from the review of the relevant literature. The second phase develops new understanding of positive experiences, first for everyday

artefacts, then for CAs in particular. The third phase develops design support that helps CA designers create more positive user experiences.

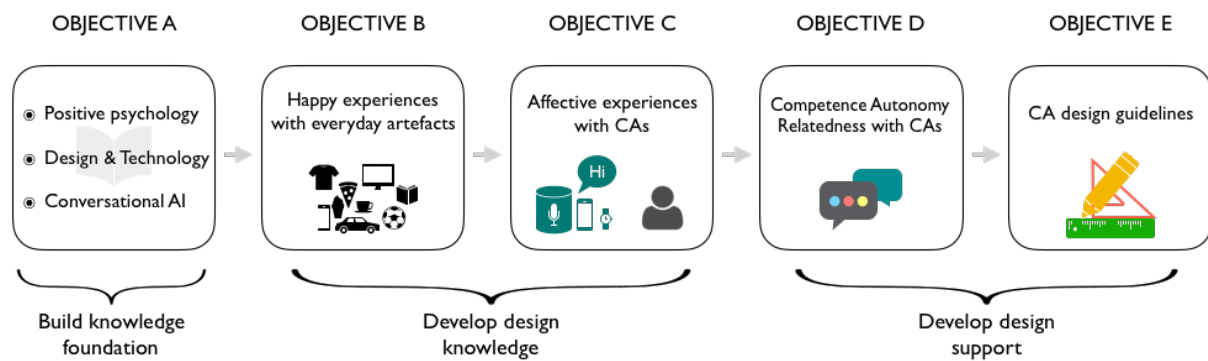


Figure 1. Research phases and objectives

1.3 Research Approach

Primarily, the research approach is based on the Design Research Methodology (DRM) proposed by Blessing and Chakrabarti (2009). DRM provides a framework which allows design researchers to follow a rigorous research process to obtain useful and valid research results. Specifically, it consists of four iterative stages: Research Clarification (RC), Descriptive Study I (DS-I), Prescriptive Study (PS) and Descriptive Study II (DS-II), Figure 2. This framework suggests a workflow that allows design researchers to plan and carry out specific studies that align with the flow. The research approach has been planned based on this framework.

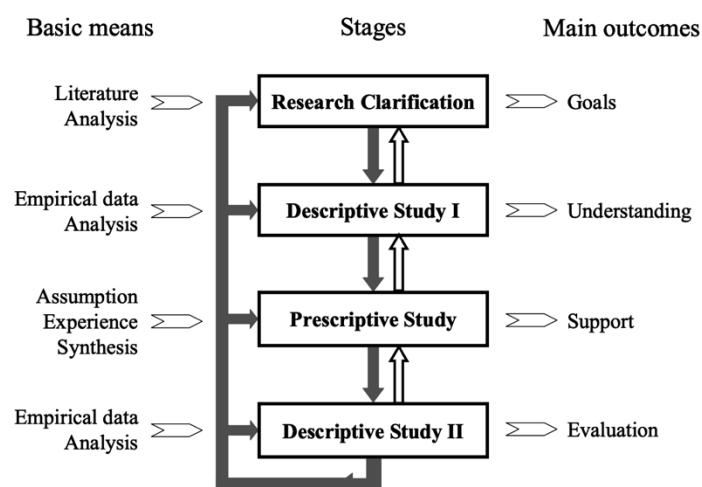


Figure 2. Design Research Methodology (DRM) framework (Blessing and Chakrabarti, 2009)

While applying the DRM framework, it is worth noting that, ‘DRM is not to be interpreted as a set of states to be executed rigidly and linearly’ (Blessing and Chakrabarti, 2009). In fact, depending on the research goals, a specific project will not necessarily include all four stages, or undertake each stage in equal depth. This is particularly common when a project is part of a larger research program, in which case, only one stage may be focused on at one time. For example, in the case of this thesis, during the first research phase, *build knowledge foundation* (Objective A), the RC stage involving the review of the relevant literature will be the focus. During the second phase, *develop design knowledge* (Objective B & C), the DS-I stage (while covering also the RC and PS stages) will be the focus with two exploratory studies. In the third research phase, *develop design support* (Objective D & E), the DS-I, PS and DS-II stages will be the focus with two in-depth research studies. Figure 3 illustrates how the DRM has been applied in this thesis to address the objectives.

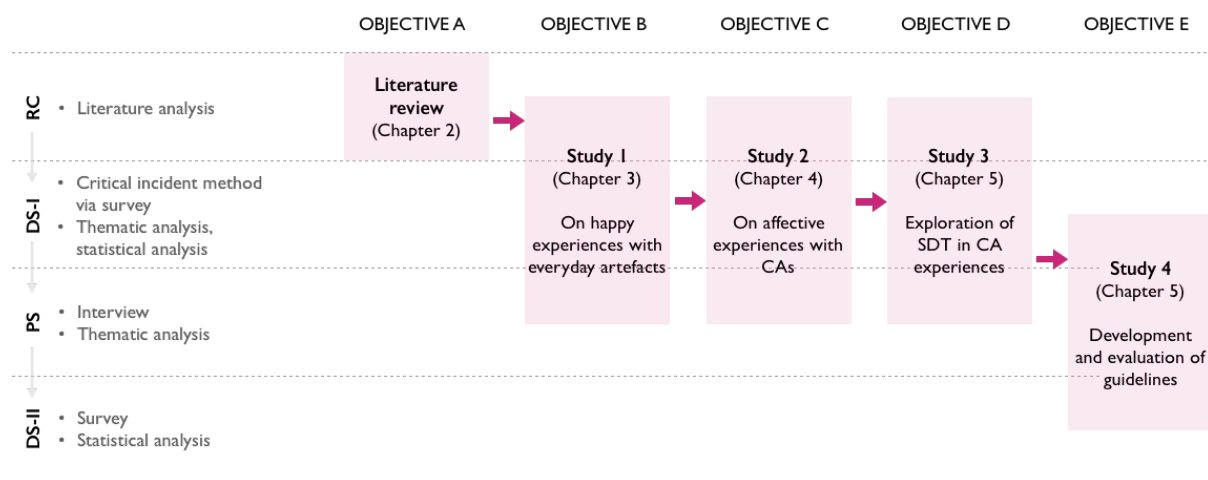


Figure 3. Applying DRM to address the objectives of the thesis

Phase I: Build knowledge foundation (Objective A)

The first phase aims to establish a scientific basis for this research. Three bodies of literature have been identified as relevant to the overall aim: well-being research in positive psychology, positive design and technology research in Human-Computer Interaction (HCI), and conversational design research in Human-AI Interaction. Objective A is to conduct a critical review of this literature. To achieve this, a literature analysis has been carried out to identify the major well-being theories, design approaches, frameworks, guidelines, and the opportunities and gaps for CAs to support well-being. The main outcome of this phase is

twofold: i) a theoretical model that synthesises key well-being theories and implications to drive design research; and ii) gaps and research opportunities which motivate the following studies.

Based on this, it is clear that there is a need to gain new and in-depth understanding of the positive experiences with products (in particular CAs), as well as a need to develop practical design support to help design positive experiences.

Phase II: Develop design knowledge (Objective B and C)

The second phase aims to gain a new understanding of positive experiences. Two studies were conducted: study 1 placed the focus on everyday artefacts; and study 2 focused on CAs. In study 1, well-being supportive products and experiences were investigated. Objective B is to understand why these experiences support well-being, and how products play a role in creating the experiences. To accomplish this objective, the critical incident method (Flanagan, 1954) was adopted via a survey study to collect user stories on the products and experiences that have contributed to their happiness and well-being. Thematic analysis (Braun and Clarke, 2006) was performed to characterise the collected experiences, specifically on why they support well-being, what activities were involved, when and where the experiences took place, who was present, and how the products affect those experiences.

After gaining knowledge of the general well-being supportive experiences from study 1, study 2 focused on investigating the experiences created by CAs. Objective C examined the affective experiences mediated by CAs and derived the implications to help design positive ones. To accomplish this objective, both qualitative data on CA users' experiences (through the critical incident method) and quantitative data on their affective responses [through the Positive and Negative Affect Scale (PANAS) (Watson et al., 1988)], and the perceived pragmatic and hedonic qualities of CAs [through the AttrakDiff questionnaire (Hassenzahl et al., 2000)] were collected. Thematic analysis and statistical analysis were performed to analyse the data. As a result, the users' emotional responses to different usage scenarios could be understood, and the contributing factors to a positive or negative experience identified.

From the DRM perspective, as shown in Figure 3, study 1 and study 2 both focused on the DS-I stage, as the primary goal was to develop an understanding of a situation and phenomenon

of interest. Both involved an initial review of the related work, which allowed the specific goals of that particular study to be defined. This is in addition to the general literature review conducted in phase I. Moreover, as suggested by the DRM (Blessing and Chakrabarti, 2009), a comprehensive DS-I study (which is the case of study 1 and study 2) should be followed by an initial PS stage to suggest how the findings could be used to improve design. Guided by this, both studies 1 and 2 have provided design implications, which were derived from the main findings.

Phase III: Develop design support (Objective D and E)

The third phase aims to develop design support for creating positive experiences with CAs. Specifically, a Self-Determination Theory (SDT) approach was adopted to drive the development of the design implications and guidelines. A three-stage research project was conducted to achieve this goal. It started with an in-depth interview study (study 3), followed by the development and evaluation of guidelines (study 4). In study 3, the SDT theory in the context of CAs was explored. This was in response to Objective D, which was to explore how to support the needs of competence, autonomy and relatedness with CAs. Specifically, participants were questioned about their perceptions and expectations underlying the three psychological needs. A thematic analysis on the collected data was then performed. Based on the analysis, the key determinants of the three needs with regards to CAs were identified, and these provided design suggestions to support the needs fulfilment.

After gaining insights into the three needs, the learnings were translated into actionable guidelines. This responds to Objective E, which was to develop practical support for CA designers. In study 4, a rigorous approach was followed, as outlined in Amershi et al. (2019), to develop such guidelines. The guidelines were then evaluated with CA users through a survey study where the following was examined: i) how important users think the guidelines are, and ii) what is the correlation between application or violation of the guidelines and the overall user satisfaction.

From the DRM perspective, as shown in Figure 3, study 3 is a comprehensive DS-I study with a primary focus on the DS-I stage, followed by an initial PS stage (in the form of the design

implications). Study 4 is a comprehensive PS study, informed by the DS-I stage and followed by an initial DS-II stage.

Throughout the thesis, a mix of qualitative methods (i.e. interview and critical incident method) and quantitative methods (i.e. standardised scales and questionnaires) have been used in the individual studies. In each of the corresponding chapters, details on the methods chosen and the rationale behind the choices are provided. In general, a thematic analysis (Braun and Clarke, 2006) was used to analyse the qualitative data, while the quantitative data was analysed through statistical analysis.

1.4 Contributions

This thesis makes the following contributions, which apply to knowledge and design.

First, a theoretical model has been developed synthesising well-being knowledge to inform positive design practice; see Figure 9 in Section 2.1.3. The model is based on the fact that well-being is achieved through a steady inflow of positive experiences (i.e. experiences which satisfy people's psychological needs). The model posits that design should set the goal of creating positive user experiences by supporting the fulfilment of needs. It points to two directions through which design and technology can achieve this goal: i) by facilitating dedicated well-being activities such as positive interventions; and ii) by rejuvenating non-dedicated ordinary daily activities with positivity. The model provides further details to support the well-being design practice. Specifically, it presents a set of psychological needs selected to be suitable for experience design (Hassenzahl et al., 2013, 2010; Sheldon et al., 2001). Additionally, it presents a summary of the hedonic and eudaimonic well-being aspects, which could be used as indicators of well-being achievement (Diener, 2000; Ryff and Keyes, 1995; Seligman, 2011).

The model has helped frame and inform the research studies undertaken in this thesis. It has the potential to benefit researchers and designers interested in discussing well-being design opportunities and defining goals and creating and evaluating positive design solutions.

Second, seven well-being supportive experience profiles have been established along with the routes to creating them through products (Yang et al., 2017). Each profile describes one of the

following experience themes: relaxing, entertaining, connecting to loved ones, developing self-image, mastering an activity, learning new knowledge, and doing things freely. In the profiles, the personal meaning of each experience to individuals is detailed, along with the primary activities and contextual information such as, when, why and how that experience takes place. In addition to the profiles, two major roles that products play in creating these experiences have been identified: enabler of activities in the current experience, and carrier of reflective meanings from past experiences.

This work contributes to the design field in the following ways: i) it provides new evidence about everyday artefacts that support well-being and demonstrate that products can produce substantial improvement on well-being (Pohlmeyer, 2012); ii) it offers a detailed characterisation of the well-being supportive experience themes, complementing the broader and general discussion in the design literature, e.g. in Desmet and Hassenzahl (2012), Desmet and Pohlmeyer (2013) and Pohlmeyer (2012); and iii) it offers empirical insights and implications to support the design of well-being supportive products and experiences.

Third, four main CA usage scenarios are identified, along with users' affective responses to the scenarios and associated contributing factors (Yang et al., 2019). The four scenarios describe a picture of how CAs are used in people's daily lives and in what contexts. In prior research (Bittner et al., 2019; Cowan et al., 2017; Huang et al., 2018; Luger and Sellen, 2016; Moore et al., 2017), users' emotional responses to CA experiences were not investigated. This thesis provides findings (Yang et al., 2019) demonstrating how emotions such as interest, joy and activation are elicited in different use scenarios. What is more, the thesis identifies a series of pragmatic and hedonic factors, which correlate with the affective responses.

This work contributes to the CA design field in the following ways: i) the four scenarios provide a structured way of analysing what people do with CAs, which can benefit designers and researchers in their own investigation of CA experiences; ii) the results of the emotional responses to different scenarios suggest directions to design CAs that elicit more positive emotions; and iii) the characterisation of the influencing factors provides implications for designing positive CA experiences through the facilitation of positive factors and the mitigation of negative ones.

Fourth, the needs of competence, autonomy and relatedness are examined with regards to the use of CAs. New insights into the CA users' perceptions and expectations on the three needs are obtained. In prior works on CA designs (Danielescu and Christian, 2018; Fast et al., 2018; Moore et al., 2017; Reeves et al., 2018), SDT had not been explored to drive design insights. Recognising its effectiveness in improving the user experience in other domains, such as game design (Ryan et al., 2006), this thesis takes the SDT approach to develop new understanding of what the three needs entailed in the CA experiences are. Specifically, it has illustrated how: users' knowledge of the CA capabilities and the effectiveness of the conversation may affect the sense of competence, the flexibility to control the conversation and to manage data may affect autonomy, and how CAs can support or undermine relatedness. These insights enable the development of informative suggestions for supporting the fulfilment of the needs in CA design.

This work contributes to the CA literature in the following ways: i) it extends the existing understanding of CAs through the exploration of SDT; ii) it offers suggestions to improve user competence and autonomy in CAs; and iii) it proposes new approaches through which relatedness could be supported with CAs. It also presents challenges explaining why relatedness may be undermined in CA interactions and makes suggestions to overcome these challenges.

And fifth, a set of specialised CA design guidelines have been developed, which complement existing guidelines such as UI design heuristics (Nielsen, 1995) and Human-AI interaction guidelines (Amershi et al., 2019). The newly developed guidelines address the fact that the existing guidelines are not fully applicable to CAs and overlook the conversational aspect of the interaction, which is, by contrast, the core of the CA interaction.

This research contributes guidelines that are centred around the CA-user conversations and associated factors. This includes suggestions to design effective and natural conversations, consider the tone and politeness of CAs, respond resourcefully when a system error occurs, educate users on CA capabilities, personalise user conversations, and offer data control and management options. These guidelines are developed through the lens of SDT, and offer actionable guidance to support the needs of competence and autonomy with CAs.

1.5 Thesis Structure

This thesis consists of six chapters as outlined below.

Chapter 1 ('Introduction') sets the stage for this thesis, providing the high-level motivations, the aim and objectives, the research approach, and a summary of key contributions.

Chapter 2 ('Literature Review') reviews relevant works from the fields of Positive Psychology, Human-Computer Interaction (HCI) and Human-AI Interaction. A knowledge foundation is built, and specific gaps are identified from the review.

Chapter 3 ('Understanding Products and Experiences That Support Well-being') presents an investigation of everyday products and experiences, specifically around what experiences are well-being supportive and how do products play a role in creating these experiences.

Chapter 4 ('Understanding Affective Experiences with Conversational Agents') presents an investigation of CAs and associated experiences, specifically around what are users' affective responses, what factors may contribute to a positive or negative experience, and how to design positive experiences.

Chapter 5 ('Designing Positive Experiences with Conversational Agents') presents a three-stage research that explores SDT theory within the context of CAs and uses the insights to drive the development of CA design guidelines.

Chapter 6 ('General Discussion and Conclusions') presents discussion on the main findings of the thesis, followed by the limitations, an outline of future works, and the final conclusion.

This page is left blank intentionally.

Chapter 2 Literature Review

This chapter reviews literature from three domains, Figure 4. I start by covering the literature on positive psychology around happiness and psychological well-being, more specifically, the core constructs of happiness, the determinants, the approaches to improving happiness and the obstacles. Then, I move on to the HCI literature on technology and product design focusing on the main theories and frameworks that have been developed to help improve psychological well-being through the design of interactive technologies. In particular, I review the literature of Human-AI Interaction concentrating on the design of conversational agents (CAs), such as Google Assistant and Alexa. I look at how these new emerging products may affect people's well-being and how to design them in the right way to promote positive effects.

The work reviewed in this chapter highlights the emerging practices and issues and the gaps in the literature, which this thesis aims to address. Reviewing the literature, I found that the lack of strategic and systematic consideration of happiness and well-being in the design process could be one of the reasons why national happiness has not been improved despite the advancement in technology and design. This occurs due to a lack of design knowledge (e.g. an understanding of positive experiences with products) and practical support (e.g. design guidelines). This gap is more evident in the literature on CAs than other product types. This chapter builds the knowledge foundation for this thesis by presenting a theoretical model and highlighting the gaps and research opportunities. More specific literature is discussed in the *Related Works* sections in the corresponding chapters.

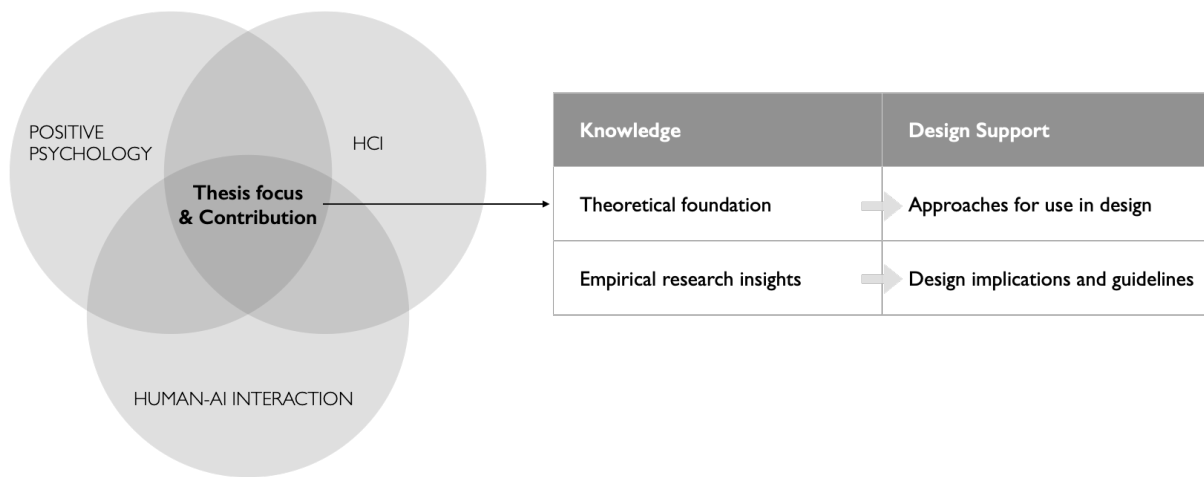


Figure 4. Venn diagram of where this thesis sits compared to relevant literature

2.1 Positive Psychology: The Science of Happiness and Well-Being

Psychology has a long history associated with healing and repairing. For example, one of the core missions of psychology is to cure mental illness, and a large body of research has examined the negative effects of environmental factors such as divorce and damaged childhoods. However, this area of research tends to neglect the positive qualities that can be found in fulfilled individuals and thriving communities, which has given rise to the field of positive psychology, as has been traced by Seligman and Csikszentmihalyi (2000). The authors state that for a long time, one of the central themes of psychology has been prevention, e.g. the prevention of depression and mental illness; positive psychology, on the other hand, focuses on the optimal functioning of people. In other words, it seeks to find ways to make normal people stronger.

Research in the domain of positive psychology achieves this aim by studying the aspects that make individuals, communities, and society flourish; e.g. what are the chief characteristics of happy people; what kinds of families result in children who are happier than others; and which work settings result in greater satisfaction among employees. The field covers topics including hedonic experiences, which are investigated in hedonic psychology (Kahneman et al., 1999), subjective well-being (SWB) theory (Diener, 2000), and other theories on optimism and optimal experiences (Delle Fave and Massimini, 2000; Peterson, 2000; Salovey et al., 2000). It also explores eudaimonic experiences, as discussed by psychological well-being (PWB) theory

(Ryff and Keyes, 1995), self-determination theory (SDT) (Ryan and Deci, 2000), flow (Csikszentmihalyi, 1997), and other theories on wisdom and exceptional performances (Baltes and Staudinger, 2000; Winner, 2000). Well-being research has demonstrated that positive affect is not the opposite of negative affect, and that well-being is not an absence of mental illness (Cacioppo and Berntson, 1999).

The field of well-being research has witnessed two relatively distinct yet overlapping perspectives: the hedonic and eudaimonic views of well-being. The hedonic view posits that well-being means experiencing a high level of positive affect and a low level of negative affect, as well as a high degree of satisfaction in one's life (Kahneman et al., 1999), while the eudaimonic view states that well-being consists of more than hedonic enjoyment, instead lying in the actualisation of human potential (Waterman, 1993). Accordingly, the two traditions of well-being research provide different views on the definition, constructs, measures, and approaches to achieving well-being.

In this section, I will begin by reviewing the two principle academic views (i.e. hedonic and eudaimonic) of well-being. Then, I will move on to a discussion of how these theories are applied in practice; that is, the various approaches to maintaining and increasing happiness and well-being. Lastly, I present a theoretical model that summarises key insights into research on well-being, with the goal of supporting design practitioners with a holistic knowledge foundation.

2.1.1 What is well-being: the hedonic and eudaimonic views

From the hedonic perspective, the definition of well-being involves the presence of positive affect and the absence of its negative counterpart. From the eudaimonic perspective, it focuses on meaning and self-actualisation. The body of knowledge derived from these two views is in some ways divergent, yet in other areas complementary (Ryan and Deci, 2001). It is, therefore, beneficial to consider well-being from a hybrid perspective, and consider it as a complex construct that concerns optimal experience and functioning.

The hedonic view

The hedonic view originated from the concept proposed by the Greek philosopher Aristippus, that happiness is the totality of one's hedonic moments, and thus the goal of life is to experience the maximum amount of pleasure. Among the many recent research avenues that have followed Aristippus' philosophical hedonism, SWB (Diener, 2000) is one of the most influential in the hedonic literature. It contributes to the notion that happiness is associated with an assessment of one's subjective well-being. According to Diener, SWB is a 'subjective definition of the quality of life' that gives each individual 'the right to decide whether his or her life is worthwhile' (Diener, 2000). That being said, SWB not only defines happiness but also provides methods of evaluation that people can perform on themselves. There are three main components to this measuring: life satisfaction (both in general and in specific domains), the amount of positive affect, and the amount of negative affect. In the hedonic literature, happiness⁵ is often used interchangeably with SWB. Table 1 summarises some of the key definitions of happiness in this body of literature.

Table 1. How happiness is defined in the hedonic literature

'Subjective well-being (SWB), is people's cognitive and affective evaluations of their lives. There are a number of separable components of SWB: life satisfaction (global judgments of one's life), satisfaction with important domains (e.g. work satisfaction), positive affect (experiencing many pleasant emotions and moods), and low levels of negative affect (experiencing few unpleasant emotions and moods)'. (Diener, 2000)
'Happiness consists of at least three independent factors: satisfaction of life, positive affect and negative affect'. (Argyle, 2013)
Happiness is 'the degree to which an individual judges the overall quality of his/her own life-as-a-whole favourably'. (Veenhoven, 2011)
Subjective well-being 'refers to one's multi-dimensional evaluation of their lives ,including cognitive judgements of life satisfaction as well as affective evaluations of moods and emotions'. (Eid and Diener, 2004)

⁵ Similarly, in colloquial terms, happiness refers more to feelings of pleasure, a good mood, or a pleasant affect. However, this does not capture the many aspects of well-being that go beyond hedonic pleasure. In this thesis, the term 'happiness' refers to both hedonic and eudaimonic aspects. SWB and PWB are used instead, if differentiation between the two is needed.

As shown in Table 1, from the hedonic perspective, happiness often means experiencing a balanced positive and negative affect, and satisfaction with life both as a whole and in certain important domains. Despite the fact that SWB has been widely associated with the idea of happiness, it has nevertheless been argued that life satisfaction is not merely a hedonic concept, but rather involves cognitive measures of one's life situation. This implies that there is room for greater integration of SWB into a eudaimonic perspective (Ryan and Deci, 2001).

The eudaimonic view

The eudaimonic perspective dates back to Aristotle's view that true happiness is found in the expression of virtue; that is, doing what is worth doing (Ryan and Deci, 2001). While the hedonic view asserts that improving well-being entails maximising positive affect and life satisfaction, the eudaimonic view challenges this, arguing that increasing the number and amount of hedonic moments does not necessarily contribute to people's true happiness. Specifically, it challenges the hedonic view as being limited in its acknowledgment of positive functioning as an indicator of well-being. It is important to differentiate between desires whose satisfaction leads to momentary pleasure and needs whose realisation leads to human growth (Fromm, 1981; Ryan and Deci, 2001). The former may be harmful to human growth, while the latter are in accordance with human nature. For example, watching TV may lead to more momentary pleasure than reading a book, but the latter may be more helpful at producing eudaimonic well-being.

This being so, the eudaimonic view posits that well-being is more than just hedonic happiness; it also concerns people's ability to fulfil their potential and live the life that they inherently intended to live (Waterman, 1993). A eudaimonic experience occurs when people feel fully engaged or authentic and are living in accordance with their values, for which Waterman (1993) uses the measure of personal expressiveness (PE). A comparison between PE and a hedonic measure (i.e. hedonic enjoyment) reveals that although the two measures correlate with each other, they indicate different types of experience. PE is found predominantly in experiences where people feel challenged or have developed a sense of personal growth and self-development, whereas hedonic enjoyment is often to be found in experiences where people feel relaxed, away from problems, and happy.

In line with the eudaimonic perspective, Ryff and Keyes (1995) proposed the notion of PWB, as distinct from SWB. PWB defines six distinctive aspects of well-being: self-acceptance (an evaluation of oneself and one's past life); personal growth (a sense of continued growth and development as a person); purpose in life (the belief that one's life is purposeful and meaningful); positive relatedness (the possession of high-quality relations with others); environmental mastery (the capacity to manage effectively one's life and the surrounding world); and autonomy (a sense of self-determination), Table 2. Studies based on PWB theory have yielded evidence that eudaimonic experiences (as defined by PWB) can contribute to optimal human functioning and promote emotional and physical human health (Ryff and Singer, 1998).

Table 2. Six aspects of psychological well-being (Ryff and Keyes, 1995)

Aspects of PWB	Definition
Self-Acceptance	Possesses a positive attitude toward the self; acknowledges and accepts multiple aspects of self, including good and bad qualities; feels positive about past life.
Personal Growth	Has a feeling of continued development; sees self as growing and expanding; is open to new experiences; has sense of realizing his or her potential; sees improvement in self and behavior over time; is changing in ways that reflect more self-knowledge and effectiveness.
Purpose in Life	Has goals in life and a sense of directedness; feels there is meaning to present and past life; holds beliefs that give life purpose; has aims and objectives for living.
Positive Relations with Other	Has warm, satisfying, trusting relationships with others; is concerned about the welfare of others; capable of strong empathy, affection, and intimacy; understands give and take of human relationships.
Environmental Mastery	Has a sense of mastery and competence in managing the environment; controls complex array of external activities; makes effective use of surrounding opportunities; able to choose or create contexts suitable to personal needs and values.
Autonomy	Is self-determining and independent; able to resist social pressures to think and act in certain ways; regulates behavior from within; evaluates self by personal standards.

SDT (Ryan and Deci, 2000) is another theory that has adopted the eudaimonic view to study well-being. Specifically, it presents three basic psychological needs—competence, autonomy, and relatedness—and posits that the fulfilment of these needs can yield enhanced intrinsic motivation, self-regulation, and well-being, while thwarting these needs can result in negative psychological consequences. These three innate psychological needs delineate many of the meanings and purposes underlying human actions (Deci and Ryan, 2000) and thus define the essential nutrients that must be supplied for people to thrive and flourish. Given that the approaches employed to develop SDT are in some ways different to those for PWB, an important difference between SDT and PWB is that the former defines the principle factor that fosters well-being, whereas the latter defines well-being (Ryan and Deci, 2001). In other words, SDT defines the causes of well-being, and PWB defines well-being itself. What is more, SDT theory has shown that the satisfaction of the three needs generates both subjective as well as eudaimonic well-being. This being so, in positive psychology, it is common for SDT to be used to explain the why of well-being, whereas SWB and PWB are used as indicators or assessing measures of well-being (Nix et al., 1999).

To describe the optimal experience that can lead to a high quality of eudaimonic living, Csikszentmihalyi introduced the state of flow, in which ‘one is completely absorbed in what he or she does’ (Csikszentmihalyi, 1997; Nakamura and Csikszentmihalyi, 2014). Aligning with SDT, a flow experience is where one’s needs for autonomy and competence are satisfied, and where one feels a sense of control and mastery over the activities that one is doing. As stated by Csikszentmihalyi, ‘the best moments in life usually occur if a person’s body or mind is stretched to its limits in a voluntary effort to accomplish something difficult and worthwhile’ (Csikszentmihalyi, 1997). The key to generating a flow experience is to achieve a balance between one’s skill level and the level of difficulty of the challenge at hand, as shown in Figure 5. That entails that the person is skilled enough to perform the task at hand, but finds it a challenge to execute the task well.

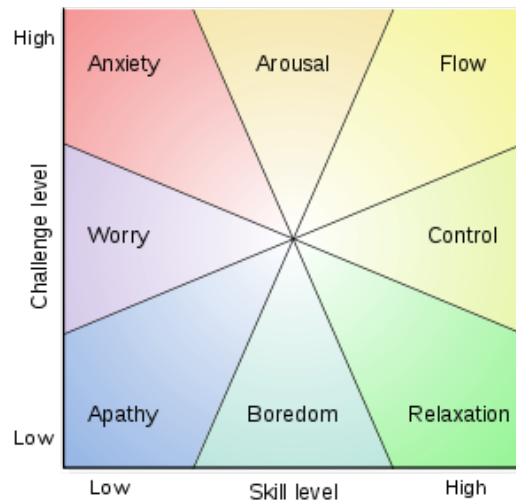


Figure 5. Finding flow (Csikszentmihalyi, 1997)

Resulting differences in the use of terms and measures

As mentioned previously, theories that adopt the hedonic view often use the terms ‘happiness’ and ‘well-being’ interchangeably. Unlike the hedonic view, the eudaimonic perspective distinguishes well-being from happiness per se, and theories adopting this view usually employ phrases such as ‘authentic happiness,’ ‘optimal well-being,’ and ‘human flourishing’ to refer to an increased state of eudaimonic well-being. In this thesis, ‘happiness’ and ‘well-being’ are used interchangeably, referring to both the hedonic as well as the eudaimonic aspects of well-being. Specifically, I borrow the definition proposed by Lyubomirsky, that happiness refers to the ‘experience of joy, contentment, or positive well-being, combined with a sense that one’s life is good, meaningful and worthwhile’ (Lyubomirsky, 2007, p. 32), a definition that I believe allows for a multi-dimensional view of happiness.

Different views on happiness have led to the use of different criteria to measure it. Following the hedonic view, happiness is measured based on people’s subjective responses to life satisfaction indicators, and the positive and negative moods that they have experienced. Examples of measurements include the Satisfaction With Life Scale (Diener et al., 1985) and Subjective Happiness Scale (Lyubomirsky, 2014). These scales evaluate subjective well-being by asking people to rate themselves against items reflecting their subjective life satisfaction, such as ‘*In most ways my life is close to my ideal*’; ‘*The conditions of my life are excellent*’; ‘*I am*

satisfied with my life’; ‘*So far I have gotten the important things I want in life*’; and ‘*If I could live my life over, I would change almost nothing*’ (Pavot et al., 1991).

Distinct from the hedonic view, theories that adopt the eudaimonic view measure happiness based on aspects that are essential for human actualisation, although the approach to measurements is similar (e.g. asking for subjective ratings against items reflecting eudaimonic living). These items are often generated based on well-being theories. For example, measures developed based on PWB theory may ask questions regarding the six aspects—autonomy, personal growth, self-acceptance, life purpose, mastery, and positive relatedness—such as ‘*I lead a purposeful and meaningful life*’; ‘*I am competent and capable in the activities that are important to me*’; ‘*I am optimistic about the future*’; ‘*I am engaged and interested in my daily activities*’; and ‘*My social relationships are supportive and rewarding*’ (Ryff and Keyes, 1995).

Taking a hybrid view

The debate between hedonism and eudaimonia is both ancient and contemporary, and will not be resolved in this thesis. Instead this thesis will take a hybrid view of well-being. Since both traditions have made significant theoretical and practical contributions to the science of well-being, I have decided to review both views separately. More importantly, although they are relatively distinct, the two traditions often overlap and interface with each other. For example, Waterman et al. (2008) found that a person who experiences eudaimonic living is also likely to experience hedonic enjoyment, although not all hedonic enjoyment is derived from eudaimonic living.

In fact, research has suggested that it is beneficial to consider well-being as a multi-dimensional construct that includes both hedonic and eudaimonic conceptions (Compton et al., 1996; King and Napa, 1998; McGregor and Little, 1998; Ryan and Deci, 2001). These studies have shown that a better understanding of well-being may be enhanced by considering both hedonic happiness and eudaimonic foci (e.g. meaningfulness). For example, Seligman’s theory of well-being (also known as PERMA, Figure 6) embraces a hybrid view of well-being at a general level (Seligman, 2018, 2011). PERMA (Positive Emotion, Engagement, Relationships, Meaning, and Accomplishment) defines five elements as the building blocks of well-being. Each of the five

contributes to well-being, and they can be independently defined, measured, and pursued for its own sake.

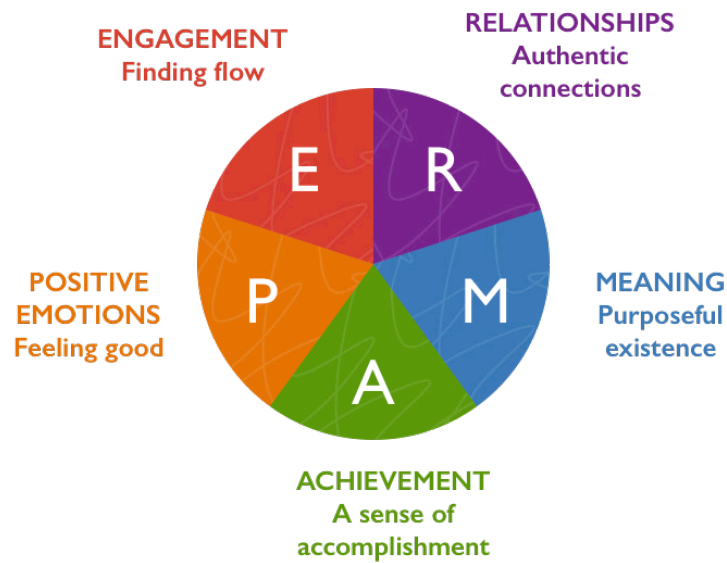


Figure 6. The PERMA well-being theory (Seligman, 2012)

The first element is positive emotion, which encompasses feelings such as pleasure, warmth, and comfort, and pursuing this element could be said to lead to a pleasant life. This element reflects the hedonic perspective of well-being and is consistent with descriptions in the literature on hedonic theories.

The second element is engagement; that is, the state of flow during an absorbing activity when one feels time to stop and a loss of consciousness. Aligning with flow theory (Csikszentmihalyi, 1997), this describes an engaging experience in which people perform intrinsically rewarding activities and feel optimally challenged, relative to their level of skill (Hektner and Csikszentmihalyi, 1996). Engaging in such experiences can increase one's level of concentration, self-esteem, and enjoyment, and often leads to more authentic happiness and an improved quality of life, compared to those with lower flow frequency (Csikszentmihalyi, 1997). Note that engagement is different to positive emotion in that the subjective state for pleasure is often in the present, whereas the subjective state for engagement is retrospective (Seligman, 2011). For example, if you ask people who are in a state of flow what they are feeling, they may reply 'nothing,' and it is only after the flow state that they may say, 'That was

wonderful.’ This is because their cognitive and emotional resources are mostly used up for the activity that created the flow.

The third element is meaning, which means doing something that you believe is meaningful and serves something bigger than the self (Seligman, 2011). This element specifies how one finds meaning in life and how that relates to becoming part of the good life. The idea here is that true meaning is found when one connects oneself to something bigger than one’s own needs and desires; for example, one may find a sense of meaning when volunteering or helping others. However, this does not mean that you have to move away from your own life or perform special activities to pursue meaning; rather, it is up to our sense of responsibility and our own choices of actions in situations that may bring humans together, and that meaning is created each time one chooses to make a meaningful experience (Frankl, 1963). Frankl also argues that to pursue a sense of meaning, one needs to be creative with regard to how one unveils oneself through expressions of love, hope, and compassion in ways that connect with others on either a large or small scale in life (Frankl, 1963).

The fourth element is positive relationships; that is, creating and maintaining positive and healthy relationships with other people. There is no denying the profound influence that positive relationships (or their absence) have on well-being. In fact, studies have shown that interpersonal relationships can be considered sources of support in negative experiences (e.g. people who emotionally engage with others such as friends and family are better at coping with difficult situations and anxiety than those who report themselves to be lonely) as well as in positive experiences (e.g. the amount of joy and pleasure can be increased when it is shared with others) (Seligman, 2011). In Seligman’s own words, ‘other people are the best antidote to the downs of life and the single most reliable up.’ Moreover, research has found that activities involving kindness produce more reliable happiness gains than any other positive activities (Lyubomirsky, 2007; Seligman, 2011).

The fifth element is accomplishment; that is, the act of achieving goals. Research has indicated that achievements in life can be helped by a growth mindset, which refers to individuals who believe that their talents can be developed through hard work, optimal strategies, and input from others (Dweck, 2016). This is because the possession of a growth mindset, as opposed to a fixed mindset (the belief that talents are innate gifts and cannot be easily changed) leads

people to concentrate more on the learning process, which makes them feel more empowered and committed. Various studies have shown the benefits for learning performance and personal growth of embracing a growth mindset (Boaler, 2013; Cutts et al., 2010; Dweck, 2014). One way in which this mindset helps is by closing achievement gaps, instead of hiding them. For example, when you see someone who is better at something that you value, a person who embraces a growth mindset will tend to feel motivated and eager to learn, rather than threatened and envious (Dweck, 2015).

2.1.2 How to improve well-being

Armed with an understanding of well-being, positive psychologists have sought to develop and evaluate strategies that can help individuals to achieve human flourishing. While most people pursue this goal by changing their life circumstances (e.g. earning a greater income, building a more prestigious career, or changing their marital status), research suggests that this is not the most effective way to improve well-being. Instead, a more reliable and sustainable approach involves cognitive and behavioural strategies; that is, how we think and act in our daily lives (Layous and Lyubomirsky, 2013). Psychologists have developed these positive strategies that are founded on the science of well-being and aim to improve well-being through psychological processes.

Positive interventions

Researchers have suggested that to employ these strategies, one should practice positive interventions (or positive activities). These are activities designed and evaluated by empirical research and that, if practiced regularly, can raise individuals from an acceptable level of human functioning to feeling good or great. Positive interventions work by mirroring the thoughts and behaviours of happy people, and in turn improving the happiness of those performing them (Layous and Lyubomirsky, 2013; Parks et al., 2013).

In agreement with the hybrid and multi-dimensional perspective on well-being, positive interventions are often developed on the basis of one or more theories of well-being intended to amplify its various aspects. For example, positive psychotherapy (PPT) (Seligman et al., 2006) was developed based on Seligman's well-being theory, which divides well-being into

manageable components such as positive emotions, engagement, and meaning. The exercises within PPT are designed around these components. For example, the exercise *savouring* is designed around the component *positive emotions*, with the aim of increasing awareness of pleasure and making the pleasant moment last. *Savouring* exercise asks people to ‘take the time to enjoy something that you usually hurry through (examples: eating a meal, taking a shower, walking to a class). When it is over, write down what you did, how you did it differently, and how it felt compared to when you rush through it’ (Seligman et al., 2006).

In addition to PPT, the eudaimonic activity model (EAM) (Martela and Sheldon, 2019; Sheldon, 2018) and the positive activity model (PAM) (Lyubomirsky and Layous, 2013) are among the common models that define the positive activities that one can practice to improve well-being. For more examples of activities and their descriptions, one can refer to the original articles in which the models were proposed [e.g. read more about the EAM (Martela and Sheldon, 2019; Sheldon, 2018) or PAM (Lyubomirsky and Layous, 2013)]. One can also read a summarised list of the positive activities proposed in the book ‘*the how of happiness*’ (Lyubomirsky, 2007). From these resources, it is possible to come across activities such as writing letters of gratitude, counting one’s blessings, practicing optimism, performing acts of kindness, affirming one’s most important values, and meditating on positive feelings towards self and others.

These positive activities are similar in that they are all self-administrated exercises that promote positive feelings, thoughts, and behaviours, rather than directly aiming to fix negative or pathological feelings, thoughts, and behaviours. In other words, they promote well-being by creating positive experiences through which people achieve positive feelings, behaviours, and cognitions, Figure 7. People can choose a variety of activities regarding what to do and think and who to associate with. As Sheldon (2018) has written, wise choices are those that generate satisfying experiences, which in turn brings happiness and improves well-being.

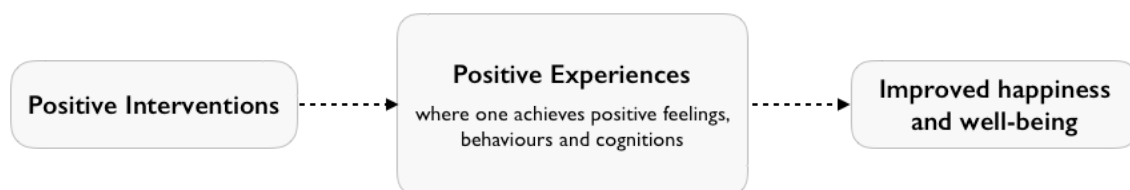


Figure 7. Positive interventions improve well-being by creating positive experiences

Creating a steady inflow of positive experiences

How do people achieve optimal well-being? Sheldon and Lyubomirsky (2019) have claimed that *‘the answer seems to be – by creating and maintaining a steady inflow of positive experiences, experiences that interest, inspire, connect, and uplift them.’* This motivates my research into the understanding and creation of positive experiences through design and technology.

Positive experiences are often those in which people’s psychological needs are satisfied, such as the needs for competence, autonomy, and relatedness, among others (Deci and Ryan, 2008; Layous and Lyubomirsky, 2013; Sheldon, 2018; Sheldon and Lyubomirsky, 2019). For example, activities such as expressing gratitude and practicing optimism can increase feelings of relatedness and autonomy, thereby improving well-being (Boehm et al., 2012), while engaging in goal achievement activities can enhance one’s sense of autonomy and thus bring about improved well-being (Sheldon et al., 2010). Sheldon et al. (2001) have identified ten psychological needs that are predominantly found in these rewarding and satisfying experiences. They consist of the three innate needs proposed in SDT—competence, autonomy, and relatedness—as well as the needs for self-actualisation-meaning, physical thriving, pleasure-stimulation, money-luxury, security, self-esteem, and popularity-influence (Sheldon et al., 2001). This indicates the importance of satisfying needs in the creation of positive experiences.

Depending on which needs are fulfilled, positive experiences could be represented differently. For example, they could be ones that are pleasant (when *pleasure-stimulation* is satisfied), engaging (*competence* and *autonomy*), meaningful (*self-actualisation-meaning*), connected (*relatedness*), or others. We describe some examples of positive experience and how they are achieved through psychological strategies. Doing this allows us to take insights from psychological studies and develop them to inform design.

In a pleasant experience, people often come to a positive evaluation of their life, both in terms of the past (life satisfaction), present (momentary feelings), and future (attitudes towards the future). Examples of emotions felt in relation to the evaluation of past are satisfaction, contentment, fulfilment, pride, and serenity (Seligman et al., 2006). Psychologists have developed activities to amplify the intensity of these emotions such as forgiveness activities

(one lets go of the negative feelings associated with the transgression and the transgressor) (Lyubomirsky et al., 2005b; McCullough, 2000; Seligman et al., 2005). Although not resulting in any behaviour change in the part of the transgressor, the emotional benefits of the forgiveness activity are found to counteract the detrimental effects of negative emotions on both well-being and physical health (Parks and Biswas-Diener, 2013; Worthington et al., 2007).

Moving from past to present, *savouring* activities (whereby one attends fully to an experience without preoccupation or distraction, and focuses on the positive aspects of that experience) are designed to make a pleasurable moment last (Seligman et al., 2006). Savouring can be about relishing ordinary experiences, such as lingering over a morning cup of coffee or tea, absorbing the aroma and texture, and feeling its warmth in your hands, or enjoying a long, hot shower after a cold walk outside. In the words of Lyubomirsky (2007), '*enjoy the little things, for one day you may look back and realise they were the big things.*' Savouring experiences can also be applied to memories of positive past events, which is also known as positive reminiscing. Research has suggested that people who reminisce on a regular basis show a considerable increase in positive affect and life satisfaction, as well as improvements in depressive and anxious symptoms (Bryant et al., 2005).

Emotions about the future include hope and optimism, faith, trust, and confidence (Seligman, 2011, 2006; Seligman et al., 2006). One can cultivate optimism through activities such as picturing one's best possible self (such as writing a narrative description of one's best possible future self on a regular basis). This involves thinking about one's dreams and goals, and the potential outcomes if one successfully accomplishes all these goals (Sheldon and Lyubomirsky, 2006). This best-possible-self activity works well because people who practice it tend to report being motivated to pursue their personal goals, and also derive enjoyment from visualising the realisation of their goals.

While a *pleasant* experience encompasses the hedonic aspects of well-being, other positive experiences concern eudaimonic well-being. For example, an *engaging* experience aligns with theories such as flow (Csikszentmihalyi, 1997), Maslow's self-actualisation (Maslow, 1971), and SDT (Deci and Ryan, 2008). In such an experience, one's attention is completely focused on the activity, and the sense of self is often lost (Csikszentmihalyi, 1997). Happiness can be obtained when one fully engages in work, intimate relations, and leisure. To live an engaged

life, the research suggests that one first identify one's personal strengths and talents, and find ways to utilise these strengths in their lives (Seligman, 2011).

A *connected* experience conforms to theories such as PWB (Ryff and Keyes, 1995), PERMA (Seligman, 2011), and SDT (Deci and Ryan, 2008). In a *connected* experience, people's need for relatedness is fulfilled. This is often achieved through activities that target social interactions. For example, kindness activities focus on performing behaviours for the benefits of others, and their effectiveness on happiness gain has been proved in prior studies (Lyubomirsky et al., 2005b). Similarly, spending money on others can also boost happiness (Dunn et al., 2008). The benefits of engaging in connected experiences are also evident among couples. Research has shown that intimate relationships between couples are more likely to succeed if they respond to each other actively (showing interest and engagement) and constructively (being supportive and encouraging) (Gable et al., 2004).

Likewise, *meaningful* experiences correspond to theories such as PWB (Ryff and Keyes, 1995) and PERMA (Seligman, 2011). To live a meaningful life, one can identify values and beliefs that are bigger than oneself and use one's strengths to serve these values. Since the meaning-making process can often benefit from forming a story about one's life (Pennebaker and Seagal, 1999), activities that produce meaningful experiences often take the form of writing or carefully thinking about one's life. For example, meaning can be derived from the best-possible-selves activity, which asks people to think about or write down their personal values and goals, and imagine achieving them.

Experiential advantages over life circumstances

As discussed above, there are significant opportunities to cultivate authentic happiness by engaging with positive experiences. This is supported by prior research, which shows that happiness gained through experiences is more reliable and sustainable than that gained through life circumstances (e.g. income, marriage), as seen in Figure 8 (Lyubomirsky et al., 2005b).

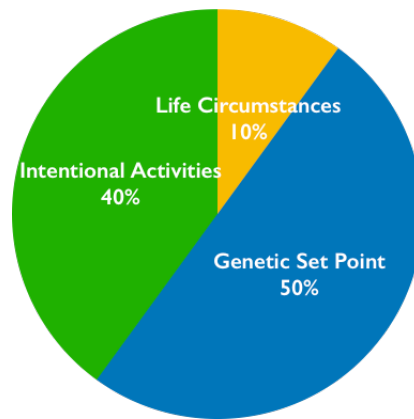


Figure 8. The sustainable happiness model (Lyubomirsky et al., 2005b)

One reason that may explain such experiential benefits is hedonic adaptation, which refers to the phenomenon that both positive feelings (e.g. the joy of love and triumphs) and negative feelings (e.g. the sorrow of losses and humiliations) fade over time (Lyubomirsky, 2011). For example, our happiness increases when we purchase a new car, but such feelings might disappear over time when we get used to the car. Life circumstances play a much less significant role than intentional activities in determining one's happiness, because circumstantial variables are often static and stable, which is easy for people to adapt to, such as by becoming the 'background' to one's life, while activities often require more effort and provide more variety, which helps to keep the experience fresh (Sheldon and Lyubomirsky, 2004). In other words, life circumstances are less resistant to hedonic adaptation than experiences.

Although intentional activities are more resistant to hedonic adaptation than life circumstances, they are still affected, which is one of the biggest obstacles to long-term happiness. To overcome this, Sheldon et al. (2012) proposed the hedonic adaptation prevention (HAP) model, which suggests two ways to forestall the adaptation process. The first is to encourage a continuous appreciation of the original positive changes, while the second is to generate continuous variety in life-changing experiences. To illustrate the first approach, one example is a promotion. After being promoted at work, one might become happier for a short period of time, but one soon adapts to such a good change, and may even start to expect more in life (e.g. a higher salary and status), which often leads to a drop in one's happiness level. To prevent this from happening, one could intentionally seek to appreciate a promotion and its benefits gradually. The essence of this approach is not to take good changes for granted, and not to let them be put into the 'background' so quickly. To illustrate the second approach, an example is exercise. One might

get bored running the same route every day, and the pleasure one derives from running may therefore decrease because of that. To prevent this, one could change the time or route of running, or choose to run with a friend, or even just wearing a new running outfit. The essence is to add variety to an experience and to keep it fresh; ‘*variety is the spice of life and happiness*’ (Sheldon et al., 2012; Sheldon and Lyubomirsky, 2012).

2.1.3 Theoretical foundation

Section 2.1 has so far provided an overview of the literature in the field of positive psychology to inform this research on the design of well-being. The work discussed above has been synthesised into the well-being design model in Figure 9.

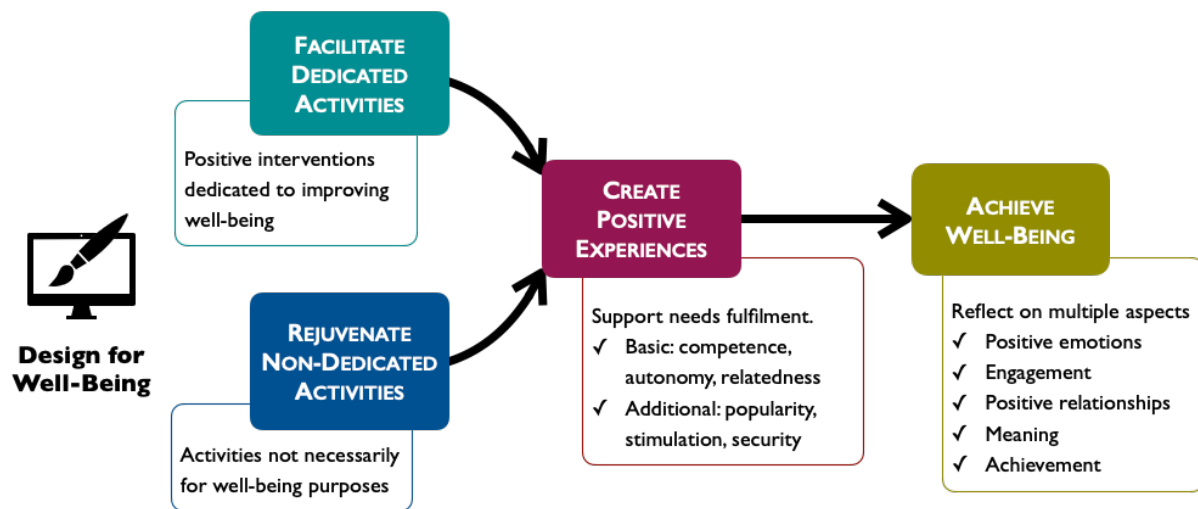


Figure 9. Well-being design model

The model describes how well-being can be achieved and how design can facilitate that process. More specifically, well-being is achieved through a steady inflow of positive experiences. Positive experiences could be gained through two ways: the first is to facilitate dedicated activities (e.g. those proposed in positive intervention strategies, such as gratitude visits or kindness activities); the second is to rejuvenate non-dedicated activities (e.g. ordinary daily activities such as working, commuting or cooking).

This model provides details (derived from positive psychology) that support the creation of positive experiences and ultimately achievement of well-being. For example, positive experiences could be created by the fulfilment of people’s psychological needs. Figure 9

presents six of such needs: competence, autonomy, relatedness, popularity, situation and security. This is a set of needs that are considered suitable for experience design (Hassenzahl et al., 2013, 2010). These needs are derived from psychological research, specifically, the SDT theory (Ryan and Deci, 2000) and Sheldon et al.'s study on the satisfying events (2001). Descriptions on the needs can be found in Table 4. Positive experiences could bring improvement in well-being. This is often reflected in the multiple building blocks of well-being such as improvement in positive emotions or social relationships. One useful theory that summaries such building blocks is PERMA (Seligman, 2011). Figure 9 has borrowed from this theory and presents the following five well-being aspects: positive emotions, engagement, positive relationships, meaning and achievement.

More details on this model are presented below, starting from the ultimate goal (achieve well-being), to the core of achieving the goal (create positive experiences) and, last, the two directions for practice (facilitate dedicated activities and rejuvenate non-dedicated activities).

Achieve well-being. This is the ultimate goal of any positive design practice. Achievements in well-being could be indicated and evaluated by the improvement of its constructing aspects such as positive emotions and positive relationships. In Section 2.1, the various well-being aspects have been discussed in detail. Table 3 presents a summary of these aspects drawing from three representative well-being definitions based, respectively, on the hedonic view (Diener, 2000), the eudaimonic view (Ryff and Keyes, 1995) and the hybrid view (Seligman, 2011). These theories are selected as their primary goal is to define well-being, and this provides the following benefits: 1) instead of focusing on a selection of factors, the theories aim to provide a complete picture of well-being, capturing its many aspects; and 2) the theories carefully decompose well-being into a number of separate building blocks, each of which can be pursued and evaluated independent of the others. Such a set of well-being aspects allows designers to define more granular and specific design goals compared to designing for well-being as a whole.

Table 3. Aspects of well-being

	SWB (Diener, 2000)	PWB (Ryff and Keyes, 1995)	PERMA (Seligman, 2012)
Hedonic view	Balance between positive and negative affect		Positive emotions (past, present, future)
	Life satisfaction	Self-acceptance: Possessing a positive attitude towards the self	
Eudaimonic view		Personal growth: The sense of continued growth and self-development	Achievement
		Purpose in life: The belief that one's life is purposeful and meaningful	Meaning
		Positive relationships: The possession of quality relations with others	Positive relationships
		Environmental mastery: Being competence in managing the surrounding environment	Engagement
		Autonomy: The feeling of independence and acting in accordance to one's own will	

Create positive experiences. A more sustainable way to achieve well-being is through positive experiences as experiences are more resilient to hedonic adaptation compared to changing life circumstances, such as income, location and marital status. Positive experiences can vary greatly depending on what you do and what artefacts are involved. Nevertheless, they have commonalities in that they all satisfy one or multiple of the human psychological needs, for example, the three basic needs of autonomy, competence and relatedness from the SDT theory (Ryan and Deci, 2000). Additionally, Sheldon et al. (2001) have identified ten needs that are consistently met in satisfying events. The suggested ten needs are further narrowed into a set of six that are suitable for experience design: autonomy, competence, relatedness, popularity, stimulation and security (Hassenzahl et al., 2013, 2010), Table 4. The notion of needs satisfaction suggests a way in which positive experiences can be designed, which means to understand user expectations in relation to the needs and design to meet the expectations.

Table 4. A set of needs suitable for experience design (Hassenzahl et al., 2013, 2010; Sheldon et al., 2001)

Needs	Description
Autonomy	Feeling that you are the cause of your own actions rather than feeling that external forces or pressure are the cause of your action.
Competence	Feeling that you are very capable and effective in your actions rather than feeling incompetent or ineffective.
Relatedness	Feeling that you have regular intimate contact with people who care about you rather than feeling lonely and uncared for.
Popularity	Feeling that you are liked, respected, and have influence over others rather than feeling like a person whose advice or opinion nobody is interested in.
Stimulation	Feeling that you get plenty of enjoyment and pleasure rather than feeling bored and understimulated by life.
Security	Feeling safe and in control of your life rather than feeling uncertain and threatened by your circumstances.

Last, the model describes two general directions that design and technology could follow to support well-being.

- **Facilitate dedicated activities.** This direction focuses on dedicated activities, which refer to those whose primary goal is well-being. Common examples are positive interventions suggested by psychological studies such as kindness activities, exercising or gratitude visits. Following this direction, design and technology are usually used to support the implementation of interventions, for example by facilitating effective practices in busy modern lives or addressing challenges of finding motivation.
- **Rejuvenate non-dedicated activities.** This direction focuses on all other activities that are not purposely carried out for well-being. They include various types of activities typically seen in daily life, ranging from work activities (e.g. drafting documents, replying to emails and scheduling meetings) to personal activities (e.g. commuting, cooking, grocery shopping, TV watching and socialising). Following this direction, design and technology should aim to enhance daily experiences with new perspectives, turning ordinary experiences into positive ones, for example, turning routine

commuting into opportunities for learning or practicing mindfulness. In contrast with dedicated activities, focusing on non-dedicated everyday activities opens up greater new opportunities for creative design ideas.

Overall, the model not only serves as the knowledge foundation for my research presented in this thesis, but it could also be used to support, inform and inspire future design and research practice with an interest in supporting well-being.

2.2 Positive Design and Technology

There has been growing effort in the pursuit of happiness and optimal well-being among individuals as well as in societies and nations, as evidenced by the United Nations' adoption of a resolution on happiness in 2011 (Assembly, 2011) and the publication of the World Happiness Report since 2012. These efforts emphasise the importance of well-being on public policy and associated developments. As psychology has demonstrated, improvement in well-being brings several beneficial consequences that make people successful in many life domains, including but not limited to physical and mental health, career, personal development and social relationships (Lyubomirsky et al., 2005a).

Given that well-being as a goal is beneficial, perhaps even necessary, the question is, do we need to explicitly focus on well-being in the disciplines of design and technology as well? The answer is yes. This is partly due to the inevitable influence that products⁶ (being technology products or traditional industrial artefacts) have on how we feel, think and behave – in general, how we live. In the literature, there has been a growing interest and body of work exploring the roles that design and technology can play in supporting well-being.

⁶ The term product, as used in this thesis, signifies a much broader concept than its commonly perceived image – an industrial, often mass-produced artefact created by industry. A product may be physical (such as a coffee-maker), virtual (such as computer software, systems or services) or a combination of both (such as a smartphone with software).

In this section, I review the body of work within the HCI literature that has focused on this topic. First, I discuss why designers, researchers and practitioners need to take responsibility for explicitly setting well-being as one of the goals for product design and development. I then discuss how design and technology can help provide an environment to make well-being more likely, for example the roles that design and technology can play in supporting well-being, the approaches to achieving it and the available frameworks and theories in this field. To conclude this section, I identify the gaps and research opportunities that motivated my PhD work.

2.2.1 Why is ‘design for well-being’ a responsibility?

Our life is inevitably shaped by the artefacts involved in it. This pertains to the philosophy that people utilise tools and materials not only to survive, but also to engage in self-realisation (Lee, 2009). In other words, it recognises the profound roles that ‘things’ play in human development. Given that well-being is ultimately a consequence of daily experiences, which are shaped by surrounding artefacts and products, there is a need to design ‘things’ so that they generate positive experiences.

A transformation is currently taking place in society as it moves from a materialistic (i.e. material wealth is the direct source of happiness) to a post-materialistic value system (i.e. higher priority is given to the fulfilment of personal goals and self-actualisation; material wealth, on the other hand, is considered only a means of achieving these goals) (Inglehart, 2015, 1971). This transformation opens up new opportunities for design because products can be seen as proxy to meaningful activities and experiences (Desmet and Pohlmeier, 2013). For example, a TV may not be designed as just an entertainment device, but also as a glue for family and social gatherings. A car can be created beyond its utilitarian function to move across space, as a space that enables autonomous experiences (individually) or social experiences (with others). In this case, design goes beyond ‘problem solving’ and towards inspiring and empowering people.

This revolution not only makes it possible to design for well-being, but also to promote well-being on a large scale. With modern developments, it can be seen how products have made our life more efficient and practicable such as faster transportation, better housing, modern tools, and technologies. These remarkable advancements can be the result of the ‘problem-solving’ approach that is popular in the design and engineering world. Despite the fact that these tools

have made our lives easier, they have not made us much happier or psychologically healthier [as indicated by the World Happiness Report 2019 (Helliwell et al., 2019)]. This means that it may not be adequate to merely solve practical problems of life; design should aim for more—that is, to focus on the emotional and social aspects of people’s lives, with the aim of promoting human flourishing.

One of the main reasons why products and technologies have not lived up to their full potential to support our well-being is that developers tend not to actively consider well-being in the design cycle (Calvo and Peters, 2014). This may be explained by the lack of awareness and support to help designers and engineers to consider the psychological aspects of human functioning, and translate them into design and development.

In this regard, designers, researchers, engineers, and decision makers should all accept the responsibility to create ‘things’ that make the world a happier place.

2.2.2 The psychological stand

If ‘design for well-being is a responsibility, the next question is how. To answer this question, it is first and foremost necessary to understand what causes well-being and how to improve well-being. The discipline of positive psychology has provided such an understanding; a comprehensive review of the science of happiness and well-being can be found in Section 2.1. Two key elements stemming from that literature are outlined below.

The first is the acceptance that happiness or well-being is a combination of both hedonic and eudaimonic aspects. This is in line with Lyubomirsky’s definition of happiness: *‘I use the term “happiness” to refer to the experience of joy, contentment or positive well-being, combined with a sense that one’s life is good, meaningful and worthwhile’* (Lyubomirsky, 2007, p. 32). This means that ‘design for well-being’ does not just refer to the design for a pleasant life, but also to the design that promotes good and meaningful life. More specifically, in addition to hedonic pleasures, well-being also comprises eudaimonic elements such as personal growth, life purpose and meaning, positive relationships with others, motivation and engagement, and self-determination (Csikszentmihalyi, 1997; Deci and Ryan, 2008; Ryff and Keyes, 1995; Seligman,

2018). Despite variations in wording, the existing design frameworks and approaches discussed in the following sections all agree in general about the multi-dimensional concept of well-being.

The second is the notion of seeking positive experiences, which entails that the prevention of pain does not guarantee well-being; it only helps reach a neutral (or acceptable) level, but an absence of negative does not necessarily equate to positive. As the World Health Organisation has stated, *'health is a state of complete positive physical, mental, and social well-being and not merely the absence of disease or infirmity'* (World Health Organization, 1946). Different strategies are needed to move towards positivity. In parallel, in the design and engineering field, although problem-solving may complement human weaknesses or even reduce them, a new perspective is necessary that is centralised on the promotion of positive states in order to help people to achieve optimal human functioning and fulfilling experiences (Desmet and Hassenzahl, 2012).

2.2.3 The role of products in supporting well-being

As described in his book (2005), Verbeek points out that products play a mediating role in shaping human experience. Products could mediate people's sensorial perceptions. Imagine 'seeing' an object even without using it may evoke certain human emotions. Products also largely mediate people's actions, as Verbeek (2005) explains, human actions are often shaped by the things they use and influenced by the environment created by the things. What Verbeek's view suggests for the design of well-being is that, products and technology should embody this mediation, for example, by providing an environment that makes well-being more likely. In the HCI literature, the roles of design and technology in supporting well-being has been discussed at great length (Calvo and Peters, 2014; Desmet and Hassenzahl, 2012; Desmet and Pohlmeier, 2013; Hassenzahl and Tractinsky, 2006; Pohlmeier, 2013). One way to summarise these works is via the Design Well-Being Matrix (Pohlmeier, 2012). This matrix proposes four roles that products can play in supporting well-being, e.g. as the source of pleasure, symbol, enablement and support (Pohlmeier, 2012).

Products can be a source of pleasure. Imagine buying the car that you've always yearned to have, or eventually seeing in person an artwork that you have read about and seen many times online. In these cases, joy comes directly from that product; they are the source of pleasure.

In addition, products can hold symbolic value that boosts well-being. The underlying cognitive reason is that people are more likely to think and behave positively if prompted by memories that carry positive meanings (Diener and Biswas-Diener, 2008). This is why we keep collections of souvenirs, photos, trophies, and things we value because they remind us of friendship, love, achievements, and meanings in life. In some circumstances, the religious symbolism of products may even have a stronger effect on well-being (Pohlmeyer, 2013). Importantly, the symbolic value of products does not always have a direct link with their functional value; a product can hold no value from a functional perspective, but still offer symbolic value to someone. What is more, this value can be subjective to individuals. In other words, the same product may contribute to one person's well-being, but not necessarily have the same effect on another person.

Products can also influence well-being by enabling valuable activities and experiences; this indicates a shift in focus from products to experiences (Desmet and Hassenzahl, 2012). For example, communication tools support well-being by enabling people to connect with each other, while a piano can support well-being by enabling a flow experience. Differently to the above two roles (source and symbolism), this role emphasises that it is the resulting activities and experiences that help improve people's well-being, rather than the products themselves (Pohlmeyer, 2012). For example, one can play different musical instruments and still derive the same flow experience. In this case, products affect well-being because they are often the mediators of the resulting experiences; imagine a poorly designed communication software that might serve to prevent a pleasurable conversation between friends.

Products can be a supporter that motivates and guides people to live a happy and fulfilling life (Pohlmeyer, 2012). The distinction between a supporter and an enabler is that the support role may not directly enable activities or experiences (as do communication tools or musical instruments), but often behave like a coach or guru. Design solutions as a support for well-being-enhancing activities are not uncommon; for example, digital tools support positive interventions such as gratitude visits, kindness activities, optimism activities, and others. Specifically, these tools are designed to tackle any issues that may prevent the successful implementation of the interventions, such as establishing a person-activity fit, balancing the frequency with which one practices activities, discovering and aligning to users' internal

motivation, or changing the exercises one performs (Layous and Lyubomirsky, 2013). Successfully addressing these factors can provide significant value that promotes the effectiveness of interventions. Such a support provider is not limited to digital technologies; it can also take the form of physical products or services, such as a keychain that prompts users to break routines and add more variety to their daily life (Ruitenberg, 2010).

2.2.4 How to design for well-being

In the HCI literature, there is increasing interest in designing towards a goal of increased well-being. Among the most recent developments are the possibility-driven approach (Desmet and Hassenzahl, 2012), the positive design framework (Desmet and Pohlmeier, 2013), experience design (Hassenzahl, 2010; McCarthy and Wright, 2004), and the positive computing framework (Calvo and Peters, 2014), all of which have laid the groundwork for design approaches that aspire to improve quality of life through design and technology.

From problem-driven to possibility-driven approach

The possibility-driven approach was put forward as an effective way of designing pleasurable and meaningful experiences (Desmet and Hassenzahl, 2012). This approach challenges the conventional problem-driven approach, in that it proposes that design should not only help to solve problems, but also bring the possibility of new and fulfilling experiences. If solving a problem brings a situation to a ‘neutral’ position, which is often the final stage obtained by most problem-driven design, possibility-driven endeavours can reach a place beyond neutral and towards good—and perhaps even great (Pohlmeier, 2014).

The problem-driven approach has a long tradition in HCI and industrial design, whereby design and technology are assigned the mission of solving problems (e.g. by making things faster and easier) (Desmet and Hassenzahl, 2012; Roozenburg and Eekels, 1995). Indeed, this approach has led to significant innovations such as the invention of the smartphone, communication technologies, and more recently, smart devices and other ubiquitous technologies. These modern tools and technologies have made our life better by serving a helpful and practical function, and are now widely considered a significant and even a fundamental part of a high-quality life. Given that modern society is well-equipped to and

experienced at removing prevailing problems (i.e. achieving a neutral state of quality of life), the question that remains is: what next? How can we push the boundary further, to unlock human potential and pursue human flourishing? Possibility-driven design, as proposed by Desmet and Hassenzahl (2012), is one way of achieving this goal.

While a problem-driven approach starts with a problem, a possibility-driven approach begins by looking at the possibilities that are rooted in our understanding of human needs and practices (Desmet and Hassenzahl, 2012). Another distinction between the two is that the problem-driven approach focuses on the current state (e.g. what are the problems in the current situation, and how to solve them), whereas the possibility-driven design concentrates on future states (e.g. what possibilities may exist in the future and how can we reach them). This distinction represents a potential risk for problem-driven design; that is, its way of looking at an activity is limited in that it only sees problems and overlooks their potential for eliciting joy and happiness (Desmet and Hassenzahl, 2012).

One example is grocery shopping. From the problem-driven point of view, one could aspire to make the shopping process more convenient and faster (e.g. the emergence of online shopping). However, this view neglects the positivity that may emerge from grocery shopping; for example, conversations concerning the shopping list may spark communication between family members, while for some people, going grocery shopping together in a local store may be a valuable experience for human connection. This also applies to other activities such as cooking, eating, and commuting, which are traditionally considered to be painful routines that need to be fixed, but in fact have great potential to generate joy and happiness.

Positive design: seeking positivity

Positive design targets in particular ways to support human flourishing through design. It translates elements and strategies in positive psychology into actionable design solutions (Pohlmeyer, 2013) and proactively promotes subjective well-being by evoking valuable experiences (Desmet and Hassenzahl, 2012). Within this realm, Desmet and Pohlmeyer (2013) proposed a positive design framework that highlights three essential components (pleasure, personal significance, and virtue) of designing for well-being, Figure 10. Their work is consistent in many aspects with other approaches such as the experiential approach

(Hassenzahl, 2010), the capability approach (Oosterlaken, 2013), and the nudge approach (Mirsch et al., 2018; Thaler and Sunstein, 2009) to design. For example, they all seek to design for quality of life and flourishing; are based on knowledge of well-being and human needs; and explore design innovations by seeing design as an enabler for positive and meaningful experiences (Desmet and Pohlmeier, 2013).

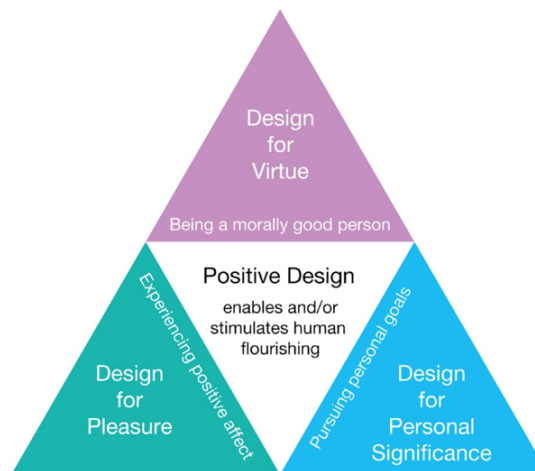


Figure 10. The positive design framework (Desmet and Pohlmeier, 2013)

This framework posits that to generate designs that promote human flourishing, all three components (pleasure, personal significance and virtue) should be expressly addressed in the design process (Desmet and Pohlmeier, 2013). Although based on a loose characterisation of the multi-compositional aspect of well-being, this framework embraces the distinction between hedonism (i.e. a pleasant life) and eudaimonia (i.e. a good life) and the necessity of considering both views. As argued by Desmet and Pohlmeier (2013), all three components are essential and must be included in the design process, although the priority of each component can vary from one scenario to the next.

Moreover, this framework emphasises the explicit and intentional design objective to support well-being. The rationale behind this approach is that it is difficult to find a product that does not make anyone happy, but it is easy to name many successful consumer products that make someone happy in some way, even if most of them were not intentionally designed to be so. The distinction between the proposed positivity-driven design and traditional design approaches (which is dominant in industrial and technology design) is that the former requires the *explicit* intention to design for well-being, and uses that to guide the design process. This is

because in accordance with the possibility-driven approach, it opens up opportunities to reach beyond the problem-solving viewpoints.

Experience design: from product- to experience-oriented

While positive design focuses on translating strategies in positive psychology into new product features, experience design focuses on examining the target experiences and provides ways of designing for that experience. Experience design encompasses a broader consideration of human factors such as emotions and meaning, which has been shown to be a promising approach to achieving enhanced experiences (Hassenzahl, 2013). This has formed part of the User Experience (UX) revolution in HCI, whereby the focus has shifted from products to experiences, and away from usability-centred perspectives to more diverse perspectives, such as the hedonic and eudaimonic facets of UX (Jordan, 2002; Mekler and Hornbæk, 2016; Müller et al., 2015; Norman, 2005).

Hassenzahl (2010) proposed a three-layer model that guides the experience design process, Figure 11. This model suggests that a design should start with *why* (clarifying the characteristics of the experiences that the design aims to achieve, including users' inner needs, emotions, and meanings). Only afterwards can one determine the functionality that is necessary or appropriate to provide that experience; that is the *what* stage. Only then can the *how* (how that functionality can be realised—e.g. details of the interaction or interface design) stage be started. While traditional HCI approaches focus on the *what* and *how*, this model prioritises *why*, which is the experiential side of design. In this way, following this model allows for the design of products that are sensitive to human needs and inner feelings.

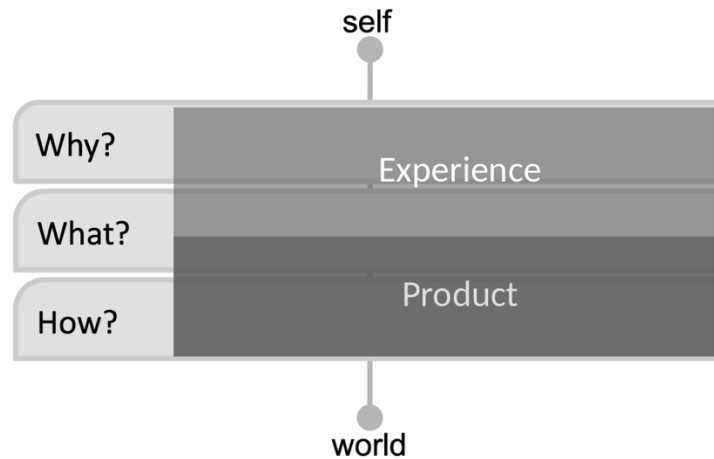


Figure 11. A three-layer experience design model. From *why* to *what* and *how* (Hassenzahl, 2011)

One way of applying this model can be seen in Hassenzahl et al. (2013), who aim to enrich people's everyday lives with positive experiences through artefacts, such as by redesigning the TV-watching experience to fulfil the need of relatedness. Figure 12 illustrates how this process works. This starts with *understanding experiences*: specifically, building experience profiles based on human psychological needs that are identified as potential sources of well-being, such as autonomy, competence, relatedness, popularity, stimulation, and security (Hassenzahl, 2010, 2008; Sheldon et al., 2001). Resulting experience profiles are created for each relevant need, such as connected or competence experiences. This is followed by the *designing experiences* stage: specifically, the experience profile is first distilled into an experience pattern (e.g. abstracting the essence of the experience, regardless of specific details). The pattern is then enriched with scenario-specific details to create new experiences (e.g. a new TV-watching experience could be created based on the connected experience pattern). Lastly, the process is completed via the *designing artefacts* stage: specifically, artefacts are created or redesigned to facilitate newly created experiences (e.g. new systems may be created to shape the newly generated TV-watching experience).

As discussed previously, the *understanding experiences* stage focuses on the *why* of the experience model, characterising experiences based on an understanding of human needs. The *designing experiences* stage examines the *what* of the model, when developers start to design scenario-specific experiences based on the understanding. The *designing artefacts* stage focuses on the *how*, which concerns the specific designs of artefacts in order to facilitate experiences.

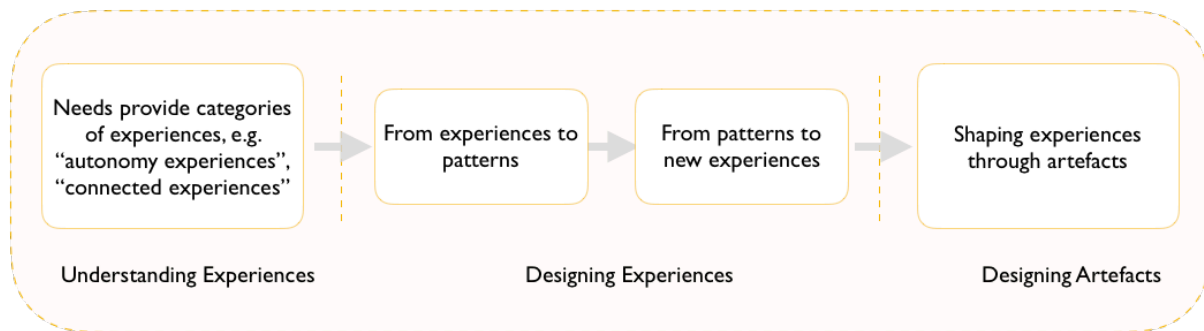


Figure 12. Designing pleasurable and meaningful experiences (Hassenzahl et al., 2013)

This method is effective at extracting patterns from existing experiences and inscribing meaning to material things to create novel experiences. However, there are two limitations that might prevent this approach from being practical. Firstly, this approach is based on the idea that each experience is dominated by one psychological need, which overlooks scenarios for which multiple needs coexist in one experience. Secondly, it has not yet explained how to select the experiences or needs that are to be inscribed to the artefacts. In Hassenzahl et al. (2013), the authors selected the need ‘connectedness’ as the design goal for a new TV-watching experience. It is also reasonable to argue that other needs such as autonomy could also be considered. Overall, this approach would benefit from coming to a more developed understanding of daily positive experiences and ways of identifying users’ psychological needs and requirements.

Positive technologies: supporting well-being

Digital technology has pervaded all aspects of our lives and influences human behaviour in a variety of ways. In tandem with the digital revolution, new technologies have emerged that are intended to empower people and change their behaviour in a way that enhances the quality of our lives. Examples of these include behavioural-change technologies (Hekler et al., 2013), personal informatics (Ayobi et al., 2016; Li et al., 2012, 2011; Pina et al., 2017), ubiquitous computing (Krumm, 2016; Poslad, 2011; Rogers, 2009; Salber et al., 1998), and affective computing (Picard, 2003; Tao and Tan, 2005). Despite the advances in technology that have improved people’s work and personal lives, there remains one challenge in HCI, which is to explore how best to support human flourishing by using the latest technologies and the growing volumes of data in meaningful ways (Calvo and Peters, 2014).

An acceptance of this challenge requires an understanding of positive technology, which can differ from traditional technologies in three ways: the primary design goal (e.g. improving psychological well-being); the assessment metrics for ‘successful products’ (e.g. whether they contribute to users’ well-being); and the theoretical foundation upon which this technology is built (i.e. positive psychology, complemented with features from fields such as cognitive science and social science).

Positive technology could benefit from an interdisciplinary perspective that draws from areas including but not limited to psychology, design, computer science, economics, and ethics. In their contribution to this field, Calvo and Peters (2014) presented a positive computing framework intended to support the design and development of tools to change people’s lives for the better. This framework spans various disciplines, which makes the integration of technology into other areas of well-being-supported work easier and more successful. Specifically, this framework posits that the design centred around well-being should focus on one or more of the determinant factors such as positive emotions, motivation and engagement, self-awareness, mindfulness, resilience, gratitude and empathy, compassion, and altruism (Calvo and Peters, 2014, p. 85). These factors, classified as individual, social, and transcendent, are presented along with the main theories and methods of evaluation. Together, they offer important references and tools to measure how successfully these factors have been designed and implemented.

Most current technology design practices do not show a considered integration of positive technology, which means that most tools and software were not designed with the specific intention of improving well-being. Although it is not uncommon to see cases in which technology has contributed to pleasurable experiences (e.g. video games) or meaningful experiences (e.g. online education), their design and development process has often not systematically considered well-being. Despite this, there are ever more technologies that have been deliberately designed for well-being. Some aim to remove the obstacles that hinder well-being, such as technology-assisted interventions to address social anxiety (Kampmann et al., 2016), while others are intended to directly support activities that promote well-being. For example, behavioural-changing technologies and personal informatics aim to help people to establish positive behaviours and guide people through the process, as can be seen in

meditation, fitness, and mood-regulation apps, and many others (Ayobi et al., 2016; Niedderer et al., 2016; Pina et al., 2017). Another factor that has begun to emerge in modern technologies is the active integration of well-being factors into the design and development of tool, even when their primary function is not dedicated to well-being (Calvo and Peters, 2014). For example, screen-time features on iOS help to monitor and visualise users' smartphone usage, and motivates people to cut back on excessive screen time, which is thought to be unnecessary or unhealthy.

2.2.5 Gaps and research opportunities

It is evident that design holds the potential to empower people to thrive intellectually, emotionally and socially. It contributes to people's well-being and quality of life by providing products that evoke valuable experiences for the user. Instead of limiting itself to solely removing problems and obstacles, the HCI community has accepted the challenge to push the boundaries of design to create optimal experiences and human flourishing. Previous works have set the groundwork giving directions and offering guidance for this endeavour. Reviewing this body of literature has helped me identify the gaps and research opportunities.

First, we (designers, researchers, engineers and other decision makers) should actively take the responsibility to design for well-being. This means intentionally setting a goal that supports individuals' well-being, equipping ourselves with knowledge on well-being and human needs and explicitly utilising this knowledge across the design and development process. However, one noticeable barrier has been identified, which may prevent this from happening: psychological knowledge on well-being is often disconnected and scattered around in the HCI and design fields, making it difficult to efficiently acquire and effectively apply such knowledge in design. There is a need to synthesise the relevant theories on well-being and present them in a way that is useful to inform design.

Second, design for well-being distinguishes itself from the traditional design concept in the following ways: it seeks for the positive rather than acceptable level of one's well-being; it focuses on exploring opportunities rather than solving problems; it is oriented towards experiences rather than products; and it is driven by psychological needs rather than practicability. That being said, existing design support should be updated and adjusted to fit

these new characteristics. Prior research has contributed to this field with supporting frameworks and design approaches, however with limitations. For example, the three ingredients—pleasure, personal significance and virtue—proposed in the positive design framework (Desmet and Pohlmeier, 2013) adopts a loose characterisation of well-being, which could overlook some necessary aspects such as positive relationships or engagement. Since well-being is a complex construct with multiple independent components, it is important to understand the specifics and distinctions between different components in order to successfully design them. For example, the design for positive relationships may be different from the design for virtue. What is more, although the possibility-driven approach (Desmet and Hassenzahl, 2012) has shown to be a promising alternative to the traditional problem-driven approach, finding possibilities is already a difficult task. This makes it harder to apply this approach to a real design practice. To address these limitations, design support should provide sufficient details on the understanding of well-being and offer actionable guidance for design practice.

Third, despite an increasing amount of research arguing for the possibility of designing for human flourishing, there is still scepticism regarding whether products can produce a substantial improvement to an individual's well-being (Pohlmeier, 2012). Research to date is limited to studying the connection between happiness and material wealth (or the material value of products) rather than with design (or the experiential value of products) (Desmet and Pohlmeier, 2013; Diener and Biswas-Diener, 2002). Recent works imply the potential impact that design may have on well-being, but the examples demonstrated in these works [e.g. (Casais et al., 2016; Desmet and Hassenzahl, 2012; Desmet and Pohlmeier, 2013; Pohlmeier, 2012)] are often one-off design examples (e.g. case studies) rather than ordinary products that most people are familiar with. Hence, there is a need to collect empirical evidence regarding whether and how everyday products affect well-being. This empirical evidence not only helps examine the design impact of existing products but also foresees future solutions that have the best potential to support individuals' well-being.

Last, while positive interventions (e.g. gratitude visits and writing journals) are shown to be effective in improving well-being, they introduce extra activities to the user. One drawback of extra activities is the difficulty of keeping a long-term engagement. This is because practicing

these interventions in a long term requires significant amount of motivation, and it is affected by various factors, such as the person-activity fit (e.g. what if the person is too shy to do a gratitude visit), timing (e.g. what if the person cannot find time for practicing), dosage (e.g. how frequently should the person practice the activity) and variations of the activities (e.g. what if the person gets bored of doing the same thing) (Layous and Lyubomirsky, 2013). This suggests an opportunity to reshape the existing activities and ‘rejuvenate the ordinary experiences with happiness’ (Hassenzahl, 2014). This means turning existing activities (such as cooking, coffee-making, cleaning and commuting) into activities that enable people to feel joy, connectedness, meaning, competence and autonomy. It is one thing knowing that positive experiences create happiness, but it is another to achieve them in daily life. Fortunately, it is the strength of design that enables this by turning psychological understanding into action.

2.3 The Rise of AI and Conversational Agents (CAs)

In the past decade, the rise of artificial intelligence (AI) (both in theory and in practice) has revolutionised modern life and the workplace. AI-infused assistance has had an impact on many aspects of our lives. For example, in business, AI has helped to enhance business operations and managements of companies (Gil et al., 2020; Ransbotham et al., 2018; Tarafdar et al., 2019); in education, AI has helped to improve students’ engagement by providing augmented classroom experiences and personalised tutoring (Afzal et al., 2019; Kokku et al., 2018); in healthcare, it offers advanced big data analysis tools, which help with the prevention and treatment of illnesses (Sheth et al., 2017; Yu et al., 2018); in transportation, it advances this domain with autonomous driving as well as having the potential to optimise energy consumption from electric vehicles (Thangaraj, 2019; Yaqoob et al., 2019); and lastly, AI technologies have also made our homes smarter (Jivani et al., 2018; Zaidan and Zaidan, 2020) and environmentally friendlier (Park et al., 2019).

One key area of AI development is advancing the ability of computing systems to interact with us in a more natural way (i.e. conversational AI). This is represented in applications, such as chatbots and personal assistants (Ram et al., 2018) such as Siri, Google Assistant and Alexa. Conversational AI offers human-like interactions between the user and the system. At a higher level, it works as follows: first, it uses natural-language understanding (NLP) technologies to

recognise text and the user's speech; it then uses machine learning (ML) technologies to understand and process the user's intent; last, it uses NLP again to respond to the user in a way that mimics human conversation. Besides conversational interaction, conversational AI also provides a level of intelligence, for example, to guide people in their decision-making or to offer personalised recommendations. Nowadays we can easily see such applications on our phones, in our cars, at home and at work, and they provide assistance in a variety of scenarios, such as managing personal tasks (reminders, calendars), providing news and entertainment (music, podcasts) or assisting in meetings (setting up conference calls) (Cohen et al., 2016; Klopfenstein et al., 2017; Yang et al., 2019).

Along with the opportunities, the advances in AI also introduce new challenges to traditional design approaches in the HCI field. In particular, conversational AI marks a significant shift from the command-based on-screen interaction towards self-learnt conversational interaction. This further distinguishes it from other AI applications. Correspondingly, specialised considerations are needed for the design of conversational AI applications.

It is worth noting that although sharing similar conversational interactions, the two types of applications (i.e. chatbots and personal assistants) differ in certain ways. Broadly, personal assistants deal with a diverse variety of tasks (e.g. reminders, music, news, car assistant, food delivery, restaurant recommendations), whereas chatbots are more topic-specific (e.g. a human resource [HR] bot may deal only with HR consultations; an insurance bot may solely help users buy insurance or make claims). In addition, the access devices and modality of the two types may differ. Personal assistants are usually accessed through devices such as smart speakers, TVs, phones and watches, whereas chatbots are often integrated into websites and communication tools, such as WhatsApp or Slack. Because of this, personal assistants generally involve a mix of voice and text-based interactions, whereas the majority of chatbot interactions are text-based. The differences imply that personal assistants could offer more task diversity, ubiquity and interaction variety (voice and text) than chatbots.

In light of this, the studies presented in this thesis have put the focus on personal assistants. This could provide the following benefits: 1) it allows for the exploration of more diverse use scenarios and contexts (not limiting to specific domains and devices); 2) it allows for the study of both voice and text-based interactions (not limiting to text-based only). Such benefits allow

this thesis to generate findings that are applicable to more types of conversational AI applications. Moreover, the value of the findings could potentially increase in future as the line between personal assistants and chatbots is blurring. For example, a chatbot can become a virtual assistant that excels in one particular area, at the same time growing its general skills, e.g. to check weather or exchange small talk. Ultimately, a personal assistant can be a highly personalised and intelligent chatbot that has many hundreds of skills.

This section reviews relevant works on conversational AI. First, I provide the background on my research scope explaining what conversational agents (CAs) are and why I have chosen to focus on them for my research. I then discuss the potential impact of CAs on well-being and people's quality of life. I conclude this section by highlighting the identified gaps and opportunities for studying the positive design of CAs. Together, they motivated my research studies presented in chapters four and five.

2.3.1 Conversational agents

In the literature, the term conversational agent (CA) is often used interchangeably with the terms 'personal assistant,' 'virtual assistant,' 'intelligent assistant,' and 'digital assistant.' Despite this variety in names, CAs are consistently interpreted as applications that provide assistance to the user by 'answering questions in natural language, making recommendations, and performing actions' (Baber, 1993; Hauswald et al., 2015; Luger and Sellen, 2016). Some commonly seen examples of CAs are Alexa, Siri, and Google Assistant. These are software systems that work with various devices, predominantly smartphones and smart speakers, as well as in-car systems, wearable devices, smart TVs, and many others.

To explain this phenomenon briefly, CA systems take users' inputs such as their voice, text, and contextual information, and the captured information is then processed using computing and artificial intelligence technologies such as NLP, ML, and data analysis. The output of the processing is then translated into human language and sent to the user through voice, visual (e.g. text, media), or a combination of both (Canbek and Mutlu, 2016). Current CA applications such as Alexa, Google Assistant, and Siri are increasingly popular among customers and generally considered fun, convenient, and easy to use.

Two of the many features that distinguish CAs from traditional applications are voice interfaces and dialogue systems, which are usually described together as ‘conversation’ (Cowan et al., 2017). This voice-enabled conversation often requires an automatic speech recogniser to transcribe users’ voices as input and convey information to the user either through text or voice outputs (Glass, 1999). Existing CAs (e.g. Siri and Google Assistant) also integrate with the graphical user interface (GUI) in order to provide users with rich and interactive content. Derived from the notion of a ‘virtual assistant’ (Payr, 2013), the primary goals of CAs are to assist users in real time and to learn from users over time to offer ever better support (Cowan et al., 2017).

Previous research has stated that a conversational interface has a number of advantages over a traditional GUI in that it offers more human-like interactions (Moore et al., 2017), as well as by easing complex tasks with filtered information (Brennan, 1990). That is to say, CAs have the ability to provide contextually relevant and personalised responses to users (Brill et al., 2019). Together, these advantages give CAs significant potential to expand their applications in various life domains, and contribute to many of our daily experiences.

The conversational nature of CAs also brings the importance of understanding the characteristics of human-human conversation, more specifically, what the human-agent conversation can learn from human-human conversation. One of the key learnings from the literature is the differentiation between transactional and social purposes of a conversation (Eggins and Slade, 2005; Schneider, 1988). Transactional conversation is often task-based and goal-oriented. Ideally, both parties of the conversation know the goal of their dialog and they work together to achieve that goal. Different from transactional conversation, social conversation is often less about a particular task or goal, but to build or maintain social relationship with other people (Clark et al., 2019; Dunbar and Dunbar, 1998; Malinowski, 1994). Such conversation often takes the form of small talks, greetings or longer interactions and it appears in a variety of scenarios such as gatherings with friends or office chats.

Understanding the two purposes helps explain the similarities and differences between human-human and human-agent conversation. For example, Clark et al. (2019) have found that social is often the principle aim of a human-human conversation, whereas transactional purposes are often dominant in current human-agent conversations. They (2019) have also found that

people's perception on human-agent conversation often takes a functional perspective. For example, trust, in human-human conversation, is often perceived as opening up or sharing vulnerability, whereas in human-agent conversation, trust is often in relation to security, privacy and transparency. Learnings on the different purposes of human conversation and the comparison between human-human and human-agent conversation allows me to better frame my research in the following studies on CAs. It also helps inform the discussion around the design of CAs.

Why CAs

I chose to focus on CAs for part of my PhD research because of the crucial role that conversational interactions play in advancing human-AI relationships and the extensive impact they can produce on human life, including well-being. By connecting CAs with the realm of well-being and positive design, I believe that this research could help to push the boundaries of CA design beyond the typical norms of user satisfaction, and to create further value for quality of life and society as a whole.

Firstly, the ability to communicate in a more natural way is critical, if the human-AI relationship is to reach its fullest potential; as Murray Campbell stated in 'How conversation will usher in the AI future' (2015), *'for people and machines to work together, they need to be able to interact in a much more natural way, and conversation is our go-to way of exchanging information.'* However, the natural progression into conversational interactions is just the first of a series of ever more sophisticated challenges, and it is difficult to live up to users' growing expectations for a natural conversation with machines; rising frustration and disappointment may occur due to the immaturity of NLP and ML technologies. Moreover, people may intuitively expect emotional responses (no matter how nuanced) from machines. Even though people are very aware that they are communicating with machines, it is unsurprising to find that people anthropomorphise them (Purington et al., 2017). It is certain that to meet these challenges, it is necessary to consistently advance technological solutions. On the other hand, an exploration of the design space of conversational interactions may offer effective solutions to mitigating the negative effects of the limitations of technology and meet users' conversational and emotional expectations in more creative ways.

Secondly, the potential impact of CAs on our lives implies valuable opportunities for CAs to improve our quality of life and well-being. In recent years, CAs have been rapidly embraced by businesses and personal users, and the number of CAs in use is likely to grow extensively in the next few years (Moar, 2019). Businesses frequently choose to integrate CAs into their existing enterprise platforms, which could not only offer substantive business value (e.g. through improved customer service experiences) but also promote productivity and collaboration at work (e.g. through automated operations and innovative business processes) (Baier et al., 2018; Bittner et al., 2019; Brill et al., 2019; Koehler, 2018). Beyond businesses, CAs are becoming increasingly popular for domestic and personal use. As CAs come to offer even more opportunities for truly seamless cross-platform experiences, it is likely that we will see the integration of CAs into expanded types of devices beyond smartphones and smart speakers. Juniper has predicted that smart TVs (with CAs integration) and smart wearable devices will grow substantially over the next five years, with growth rates of 121.3% and 40.2%, respectively (Moar, 2019). All these possibilities suggest a future in which CAs form part of people's daily lives, and this has motivated me to explore the opportunities for CAs to improve well-being, as well as the challenges and how to overcome them.

2.3.2 CAs and well-being

The rise of CAs has made it possible to integrate this technology into various life domains, among which is well-being. A review of the literature reveals two themes of such integration, and allows me to identify gaps that have been largely overlooked in prior research.

CAs supporting e-healthcare

The first theme is the integration of CA into existing e-healthcare systems (e.g. assisting home care). CAs enjoy certain advantages over existing computing systems in that they can develop rapport and build empathy with patients (Lucas et al., 2018; Wolters et al., 2016) and offer effective support, which is also referred to as building a therapeutic alliance with patients (Kim et al., 2019). CAs can offer such support to patients by providing reminders, answering questions, and assisting with self-monitoring tasks. These CAs often target particular groups of users. For example, there are CAs that serve as virtual dieticians for diabetic patients (Fadhil and Gabrielli, 2017), where the agents offer personalised advice based on the patient's current

situation, and CAs that help the elderly monitor their health conditions after hospital discharge (Fadhil, 2018). Despite the heavy dependency on computing power and the immaturity of similar applications to date, it has been argued that in the future, CAs will play a leading role in bridging the gap between patients and doctors (Denecke et al., 2019; Fadhil, 2018).

CAs supporting positive interventions and behavioural changes

While the first theme focuses on healthcare for patients, the second concerns supporting positive behavioural change, and the audience could include anyone who wants to maintain or boost physical and psychological well-being. In this theme, CAs are often integrated with systems that support interventions or positive behavioural changes, such as systems to support fitness training (Kocielnik et al., 2018), nutrition (Graf et al., 2015), meditation (Shamekhi and Bickmore, 2015), reminiscing (Nikitina et al., 2018), or helping with anxiety and depression (Fitzpatrick et al., 2017). It is not uncommon to see similar applications in traditional formats (e.g. as mobile apps). In fact, over the last decade, the revolution in mobile technologies has boosted the popularity of such apps, as can be seen in areas such as personal informatics (Ayobi et al., 2016; Li et al., 2012, 2011; Pina et al., 2017), self-tracking (Lupton, 2016; Nafus and Sherman, 2014), and ubiquitous computing (Krumm, 2016; Poslad, 2011; Rogers, 2009; Salber et al., 1998). However, one of the biggest challenges of these apps is that they often fail to sustain long-term user engagement (Fadhil and Gabrielli, 2017), which is vital for positive intervention.

CAs, on the other hand, enjoy certain advantages over traditional applications in the quest to achieve sustainable engagement with intervention strategies. These take user profiles into consideration and are able to provide recommendations that fit individual users' personalities and preferences (Fadhil and Gabrielli, 2017). For example, as described by Graf et al. (2015), an CA has been designed that makes use of various motivation strategies (e.g. suggestion, self-monitoring, comparison, and competition) to effectively motivate users to record their nutrition intake. This allows the CA to employ the strategy that works best for the user (e.g. some people are better motivated by comparisons with peers, whereas others prefer self-monitoring). Moreover, the strategy can change in real time, adapting to a user's changing preferences and needs.

In addition, a few studies (Fadhil and Gabrielli, 2017; Ghandeharioun et al., 2018) have designed CAs that can provide interactions in response to users' emotional states, which is achieved by performing a sentiment analysis of user input (such as in Fadhil and Gabrielli (2017)) or by detecting users' moods from sensor data (such as in Ghandeharioun et al. (2018)). The ability to detect and respond to users' emotions is significant because many human behaviours are strongly affected by mood, such as eating, physical exercises, and mindfulness activities. If CAs are able to respond to users' emotional states, they are more likely to be perceived as intelligent and trustworthy (Bickmore and Cassell, 2001; Lucas et al., 2014).

Overall, CAs have been shown to display a great deal of promise in terms of addressing the existing challenges in positive psychology (Ghandeharioun et al., 2019, 2018) such as the provision of personalised interventions tailored to users' individual personalities, preferences, life situations, and emotional states (Layous and Lyubomirsky, 2013; Lyubomirsky et al., 2005b).

It is worth noting that existing CA applications built for well-being purposes are still in their infancy, and mainly support limited activities with regard to fitness tracking or food recommendations. The majority of these applications use pre-defined rules instead of intelligent responses (i.e. a user's action triggers a pre-defined answer). Current technologies in the areas of sentiment analysis and emotion detection are limited to small sets of simplified data, and more sophisticated ML models and technologies are needed to tackle complex scenarios. Nevertheless, prior studies have shown the value of CAs, which mitigate the limitations of mobile technologies.

2.3.3 Gaps and research opportunities

In their book, Calvo and Peters (2014, p. 90) describe three ways that technology can be built to support well-being: preventive (applications whose primary goal is to remove obstacles and hindrances to well-being), dedicated (applications that are purposefully designed to support well-being and whose primary goal is centred around well-being-related behaviours) and active (applications that are actively designed to support well-being, while having a different goal from well-being behaviours). The two themes of how CAs support well-being (discussed in the previous section) represent the preventive and dedicated approaches. For example, in the case

of the preventive approach, CAs help address social isolation and loneliness of the elderly (Denecke et al., 2019; Reis et al., 2017). In the case of the dedicated approach, CAs support the establishment of a positive lifestyle and behaviour change (Fadhil and Gabrielli, 2017; Ghandeharioun et al., 2019). However, this leaves a large unexplored area of the active approach.

The CA literature has overlooked the opportunity to actively design for well-being, which means enhancing existing CA experiences with positivity through intentional consideration of well-being when designing. As mentioned by Calvo and Peters (2014), the active design approach could apply to applications of any kind, regardless of their primary purposes (whether that is email, calendar, word processing or social media). In other words, the key is to incorporate a positive design concept (e.g. aiming to foster well-being factors) into products that are not primarily built for well-being purposes. Calvo and Peters (2014) use the ‘focus view’ feature of Microsoft Word to explain this concept: although Microsoft Word is not built for well-being purposes, the ‘focus view’ may help improve well-being by facilitating engagement and flow in the writing experience.

Given that CAs have already been applied in many scenarios, from helping with personal tasks (reminders, schedules and play music) to providing recommendations (restaurants, tourist places) and facilitating daily habits (morning routine, weekend routine) (Cowan et al., 2017; Luger and Sellen, 2016; Yang et al., 2019), active design suggests incorporating the existing functionality with a positive design concept. For example, ‘how might a morning routine be designed to boost positivity?’, ‘how might the CA provide healthier food recommendations?’ or ‘how might the CA play music to regulate users’ moods?’. Given the vast diversity of CA uses, numerous opportunities are available to positively enhance the existing user experience.

Therefore, more research is needed to explore the opportunities and understand how to design them. First, to achieve this goal, there is a need to gain a better understanding of CA experiences, both from hedonic and eudaimonic perspectives. Such understanding helps to clarify existing experiences as well as foresee what ‘successful positive experiences’ may look like. Second, after acquiring the knowledge on positive CA experiences, practical design guidance is needed regarding how to design these positive experiences.

2.4 Conclusions

In this chapter, I have reviewed three bodies of research and highlighted new opportunities and challenges at the intersection of positive psychology, positive design and technology, and conversational AI. This chapter has made two contributions to the thesis: first, it provides the theoretical background and knowledge foundation for my research and, second, it outlines gaps and opportunities for future work, upon which this thesis is built.

Reviewing well-being literature in positive psychology provides empirical evidence for me to establish the theoretical foundation for my research, which is summarised in a well-being design model, Figure 9, Section 2.1.3. More specifically, it concludes that well-being is achieved through the accumulation of positive experiences. Increased well-being is usually indicated by improvements in one or more of the well-being aspects. Positive experiences are often found when people's psychological needs are fulfilled, for example, the needs of autonomy, competence, relatedness, popularity, stimulation and security. This model suggests design sets the goal of creating positive user experiences by supporting needs fulfilment. In addition, it points in two directions to achieve this goal: facilitating dedicated well-being activities and rejuvenating non-dedicated everyday activities using positive design thinking.

In the HCI literature, both directions have been explored, although with a higher volume of work on the first direction. For example, most positive design and technology examples have the primary purpose of supporting well-being related activities. This could be seen in behaviour change technologies and digital tools that motivate people to practice positive interventions. On the other hand, the latter direction applies to any type of products, regardless of their functionality. The key is to enhance existing experiences by intentionally integrating well-being into the design. This direction has advantages over the prior one because it does not introduce new activities (thus a burden) to the user. This addresses the issue of long-term user engagement, which is one of the biggest challenges for effective positive interventions (Parks and Biswas-Diener, 2013).

Prior works, such as the experience design approach (Hassenzahl, 2010), the possibility-driven approach (Desmet and Hassenzahl, 2012) and the active design approach (Calvo and Peters,

2014), share the closest connection with the second direction. All the approaches encourage taking the responsibility to explicitly design for well-being, putting the focus on experiences rather than a product, and taking a possibility-driven instead of problem-driven perspective to brainstorm design solutions. They have laid the groundwork for the field of positive design and computing and pointed out the directions for future research at a higher level. However, at a practical level, they are limited in providing sufficient empirical design knowledge and actionable design support. More specifically, two major gaps are identified: first, designers are either provided with insufficient knowledge on well-being or the knowledge is not translated effectively for design use, which makes it challenging to strategically apply this knowledge into design; second, empirical evidence regarding whether and how everyday products contribute to well-being is lacking, which results in limited empirical insights into the design of everyday experiences.

Particularly in the CA literature, the second direction (i.e. actively designing for positive CA experiences) is largely unexplored. Most works concern creating dedicated CA applications to support health treatments or promote well-being. Little work has been found to explore the positive design opportunities for CAs and to provide the necessary knowledge and design support. More specifically, two gaps are identified: first, there is a lack of understanding on the affective experiences of CAs, for example, what the contributing factors are of a positive (or negative) experience and how to facilitate or mitigate these factors in design; second, there is a lack, yet urgent need, of practical CA design guidelines that are grounded in and incorporated with well-being theories.

Chapter 3 Understanding Products and Experiences That Support Well-Being

[Parts of this chapter have been published in (Yang et al., 2017)].

3.1 Motivation

In Chapter 2, the shift of society's focus towards well-being, particularly the growing interest and development in the design and technology fields in order to support well-being, was discussed. However, empirical findings regarding the influence of design on individuals' well-being are lacking. In order to design products that support human flourishing, we first need to gain a better understanding of such products and the experiences they create. Specifically, what makes them well-being supportive and how? This chapter presents the research that was carried out to provide this understanding.

It is increasingly evident that happy people are successful across many life domains, including marriage, friendship, career and physical health (Lyubomirsky et al., 2005a). Sustaining or increasing happiness is one of most people's major goals in life. Since the start of positive psychology (Seligman and Csikszentmihalyi, 2000), considerable progress has been made in understanding the dynamics of happiness and evidencing ways of achieving it. Reflecting on both its hedonic and eudaimonic aspects, happiness is defined as the 'experience of joy, contentment, or positive well-being, combined with a sense that one's life is good, meaningful

and worthwhile' (Lyubomirsky, 2007, p. 32). It has been shown that only 10% of happiness is determined by factors such as money or living conditions, whereas 40% is determined by how we think and act in our everyday lives (Lyubomirsky et al., 2005b). In other words, the pursuit of happiness involves achieving more positive experiences in life. As everyday experiences are inevitably shaped by products, it is impossible to neglect the influence that they have on our lives and the value that they bring to our well-being.

Despite the advancement in product innovation and proliferation of material goods, little is known in terms of their influence on people's well-being. According to the World Happiness Report 2019 (Helliwell et al., 2019), there is no clear connection between the development of the material world and an improvement in happiness. This indicates the possibility that well-being has not been adequately considered in the design cycle of products and technology (Calvo and Peters, 2012). This could be due to the historical tendency of designers and engineers to stay clear of the ambiguity associated with the psychological aspects of the human being or due to insufficient support for designing positive products. Regardless of the reason, there is scope to further explore the opportunities for and approaches to designing products that can produce positive experiences.

The emergence of positive design (Desmet and Pohlmeier, 2013) has begun to bring to light how well-being can be improved via the design of everyday things. New frameworks, such as the Positive Design Framework (Desmet and Pohlmeier, 2013) and Experience Design Model (Hassenzahl, 2010), and approaches, for example the possibility-driven approach (Desmet and Hassenzahl, 2012) and experience design approach (Hassenzahl et al., 2013), have been introduced to guide the design of pleasurable and meaningful experiences. However, it is still unclear if products can have long-lasting effects on well-being and empirical evidence regarding the impact of design is lacking (Pohlmeier, 2013). Gathering such evidence is important as studies investigating the relationship between material goods and well-being (Diener and Biswas-Diener, 2002; Kahneman and Deaton, 2010) often tend to focus on the material value of products, overlooking the potential psychological benefits of products (Desmet and Pohlmeier, 2013). Therefore, it is important to conduct further research to understand how products contribute to our everyday lives and the well-being of people.

The sections that follow present an empirical study to investigate: the products that contribute to happiness and well-being, the experiences created by these products and the roles that products play in creating these experiences. Specifically, it answers the following research questions:

- RQ1: What products could contribute to well-being, and why?
- RQ2: What experiences do these products create, and how?

3.2 Related Works

Achieving well-being from experiences

As discussed in Chapter 2, well-being includes both a hedonic component, which arises from the experience of pleasure, and an eudaimonic component, which arises from self-actualisation and the fulfilment of human potential (Desmet and Hassenzahl, 2012; Lyubomirsky, 2007; Ryan and Deci, 2001).

Experiences, having the potential to yield great expression of the true self, are valuable in providing enduring well-being (Carter and Gilovich, 2012, 2010; Van Boven and Gilovich, 2003). Hassenzahl interprets experience as ‘a story emerging from the dialogue of a person with her or his world through action’ (Hassenzahl, 2010, p. 8). When involved in an experience, people often engage themselves in a meaning-making process (Baumeister and Newman, 1994). That is to say, if such a process yields positive meanings, such as achievement or self-esteem, well-being is more likely to be achieved through this experience.

Experience, as it develops over time, can be characterised as *experience* or *experiencing*. *Experience* refers to practical contacts and observations gathered in the past and it has a beginning and an end that can be named, while *experiencing* refers to a constant stream of ‘self-talk’ when the user-product interaction happens (Forlizzi and Battarbee, 2004; McCarthy and Wright, 2004). This distinction is important as *an experience* or better the accumulation of *experiences* often affects *experiencing* that happens at later times, as illustrated in Figure 13 (Ortiz Nicolas, 2013; Ortíz Nicolás and Aurisicchio, 2011). In the context of achieving well-being supportive experiences, it is thus important to distinguish the triggering factor of well-

being and whether it is a reflection from past experiences or due to the activities involved in experiencing.

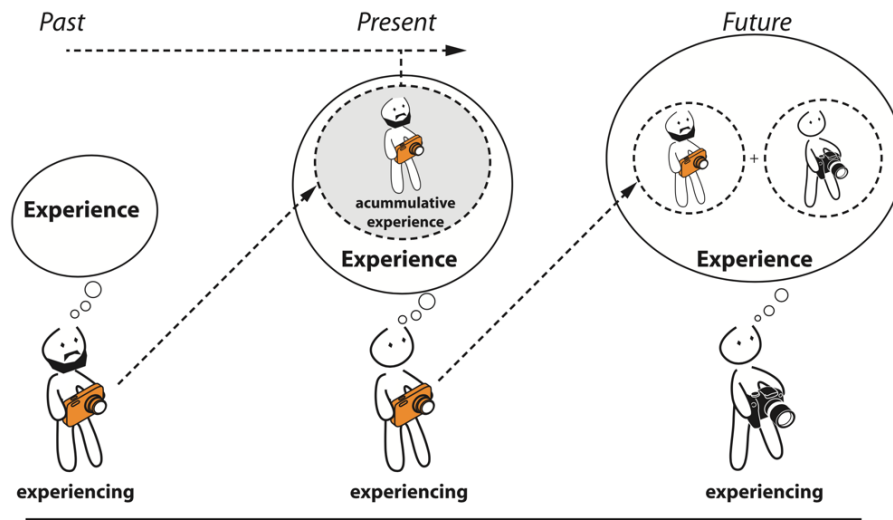


Figure 13. The relationship between experience and experiencing (Ortiz Nicolas, 2013)

Designing well-being through products

In design research, attention has been given to the hedonic component of well-being, in other words the emotional aspects of product experiences (Diefenbach et al., 2014; Mekler and Hornbæk, 2016). For example, Demirbilek and Sener have shown that product attributes conveying 'fun' and 'cuteness' can help convey a sense of happiness (Demirbilek and Sener, 2003). Happiness is also often considered as a positive emotion (Desmet, 2012; Ortiz Nicolas et al., 2013). For example, Norman (2005) points out that emotions such as love and happiness are 'critical to learning, curiosity and creative thought' and that 'being happy broadens the thought processes and facilitates creative thinking'. Clearly, the potential for positive emotions to improve well-being is extensive. However, positive emotions alone are not fully descriptive of well-being (Ryan and Deci, 2001) as they are often momentary forms of pleasure. It is when they co-occur with eudaimonic factors such as personal growth and meaning that they can trigger a greater expression of happiness and long-lasting flourishing.

Over recent years, the field of design has started to adopt a holistic understanding of well-being, emphasising the importance of considering both hedonic and eudaimonic aspects. Noticeable progress has been made in the development of things that can contribute to both a pleasurable

and meaningful life. In his book *Experience Design*, Hassenzahl (2010) posits that the core of designing pleasurable and meaningful experiences is to put the resulting experiences in the fore, in other words human needs and personal meanings should be defined before considering functional requirements. Possibility-driven design is an approach that suggests how to design such experiences (Desmet and Hassenzahl, 2012). Unlike the traditional problem-driven approach that typically starts with a problem to solve, possibility-driven design starts with exploring experiences that have the potential to support well-being and human flourishing. This approach has opened up new opportunities and challenges regarding designing for well-being. The Positive Design Framework (Desmet and Pohlmeier, 2013) further explores how design can contribute to well-being, with it putting forward three positive design ingredients, namely design for pleasure, personal significance and virtue.

Products are an essential part of experience and their values have been studied extensively. In general terms, products shape human experience through the reflective meanings that they carry and the functions that they perform (Arhippainen and Tähti, 2003; Desmet and Hekkert, 2007; Forlizzi and Battarbee, 2004; Hassenzahl, 2010; Hekkert and Schifferstein, 2008; Mahlke and Thüning, 2007; Ortíz Nicolás and Aurisicchio, 2011). For example, in the context of design for well-being, Pohlmeier (2012) proposes four roles that a product may play in achieving well-being: a source of pleasure or meaning, symbol of reflective meanings, enabler of positive activities and supporter of behaviour change and positive thinking.

Research gap

Despite growing research on positive design, there is a lack of literature examining the contribution and influence of products on everyday experiences and well-being. Further research is needed to investigate which products are more likely to support well-being and how. Additionally, more research is needed to understand the experiences resulting from these products, including the personal meaning that is relevant to human flourishing and the contextual factors of these experiences, as well as the roles that products play in shaping these experiences. Such empirical evidence will not only assist with the investigation of existing design solutions but will also inspire future solutions to intentionally design for well-being (Desmet and Pohlmeier, 2013).

3.3 Methods

A qualitative survey study utilising the critical incident technique (Flanagan, 1954; Woolsey, 1986) was designed to conduct an in-depth investigation of the well-being supportive products and their associated experiences. In this study, 87 reports of product-mediated experiences were examined and their association to well-being was analysed.

3.3.1 Data collection

Participants and procedure

The study was carried out online via CrowdFlower⁷. A total of 100 participants (64 male, 36 female) completed the study. They were from 29 different countries (18 from Europe, six from the Americas, four from Asia and one from Africa). The average age was 34.5 years old (SD = 10.3). Participants' educational level was distributed as follows: 18% high school, 59% graduate and 23% post-graduate. Participants were guided through a three-part questionnaire. They were firstly given an introduction and a consent form. If the participant agreed to continue, they were asked to answer questions regarding products and experiences that contribute to their well-being (the details are presented in the survey design section that follows). Lastly, participants were asked to provide their demographic data, including gender, age, nationality and education status. The average task duration for each response is 5 minutes. Participants were given incentives (at an average rate of \$10/hour) as acknowledgement of taking part.

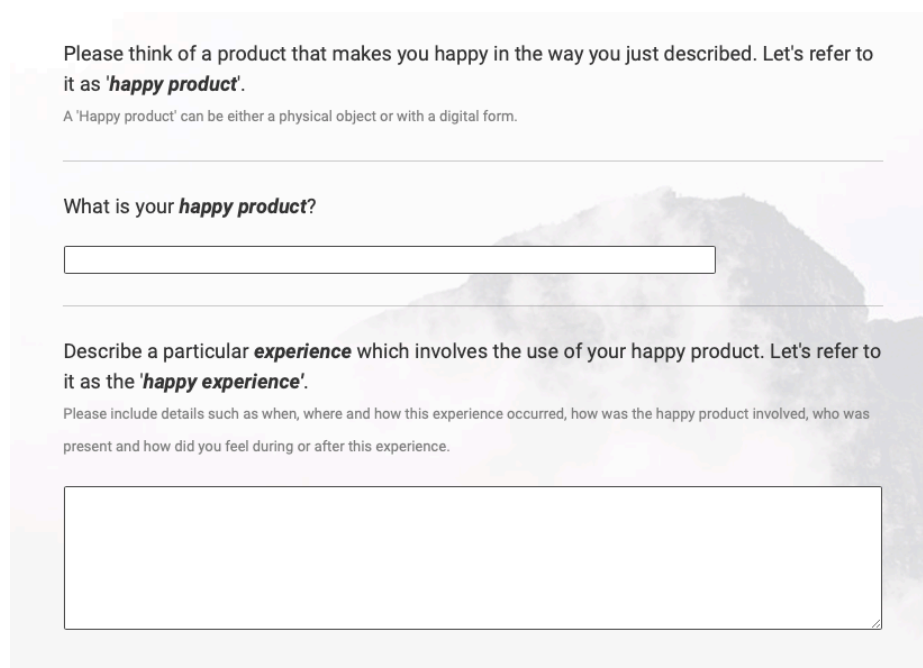
Survey design

To collect data about the well-being supportive experiences, the critical incident method, which has been successfully used to observe characteristics of user experiences (Hassenzahl et al., 2015; Mekler and Hornbæk, 2016; Müller et al., 2015; Partala and Kallinen, 2012; Tuch et al., 2013) was adopted. In the survey, participants were asked about: 1) their general view on happiness,

⁷ Rebranded to Figure Eight in 2018: <https://www.figure-eight.com>

2) a product that typically brings happiness to them and 3) an experience that involves the use of this product. All questions were open-ended.

The first question was asked to set the context and let participants reflect on what happiness truly means to them, thereby allowing this reflection to inform their subsequent answers. Next, participants were asked to write about a product that makes them happy in the way they just described. In terms of the product type or form, participants were explicitly told that it could be any type or form and physical or virtual. After this, participants were asked to describe a particular experience involving the use of this product in as much detail as possible. To encourage and help participants with detailed reflection, they were explicitly instructed to include specifics such as when, where and how this experience occurred, how the product was involved, who was present and how they felt during or after the experience. Similar instructions have been used in previous studies to elicit rich information from participants when using the critical incident method, for example in studies by Hassenzahl et al. (2015, 2010), Mekler and Hornbæk (2016), Müller et al. (2015), Partala and Kallinen (2012) and Tuch et al. (2013). Figure 14 is a screenshot of the survey.



Please think of a product that makes you happy in the way you just described. Let's refer to it as '**happy product**'.

A 'Happy product' can be either a physical object or with a digital form.

What is your **happy product**?

Describe a particular **experience** which involves the use of your happy product. Let's refer to it as the '**happy experience**'.

Please include details such as when, where and how this experience occurred, how was the happy product involved, who was present and how did you feel during or after this experience.

Figure 14. Data collection on products and experiences that contribute to well-being

3.3.2 Data analysis

The analysis started with a cleaning process. With the collected 100 responses, those that were incomplete or did not provide sufficient information were excluded, leaving 87 valid responses. Invalid responses included those that were very short, abstract or did not provide appropriate answers to the questions. For example, one participant reported 'money' as the answer to product and used only one word 'vacation' to describe the experience. Another invalid example was 'sea' as the product and 'go to sea' as the experience. They were excluded as they did not provide enough useful information for analysis. After this process, the following analysis is based on the cleaned data.

Analysis involved two main steps. Firstly, the types of products that participants reported to bring them happiness were identified and categorised. Secondly, themes of experiences were derived following the thematic analysis process outlined by Braun and Clarke (2006). For each theme, the personal meaning relevant to well-being (e.g. connecting with family or entertainment), the activities involved, the contextual factors, the dimensions of experience (an experience or experiencing) and the role of the product within the experience were identified.

Categorising the reported products

The process was iterative and involved two researchers. In the first iteration, an initial set of nine categories was derived by Researcher 1 and reviewed by Researcher 2. The development of the initial category left two responses not categorised, namely social media and WhatsApp. These responses were then reanalysed by both researchers and categorised in the closest category, namely the mobile phones category. This is because social media and WhatsApp are often installed as mobile applications and share similar communication functions. In the second iteration, upon agreement of both researchers, the data was aggregated to improve the distinctiveness of the categories. In particular, computers, mobile phones, video games and TV were classified as subcategories of a new digital devices category. This was driven by the fact that the functionality of these devices often overlaps. For example, a computer can be a hybrid of a mobile phone, TV and game console. Eventually, six categories of products that people reported brought happiness to them were derived.

Thematic analysis of experiences

Following the classification of the collected products, a thematic analysis of the reported experiences was conducted. The analysis involved two researchers. Researcher 1 performed the main analysis guided by the six phases described by Braun and Clarke (2006), while researcher 2 was invited to evaluate the identified themes to ensure that they were clear. In the early phases, researcher 1 analysed the data and coded each experience report in terms of the personal meaning that was important to the user's well-being, for instance connecting to friends and family and self-development. As a result of this coding work, a set of initial themes emerged. While reanalysing the themes, it was found that differences existed between items within the same theme. Therefore, new themes were added and a set of seven themes was established, namely relaxing, entertaining, connecting to loved ones, developing self-image, mastering an activity, learning new knowledge and doing things freely. Researcher 2 was then invited to evaluate the identified themes. He was given a random list of 60 reports and asked to either map the reports according to the existing themes or to suggest new themes. Upon agreement on the mapping of the themes, each theme was further defined, with attention being paid to the naming of the seven themes. Since the analysis was data-driven, the names of the themes were informed by the terminology used by the participants as much as possible. When no suitable name could be found, terms were borrowed from psychological theories.

For each theme, the personal meaning relevant to well-being was described; the participants' activities were mapped into productive, maintenance and leisure activities as proposed by Csikszentmihalyi (1997), Csikszentmihalyi and Graef (1980), Kubey and Csikszentmihalyi (1990) and Larson et al. (1994); the contextual factors were characterised, considering the personal context (the state of the user), social context (social aspects), task context (tasks, actions or activities that the user is engaged in) and device context (characteristics and conditions of the product) (Korhonen et al., 2010) where possible; and finally the dimensions of experience (*an experience* or *experiencing*) (Ortíz Nicolás and Aurisicchio, 2011) and the roles of products within the experiences were examined.

3.4 Findings

This section presents the types of products and experiences that contribute to people's well-being, along with details on why and how. Six types of products are reported to contribute more systematically to participants' well-being. Digital devices and food⁸ are the two dominant product types, followed by vehicles, clothing and accessories, books and sports-related products. These products support well-being by creating hedonic experiences, in which people relieve stress, get rest and receive joy, as well as eudaimonic experiences, in which people establish positive social relationships, develop self-identity, achieve personal growth and gain competence and autonomy. In such experiences, products play the role of carriers of reflective meanings from people's past experiences and the role of enablers of experiencing (the present). These findings provide insights into people's everyday happy experiences and suggest approaches to designing products that create such experiences.

3.4.1 What products support well-being

Six categories of products were identified, Figure 15. Digital devices were found to be associated with productive activities such as working and studying and leisure activities such as socialising, consuming media and pursuing hobbies. Food, vehicles and clothing and accessories were often involved in maintenance activities such as eating, driving or dressing. Books and sports equipment were usually employed in leisure activities such as consuming media and pursuing hobbies. Of the six categories, two categories attracted the author's attention.

It was surprising to find that in almost half of the responses, a digital device was considered as the product that contributed to the participant's happiness, despite the fact that they are a common cause of distraction, anxiety, reduced sleep quality and other mental or physical health issues (Adams and Kisler, 2013). However, the study's findings confirm the double-

⁸ Although food is not a type of product in traditional understanding, it is included in the analysis due to its large portion of appearance in the collected data as well as its potential significant implications for the design of other products. To simplify the description, it is referred to as a type of product in this thesis.

edged-sword nature of digital technology. This research's data implies that the main reason why digital devices contribute to happiness is because they are often a facilitator of activities involving entertainment, communication and learning.

Food, being a special type of product (i.e. not designed and manufactured in the common sense), is the second-largest category being reported. The study's data shows that food often brings happiness because it reminds participants of meaningful memories of family traditions or meaningful life events such as getting married or meeting a first love. The particular food involved in these events, for instance a special vanilla tea or the routine Coca-Cola drunk at family dinner, becomes a reminder of the event. In addition, food can also bring happiness because of its comforting effect, for example ice-cream and chocolate have been found to assist with recovery from a negative mood (momentarily). The sections that follow provide additional explanations about how these products contribute to well-being and why.

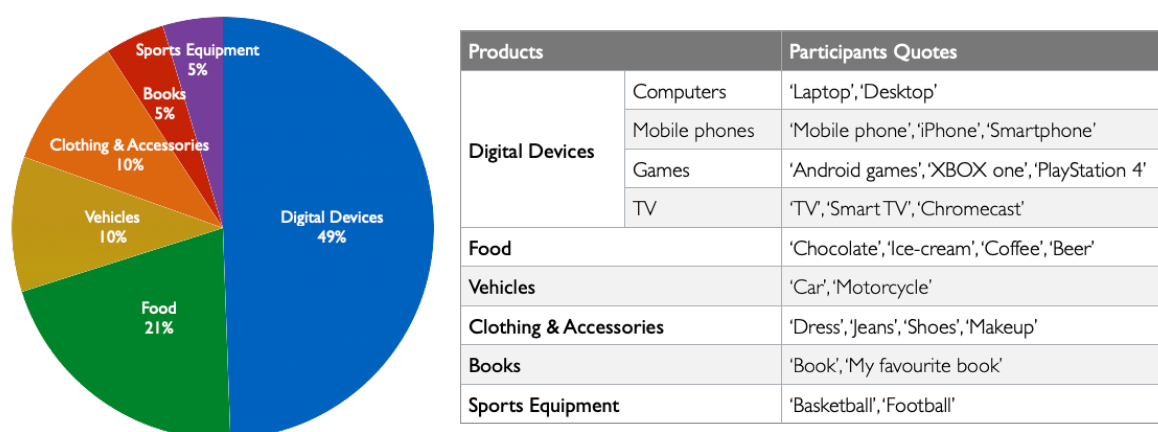


Figure 15. Products that contribute to participants' well-being

3.4.2 How do products support well-being

The findings show that products support well-being via seven themes of experiences: relaxing, entertaining, connecting to loved ones, developing self-image, mastering an activity, learning new knowledge, and doing things freely.

Routes from products to well-being: seven themes of experiences

Figure 16 shows how the reported products are connected with different themes of experiences, through which they contribute to hedonic and eudaimonic well-being. The thickness of the grey lines depicts the frequency of route occurrence. The height of the bar represents the frequency of product and experience occurrence. For example, digital devices comprise 49% of all reported products, thus having a longer bar than other product categories. Similarly, the connecting to loved ones theme appears more frequently than the other themes. Thus, it has a longer bar than the others.

It is worth noting that each product can create or facilitate multiple themes of experiences and vice versa. As shown in Figure 16, digital devices have routes to all themes of experiences. Vehicles come after digital devices, with routes to five themes. For example, a vehicle can create a connecting experience by providing a place where a family undertakes activities together. It may also induce feelings of autonomy in the driver. Additionally, it can entertain someone who drives for enjoyment. The other types of products have routes to at least two or three themes of experiences. Food, for example, can create a connecting experience to loved ones, as participant P26 describes, *‘[my happy experience is] when my whole family and I go to a restaurant that serves my favourite food’*. It can also create a relaxing experience, with participant P57 providing the following example: *‘during the summer when I am in town, I buy an ice-cream to refresh, and I am happy.’*

In addition, each experience theme can be achieved through multiple products. As shown in Figure 16, the connecting to loved ones theme is found to be associated with all product types, and the other themes are associated with two to four types of products. For example, the connecting experience theme can be achieved through food (*‘pizza has a taste that leaves us excited, makes us happy, and joins the family for unforgettable moments’* (P22)) and digital devices (*‘whenever I got text from someone special it made me happy and connected to that special person’* (P68)), as well as other product types.

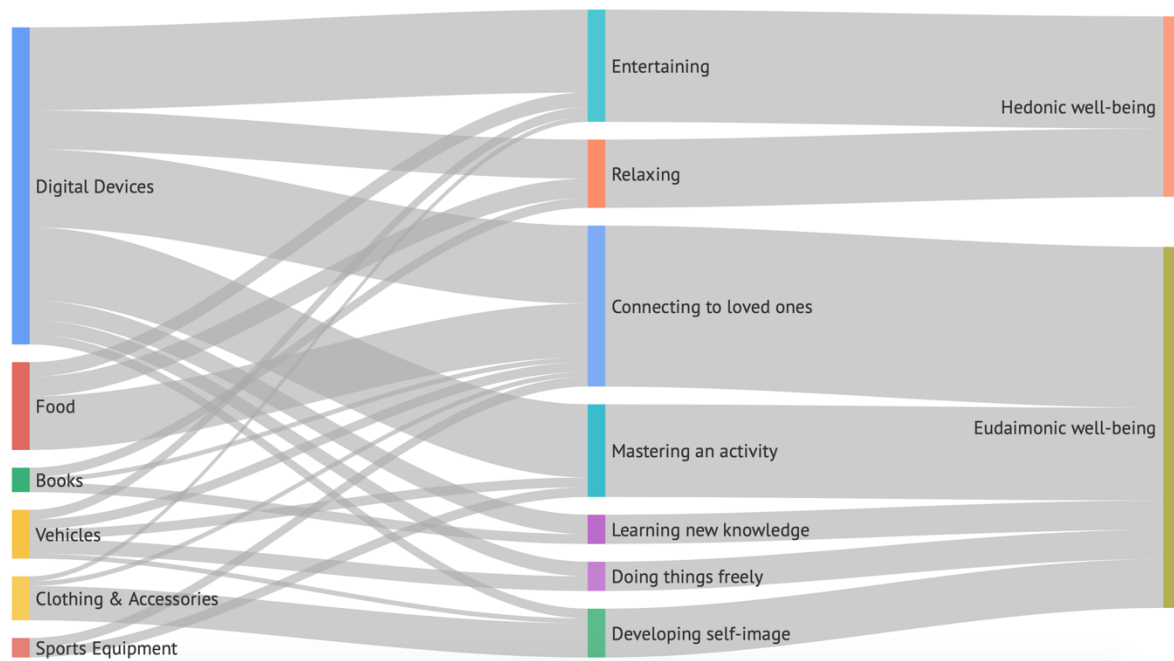


Figure 16. Everyday products support well-being via seven themes of experiences

The following sections present the profiles that describe each of the experience themes. For each theme, the personal meaning central to that experience (why does this experience improve this person's well-being), the types of activities involved (the core acts or behaviours taking place in that particular setting) and the relevant contextual factors (the core context when that activity happened) are explained.

Experience theme: Relaxing

This theme describes an experience where people feel relaxed, calm and relieved after stressful or exhausting situations, Figure 17. One participant (P89) provided the example of relaxing with a cup of tea after a difficult working day, writing '*after a hard working day, Friday, took a dinner in a good place, returned home, took a big cup of tea and a big chocolate*', while another participant (P107) provided the example of recovering after poor exam results with one's favourite meal, writing '*I was in a bad mood due to a failure in exam. But at night when I ate my favourite dish, I forgot about everything and got focused on the future*'.

It is not surprising that food, digital devices and books are among the three product types associated with this theme of experience. The psychological benefits of eating have been proven in previous studies showing that it can significantly improve mood (Wagner et al., 2014) and

elicit positive emotions, for instance the coffee drinking experience (Bhumiratana et al., 2014). Digital devices are the primary means by which people listen to music or engage in other leisure activities. These activities allow people to get rest and recharge. One participant (P87) noted: *‘When I’m listening to my favourite songs, all my problems seem far away and no longer serious and big. I’m feeling stronger, more beautiful and live.’* Books also facilitate such moments of peace. A participant (P104) who designated a book as her happy product described the following scene as her happy experience: *‘Lying on the beach last summer, my husband next to me, sun, sea and my favourite book – Love in the Age of Cholera.’*

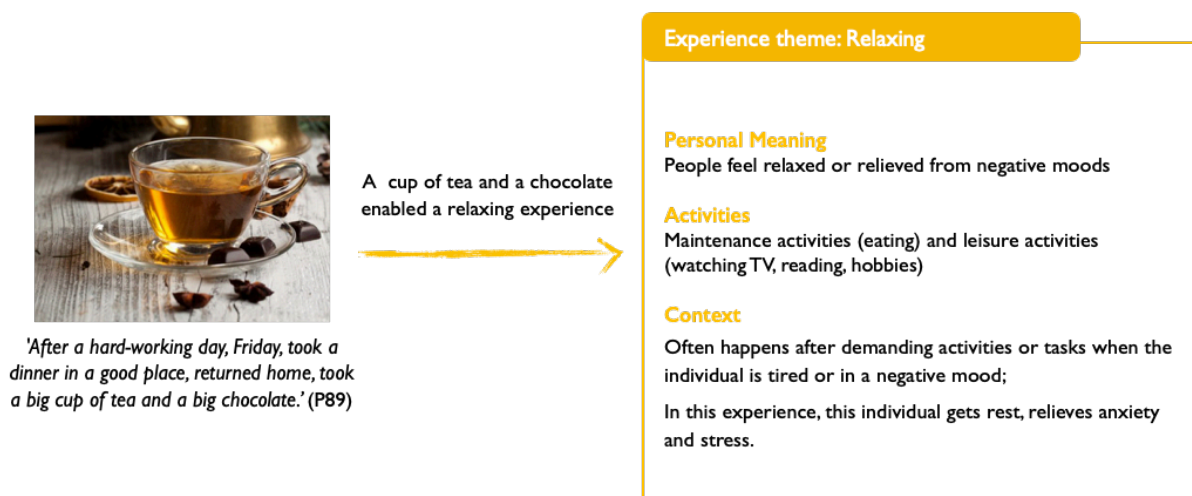


Figure 17. Description of the relaxing experience theme

Experience theme: Entertaining

In this theme of experience, people feel high-arousal emotions such as joy, pleasure and excitement while engaging in playful and pleasurable activities such as games or social gatherings, Figure 18. For example, one participant (P96) noted: *‘Weekends at home, friends and I play games together. I feel excited and passionate.’* It is important to note that the core activity does not necessarily need to be an entertainment activity, but it can be any activity that interests the person or that they engage with. This could be sports, driving or a hobby, for example participant P113 said that riding a motorbike gave him the feeling of ‘magic’. While, for some people, dressing up can be an entertaining experience. Having said that, this experience can be associated with many products; although, as shown by this study’s data, this is primarily linked to digital devices.

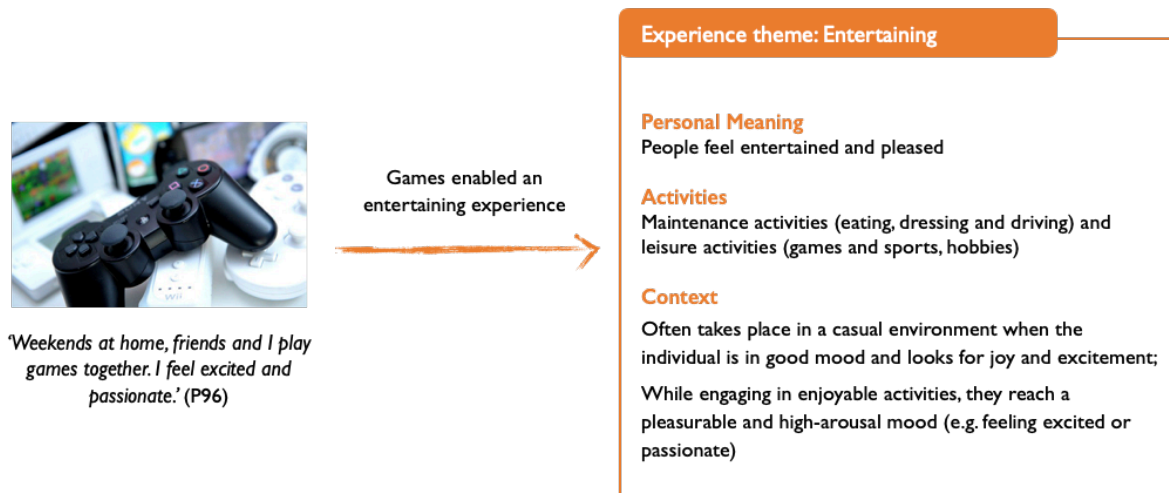


Figure 18. Description of the entertaining experience theme

Experience theme: Connecting to loved ones

This theme supports well-being because in this experience, people feel a sense of belonging and relatedness to the ones they care about, Figure 19. A connecting experience can occur both with and without a social context. Within a social environment, this experience is often attained when a person spends quality time with loved ones. Examples provided by participants were a family trip and a video chat with long-distance friends. When it is not in a social environment, a connecting experience often occurs due to a product triggering reminiscing about a meaningful past experience. For example, one participant (P8) wrote: *'Because of a hot chocolate I met my husband. I associate it with love since then.'*

This study's data shows that digital devices are largely associated with this experience as they provide a means of communication and that food is also frequently involved in connecting experiences as well. Similarly, other product types can facilitate such an experience, for example, one participant's (P98) car allows them to take *'a long-distance trip with his family sharing laugh and joy'*.

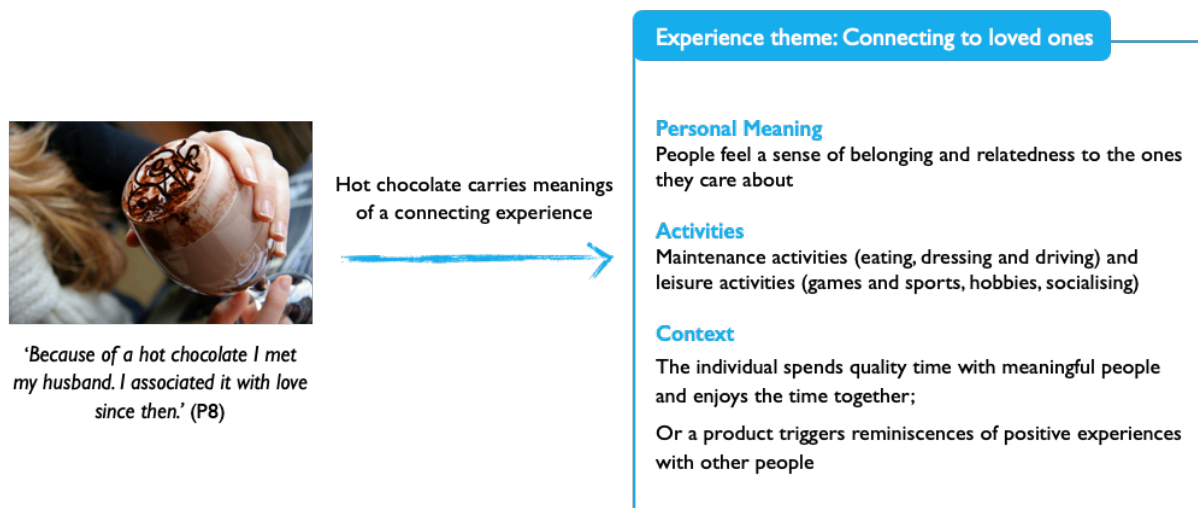


Figure 19. Description of the connecting to loved ones experience theme

Experience theme: Developing self-image

This theme of experience supports well-being because it makes people feel confident and more satisfied with their current self-image, Figure 20. This experience is usually attained when the person receives positive comments about how they look (e.g. 'compliments from colleagues on my outfit') or signals indicating fitness achievements (e.g. 'fitting into a size 2 jeans'). It may also occur through possessing a product that adds value to the person's self-image (e.g. 'a new BMW car'). What's common among these situations is that the person's self-confidence is boosted. One participant (P38) wrote: *'Wearing a beautiful vintage dress from the 1950s to attend a fancy event and feeling happy and confident in my appearance. I enjoyed getting compliments about my look, but what was more important was feeling happy about my own self-image.'* Not surprisingly, this theme was found to be primarily associated with products within the clothing and accessories category that the participants used to improve their personal appearance. They then gained confidence because of these improvements.

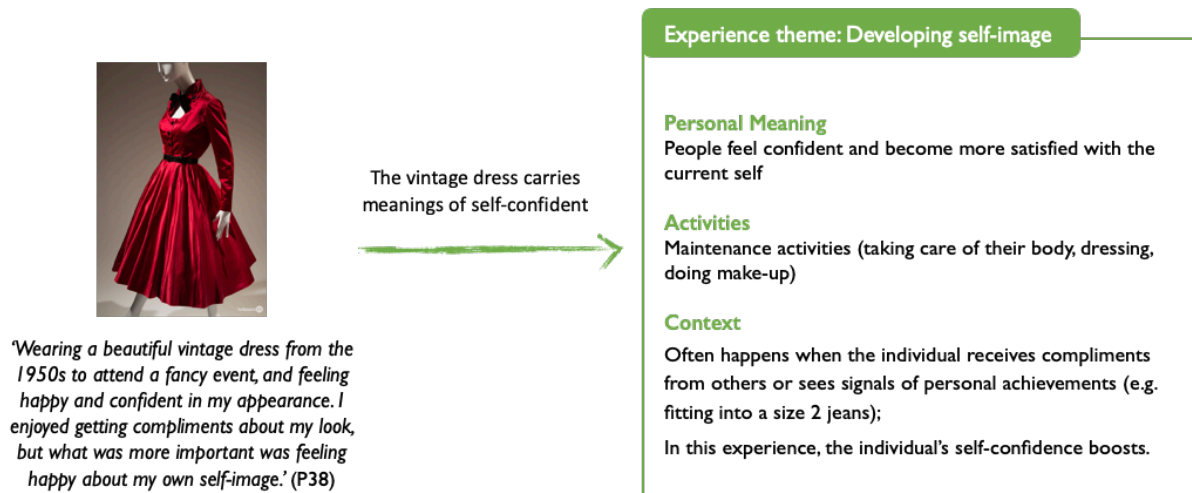


Figure 20. Description of the developing self-image experience theme

Experience theme: Mastering an activity

This experience promotes well-being because people feel a sense of competence and mastery, Figure 21. A mastering experience is often attained when a person has acquired the skills for the current activity, for example participant P3 noted: *'Learning to ride a motorbike and driving fast make me feel happy'*. It is also achieved when a person receives support to handle difficult tasks, for example with the help of a computer one participant (P63) could solve problems independently and work more efficiently, with them noting: *'What I needed, I can get it through the help of my PC.'* As a result, digital devices was the largest product category associated with the mastering experience, with vehicles and sports equipment also featuring.

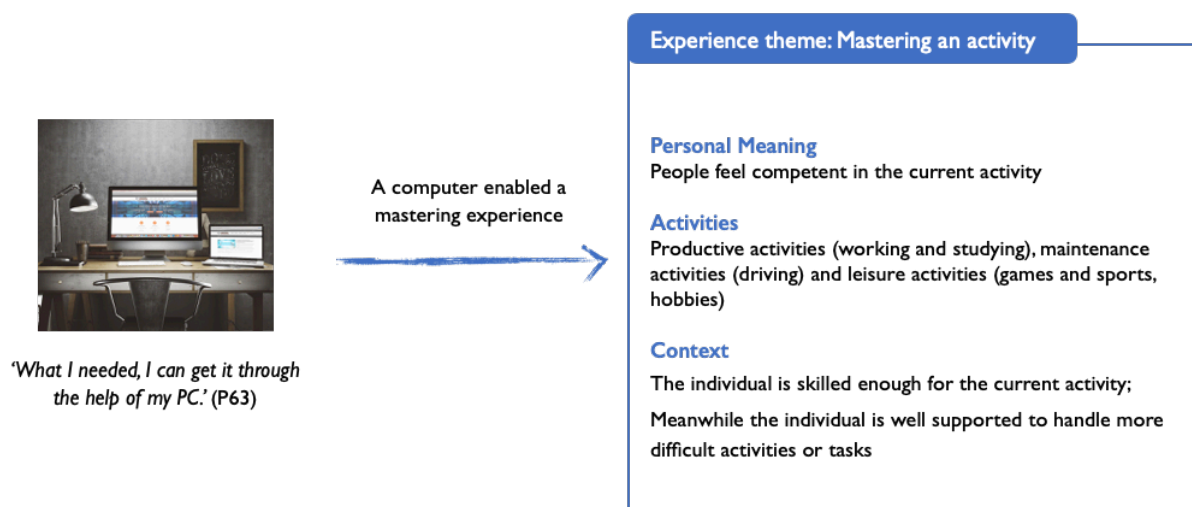


Figure 21. Description of the mastering an activity experience theme

Experience theme: Learning new knowledge

This experience contributes to well-being because people feel a sense of self-development by learning new knowledge and making progress in their personal growth, Figure 22. It is often sought when a person aspires to gain new knowledge. By taking actions to learn, for example taking online lectures, a person develops a sense of achievement. Naturally, this theme of experience often involves productive activities such as working or studying. Importantly, learning also frequently happens during other activities when the primary goal is not to learn, for example while watching a movie for entertainment, having a meal with new friends or reading a book to relax. This means that the learning experience often coexists with other themes and such opportunities should not be overlooked.

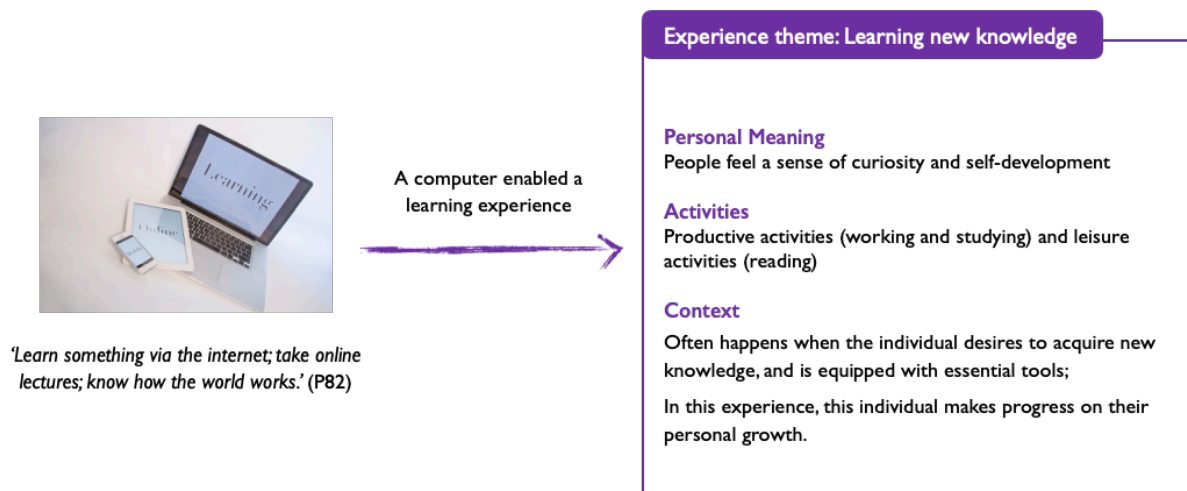


Figure 22. Description of the learning new knowledge experience theme

Experience theme: Doing things freely

This theme of experience improves well-being because people feel a sense of autonomy and self-determination, Figure 23. It often occurs when a person has the freedom to make a choice (physically or virtually) that allows them to feel free. An example from a participant (P78) is: *'I made a pleasant trip using my car which gave me freedom to go to the places I wanted.'* The study's data shows that this experience is often associated with vehicles and digital devices such as computers and smartphones.

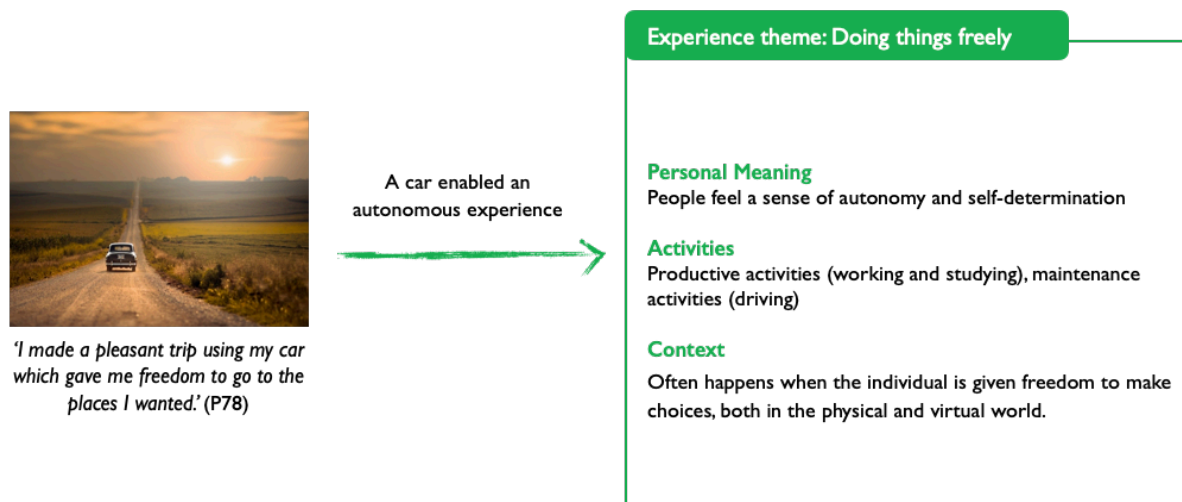


Figure 23. Description of the doing things freely experience theme

3.4.3 Role of products in creating well-being supportive experiences

The results show that products facilitate well-being supportive experiences in two ways: 1) as carriers of reflective meanings from past experiences; and 2) as enablers of experiencing present interactions or events, Figure 24.

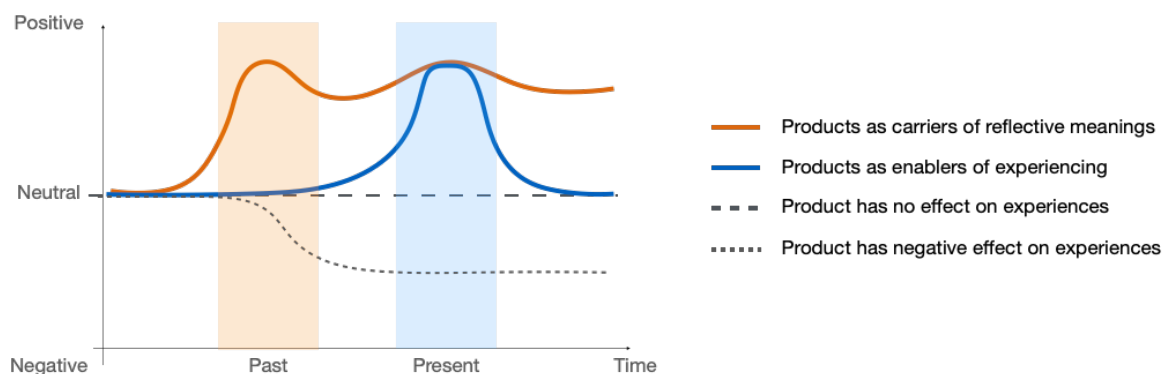


Figure 24. Products play two roles in creating well-being supportive experiences

In Figure 24, the orange solid line illustrates the former case in which something meaningful happened in the past, a product becomes associated with the story and the product brings happiness to future interactions because of the meaning it carries (e.g. *'Because of a hot chocolate I met my husband. I associate it with love since then'* (P8)). In the same figure, the blue solid line illustrates the latter case, in which a product contributes to well-being by enabling a current experience (e.g. *'I talked to a long-lost childhood friend using Skype on my laptop. It was*

a truly happy experience' (P71)). Table 5 provides participants' examples of how these two roles are performed by each product type. In addition to positive experiences, products can also cause users to have neutral or even negative experiences as illustrated by the dotted lines in Figure 24. It is this thesis' aim to help push these experiences into the positive zone.

Table 5. Examples of the two product roles

	Products	Descriptions
As carriers of reflective meanings	Digital Devices	Representation of self-image e.g. receive compliment of having a nice phone
	Food	It is attached with a memorable experience It is this person's comfort food It is related to a family/friendship tradition
	Vehicle	Representation of self-image e.g. a brand-new BMW car
	Clothing & Accessories	Representation of connectedness, achievement and positive attitude
	Books	Representation of positive belief
	Sports Equipment	Representation of connectedness and achievement
As enablers of experiencing	Digital Devices	Enable efficient work and study, social communication, and leisure activities
	Food	Enable a shared experience with friends and family Eating/drinking gives this person satisfaction
	Vehicle	Enable a shared experience with friends and family Enable this person to enjoy a solo free trip Driving gives this person satisfaction
	Clothing & Accessories	Enable this person to receive compliment, improve self-appearance, and to take care of their body
	Books	Enable this person to learn new knowledge, and enjoy time with themselves
	Sports Equipment	Playing sports gives this person satisfaction

3.5 Discussion

3.5.1 Well-being supportive products

Six types of products have been found to support well-being, namely digital devices, food, vehicles, clothing and accessories, books and sports equipment. Of these, digital devices, vehicles, books and sporting goods are types of experiential products (Guevarra and Howell, 2015). This is a class of possessions in between material items and life experiences that is purchased ‘to have in order to do’ (Guevarra and Howell, 2015). These products are designed to create and enhance experiences. For example, digital devices such as laptop computers and mobile phones allow users to utilise and develop new skills and knowledge and connect to family and friends while offering rich multisensory and interactive experiences. Similarly, vehicles such as cars allow drivers and their family to have pleasant travel experiences.

In general, digital devices are social and developmental material possessions that play a significant role in product-mediated positive experiences due to their hybrid functionality and ubiquitous features. This result reinforces the impact that technology has on well-being (Calvo and Peters, 2012) and brings forward the question of how technology can enhance traditional experiences. Although food and clothing and accessories have been traditionally perceived as material possessions serving utilitarian purposes (Guevarra and Howell, 2015), this study’s results challenge this perspective, indicating that these items can also be seen as experiential products. For example, clothing items such as a boutique dress and vintage shoes were both found to support the need for identity expression.

3.5.2 Well-being supportive experiences

The themes of well-being supportive experiences identified in this research could be explained by psychological well-being theories. These experiences make people happier by evoking positive emotions (Deci and Ryan, 2012; Lyubomirsky and Layous, 2013) and help people be successful in aspects such as positive relations with others, environmental mastery, personal growth, purpose in life, self-acceptance and autonomy (Ryan and Deci, 2000; Ryff and Keyes, 1995). More specifically, relaxing and entertaining themes are closely related to eliciting positive emotions including low-arousal emotions such as calm and relaxation and high-

arousal emotions such as joy and excitement; connecting to loved ones theme is closely related to strengthening positive relationships with others; mastering an activity theme is closely related to improving individuals' environmental mastery and the sense of competence in the activity; developing self-image theme is closely related to self-development and the sense of satisfaction with the self; learning new knowledge is closely related to purpose in life; and doing things freely is closely related to autonomy. Although each theme of experience focuses on one aspect only, it may also include others. For example, connecting to loved ones can lead to positive emotions and learning new knowledge can contribute to environmental mastery.

Furthermore, the experience themes presented in this study could be supported by the fulfilment of psychological needs as identified by Sheldon et al. (2001). Specifically, in relaxing and entertaining experiences, the individual's need for pleasure-stimulation is often fulfilled; in connecting to loved ones experience, the need for relatedness is fulfilled; in developing self-image experience, one's sense of self-esteem is improved; in mastering an activity and learning new knowledge experiences, the person's need for competence is satisfied; and finally in doing things freely experience, the sense of autonomy is enhanced. This finding agrees with needs satisfaction theories such as Self-Determination Theory (Ryan and Deci, 2000) and Sheldon et al.'s (2001) conclusion that relatedness, competence and autonomy are among the most salient needs in a satisfying event. On the other hand, this finding suggests that the needs of pleasure-stimulation and self-esteem also have significant importance to product-mediated positive experiences.

Backed by well-being theories and grounded in empirical data, the experience profiles provided in this study offer more detailed mapping of experiences onto the well-being aspects. This is in comparison to the more general consideration of well-being in prior design theories, for example, in Positive Design framework (Desmet and Pohlmeier, 2013), the design of well-being is discussed at a higher level as the design of pleasure, personal significance and virtue. In addition, the experience profiles extend existing design approaches such as the experience design approach (Hassenzahl, 2010; McCarthy and Wright, 2004) and possibility-driven approach (Desmet and Hassenzahl, 2012) by offering insights into how products are involved in each of the experience themes and how they influence the creation of the positive experiences.

3.5.3 Design implications

Each of the products identified by this research can create or facilitate multiple themes of experiences. This result offers two insights regarding designing for well-being. First, the existing connections between products and well-being supportive experiences, as shown in Figure 16, could be employed to strengthen the products' positive impact. Second, new connections could be established to create new possibilities for positive design. It has also been found that each experience theme can be achieved through different products. This result is valuable as it gives designers the flexibility to choose alternative design ideas depending on the end users' preferences and requirements. For example, in the design of a restaurant dining experience, it can be imagined that along with food, digital devices can also be used as design elements to satisfy psychological needs for relatedness and entertainment. However, it is noteworthy that this is relevant to designing experiences rather than specific products as experience design offers the opportunity to specify and integrate multiple experiential products. Finally, the results suggest that to understand how to create positive experiences, it is important to learn from both past and present experiences, as the reflected meanings from the past could be transferred to the present via products.

3.5.4 Limitations

Due to the nature of this study's research questions, its evidence is based on self-reported data. This could be criticised of being highly dependent on the participants' willingness to write a complete story, which is often difficult to guarantee. Despite of this, the critical incident method is believed to be a suitable approach to answer this study's research questions. This is because the study is more interested in understanding people's everyday experiences and the critical incident technique can help achieve this by enabling the collection of rich user experience stories and providing users with the flexibility to report from their own perspective in their own words, consistent with other works in the HCI and design research field, such as that from Hassenzahl et al. (2010) and Mekler and Hornbæk (2016). Nevertheless, this limitation is mitigated by providing participants with specific instructions to help them reflect on and describe their experiences in more detail. Another limitation could be caused by the arrangement of questions on the survey. In the current survey design, all three open-ended questions were revealed to participants on the same screen. This is because it brings the benefits

of adding additional context to each of the questions. However, I acknowledge that seeing the follow-up questions in advance might affect participants' response to the current question, and that showing questions in separate screens may lead to different responses. Therefore, it is worth experimenting with this alternative survey design in future works.

3.6 Conclusions

This chapter presents an empirical study that investigates products and the resulting well-being supportive experiences. It found evidence of six types of products with experiential value that create and facilitate well-being supportive experiences. They are digital devices, food, vehicles, clothing and accessories, books and sports equipment. These products contribute to well-being by enabling seven themes of experiences, where people feel relaxed or entertained, or they feel connected to their loved ones, competent at current tasks, confident about self-image, or satisfied with their self-development or the autonomy they have gained. The results provide implications and inspiration for the creation of opportunities to enhance everyday lives. Moreover, it was found that products play two major roles in creating these experiences: as carriers of meanings from past memorable experiences and as enablers of present experiencing. This study expands the understanding of product experiences emphasising the ones that have the potential to make people psychologically healthier. The results of this study could also facilitate future exploration of products on their positive impact on people's lives.

Chapter 4 Understanding Affective Experiences with Conversational Agents

[Parts of this chapter have been published in (Yang et al., 2019)].

4.1 Motivation

While previous studies of Conversational Agents (e.g. Siri, Google Assistant, Alexa and Cortana) have focused on evaluating usability and exploring capabilities of these systems, little work has examined users' affective experiences.

Conversational Agents (CAs) have been widely discussed since the beginning of this century. At that point, much of the research was around creating and evaluating human-like conversations with machines (Cassell, 2000; Cassell et al., 1994; Cassell and Thorisson, 1999; Vertegaal et al., 2001). This helped inform how CAs might be designed for wide scale use. In the past few years, CAs have become more ubiquitous. They have become widely available on smart phones (e.g. Apple Siri, Google Assistant), and are increasingly integrated into homes (e.g. Amazon Echo and Google Home) and cars (e.g. Google Assistant integration with Hyundai). Consequently, research has shifted to focus on how CAs can and will fundamentally contribute to many of our daily interactions. Examples of such research include explorations of how CAs can be used in healthcare and problem solving (Graesser et al., 2017; Provoost et al., 2017; Rammohan et al., 2017; Sebastian and Richards, 2017). With CA use now more

common for the average person in everyday life, more research is needed to understand the experiences that users are having.

Recent research has investigated users' experiences with CAs focusing on system capabilities and gaps between users' expectations contrasted with their actual experiences (Luger and Sellen, 2016; Nguyen and Sidorova, 2017; Zamora, 2017), which lends itself to understanding user satisfaction. Other work has evaluated user satisfaction in the context of specific tasks, e.g. searching for information (Avula, 2017; Kiseleva et al., 2016; Vtyurina et al., 2017), food tracking (Graf et al., 2015), or design (Vandenberghe, 2017). The experience explored in these studies is typically one of usability. In addition, these studies are often conducted as lab experiments, which can limit generalisability to real life scenarios (Kiseleva et al., 2016; Vtyurina et al., 2017). There remains relatively little work about understanding the affective responses towards conversational agents in real world situations. The most relevant work has been found in (Cohen et al., 2016; Jung, 2017; Purington et al., 2017), where the authors propose the focus on affective capabilities of CAs such as how to take into consideration users' emotions. However, a deeper investigation of affective experiences in real world scenarios is still missing.

Emotions are at the heart of human experience (Forlizzi and Battarbee, 2004). Understanding users' affective experiences is thus crucial to designing compelling CAs. This helps designers and engineers understand affective responses so they can reinforce the factors that people enjoy and mitigate the factors preventing positive experiences. As will be argued in this chapter, the affective responses to a conversational agent are often as important as many of the functional evaluations that users make of CAs. The focus on affect is consistent with creating and enjoying a human-like interaction with digital entities, which is the ultimate goal of designing CAs.

The present study contributes new understanding of affective experiences with CAs and of the effects of perceived hedonic and pragmatic qualities of the agents on affective responses. The following research questions were asked to achieve this aim:

- RQ1: What experiences do users have with CAs?
- RQ2: What are the affective responses to these experiences?
- RQ3: What product qualities influence affective experiences and how?

4.2 Related Works

Conversational agents

Within the HCI community, one stream of CA research has focused on identifying important issues for CAs design and guiding directions for future research. For example, Cohen et al. (2016) have outlined four requirements for future generations of CAs, including them being able to recognise users' attentions, actively fulfil those attentions, collaborate with people or other assistants and engage in the conversations. Another stream of research has focused on identifying user requirements and evaluating user satisfaction [e.g. in (Korhonen et al., 2010; Luger and Sellen, 2016; Moore et al., 2017; Nguyen and Sidorova, 2017; Zamora, 2017)]. For example, Zamora (2017) has identified the need for '*high performing, smart, seamless and personal*' agents. The reality of current CAs, however, does not live up to these expectations, for example, as Luger and Sellen indicated that there is still a '*gulf between user expectation and experience*' (Luger and Sellen, 2016). A third stream of research has focused on studying CAs in specific domains such as complex searches (Avula, 2017; Kiseleva et al., 2016; Vtyurina et al., 2017), food tracking (Graf et al., 2015), and personas in design (Vandenberghe, 2017). These studies have shown that it is promising to use CAs in novel scenarios. For example, Graf et al. (2015) have shown that users prefer to record their food intake through chatbots than through mobile and web applications. Similarly, Vtyurina et al. (2017) have observed that users are willing to use conversational agents for complex searches provided their expectations for accuracy were satisfied.

The experiences explored in previous studies are typically usability-oriented. There is relatively little work on understanding the affective responses towards CAs. The most relevant work is reported in Cohen et al. (2016) and Purington et al. (2017) where the affective capabilities of CAs are proposed to be as important as practical capabilities. For example, study by Purington et al. (2017) examines the relationship between the personification and sociability of Alexa and their effect on user satisfaction. They have found that personification predicts a higher level of sociability, and that sociability is positively related with user satisfaction. Cohen et al. (2016) have proposed important emotion-related issues to be addressed in the design of future CA such as how a CA should track user emotions and react to them. The above studies have

contributed the understanding of the affective capabilities of CAs and the influence of such capabilities on user satisfaction. However, the literature still shows no large-scale examination of users' affective experiences with CAs in their daily lives.

Affective experiences

It has been argued that user experience should go beyond the task-oriented approach of traditional HCI and focus on hedonic aspects such as fun and pleasure (Hassenzahl and Tractinsky, 2006). The importance of affective experience has been seen in various UX models and frameworks such as Norman's emotional design (2005), Jordan's four levels of pleasures (2002) and Hassenzahl's experience design model (2010). Inevitably, emotions are at the heart of human experience and thus the hedonic aspects of UX are the keys to creating delightful and compelling experiences with CAs. Affective experience is often evaluated by capturing people's emotional responses, which can, for example, be assessed using the Positive Affect Negative Affect Schedule (PANAS) (Watson et al., 1988). This widely used and validated scale provides rich affective information including the nuances of positive and negative affect.

A holistic understanding of UX requires the enrichment of traditional quality morals with non-utilitarian concepts, resulting in two types of product quality, i.e. pragmatic and hedonic qualities (Hassenzahl, 2003). As described by Hassenzahl (2003), pragmatic qualities are related to the functionality and usability of the system, which often fulfil users' behavioural goals, whereas hedonic qualities are related to non-instrumental qualities such as aesthetics, innovativeness and originality, which often emphasise users' psychological well-being. As shown in studies such as (Hassenzahl et al., 2015, 2010; Müller et al., 2015), pragmatic and hedonic qualities can be assessed using the AttrakDiff questionnaire (Hassenzahl and Monk, 2010).

Informed by this literature, the study presented in this chapter has adopted the above methods to examine the affective experiences of CAs. Specifically, the PANAS scale (Watson et al., 1988) and AttrakDiff questionnaire (Hassenzahl and Monk, 2010) were used to measure affective experiences and the perceived pragmatic and hedonic qualities. Details of the methods will be presented in the following section.

4.3 Methods

4.3.1 Data collection

To answer the research questions, a survey study was designed to collect data on: 1) user experiences with CAs; 2) affective responses; and 3) perceived product qualities.

User experiences with CAs were collected using the critical incident method, which requires users to report an experience that they have had (Flanagan, 1954). This method has been widely adopted in studies such as (Eiband et al., 2017; Hassenzahl et al., 2015, 2010; Mekler and Hornbæk, 2016; Müller et al., 2015; Sheldon et al., 2001; Tuch et al., 2013) to collect user experiences. In these studies, participants were asked to recall and report an experience. This is usually followed by a list of open-ended questions asking for more details of the reported experience. As this method is often effective in capturing rich information about an experience such as contextual information (Eiband et al., 2017; Flanagan, 1954), it is usually employed in studies which aim to collect and analyse real life user experiences.

Affective responses were measured using the PANAS scale (Watson et al., 1988). In the literature, this scale is often used together with the critical incident method to assess affective responses of a recent experience. For example, in the study of people's psychological needs in satisfying events, Sheldon et al. (2001) asked participants to report on a recent, satisfying life event, and to rate the event using the PANAS scale indicating '*the extent to which they felt each of the different moods during the event*'. Similarly, this approach has been shown effective in examining user experience with interactive technologies (Hassenzahl et al., 2015, 2010; Mekler and Hornbæk, 2016; Müller et al., 2015). For example, in the study by Hassenzahl et al. (2015), participants were firstly asked to recall and report a recent experience with an interactive technology such as a computer or a smartphone, then they were asked to relive the experience and rate it on a series of scales including PANAS.

Perceived product qualities were measured using the AttrakDiff questionnaire (Hassenzahl and Monk, 2010). This questionnaire measures three types of product qualities, namely pragmatic quality, hedonic quality and the overall appeal. Similar to the PANAS scale, this questionnaire is also often used together with critical incident method. For example, in studies examining

technology-involved user experiences such as (Hassenzahl et al., 2015, 2010; Müller et al., 2015), the AttrakDiff scale was used together with the critical incident method to measure the pragmatic and hedonic qualities of products.

A survey method was adopted to collect the data mentioned above, as it allows this research to gain a broad overview of user experiences and quickly gain insights into the state of current practice. The survey was conducted across June and July 2017 using the Qualtrics platform⁹ and distributed using two participant recruitment services: Amazon Mechanical Turk¹⁰ and CrowdFlower¹¹. The average task duration for each response is 12 min 27 seconds. Participants were given incentives (at an average rate of \$10/hour) as acknowledgement of taking part.

With regard to the study design, two considerations are worth mentioning. First, since the main interest of the study was to examine affective experiences, it has been designed not to introduce other factors such as variations of application into the analysis. More specifically, it is known that different CA products have different strengths, for example, Alexa may be better at supporting Amazon shopping experiences than other CAs; Siri may provide better support on iOS. Because of this, the decision has been made to focus on one of the CA products in this study. Second, the study is interested in accounting for the ubiquitous experiences that users increasingly have with CAs, and thus it needs to choose a CA which supports such ubiquity. In this regard, Google Assistant (GA) was considered suitable to address this requirement, because, when this study was conducted, it was available on multiple types of devices (including smartphone, smart speaker, smart watch, in-car systems) and was used in various contexts. Whereas other CAs did not provide such availability across various devices. For example, in the year 2017, Alexa was dominantly accessed via smart speakers (Amazon Echo) without stand-alone smartphone applications. Consequently, the recruitment criteria for the survey consisted of having had a recent experience of using the GA via any of its access devices.

⁹ <https://www.qualtrics.com/uk/core-xm/survey-software/>

¹⁰ <https://www.mturk.com>

¹¹ Rebranded to Figure Eight in 2018: <https://www.figure-eight.com>

This was implemented through screener questions at the beginning of the survey. Participants were first asked whether they consider themselves regular users of Google Assistant (allowing participants to self-identify as regular users has also been used in previous studies, e.g. Luger and Sellen (2016)). If yes, they were then asked whether they have used Google Assistant in the past month. Responding with yes to both questions makes this participant eligible for taking part. Eligible participants were then presented with the consent page. Their consent was collected before entering the main section of the study.

Survey Design

The first section of the survey introduced the study to the participants and collected consent.

The second section contained a series of open-ended questions asking participants about their most recent experience with the GA. Participants were explicitly made aware that the experience they reported could be either positive, negative or neutral. Participants were asked to first describe their experience and then answer questions regarding specific details, such as the device they used, the social and situational context, and the factors they enjoyed or were challenged by while using the GA.

The third section assessed users' affective responses using the PANAS scale (Watson et al., 1988) with 10 positive affect descriptors (i.e. *active, alert, attentive, determined, enthusiastic, excited, inspired, proud, strong* and *interest*) and 10 negative descriptors (i.e. *afraid, scared, nervous, jittery, irritable, hostile, guilty, ashamed, upset, and distressed*). On a scale from 1 (not at all) to 5 (extremely), participants were asked to indicate to what extent they experienced a particular emotion.

The fourth section evaluated the perceived qualities of the GA using the abridged version of the AttrakDiff2 questionnaire (Hassenzahl and Monk, 2010). It consists of 10 items in the form of semantic differential scale (from -3 to 3), including *confusing-structured*, *impractical-practical*, *unpredictable-predictable*, and *complicated-simple* for the pragmatic quality, *dull-captivating*, *tacky-stylish*, *cheap-premium*, *unimaginative-creative* for the hedonic quality, and *good-bad* and *beautiful-ugly* for the overall attraction.

The fifth section collected participants' demographic data, and the duration and frequency of using the GA.

4.3.2 Data analysis

Cleaning and preparation

A total of 210 individuals participated in the survey. Given that some reported experiences did not provide sufficient information, the collected data went through an initial cleaning process. Examples of insufficient descriptions included those that were very short, abstract or general, for example, one participant wrote '*I am happy to try*'. Responses like this were excluded as they provided little useful information for analysis. After the cleaning process, 178 valid responses were left.

The data was further assessed regarding which device was used in the experience. In some cases, participants reported more than one device being used. This may have happened because some interactions relied on multiple devices, for example, users may need to use a smartphone application in order to use Google Home. For these cases, the device type was coded according to the primary device used to access the GA. Participants may have also chosen more than one device because they possibly selected all the devices that they had used in the past. To tackle this issue, the reported experience was examined further to identify which was the primary device used in that particular report. Where the primary device could not be identified, the data entry was excluded from valid responses.

After this process, 171 valid responses were left for further analysis. Table 6 summarises participants' information. In this study, both quantitative and qualitative data were collected and analysed. The following analysis is based on the cleaned data.

Table 6. Participants' information

Age	Average 29.7 (SD=9.4)
Gender	73% male; 27% female
Nationality	70% the Americas; 16% Europe; 12% Asia; 2% Africa
Education	19% post-graduate; 71% graduate; 10% high school
Duration of use	50% > 12 months; 40% 1~12 months; 10% < 1 month
Frequency of use	19% > 7 times; 21% 4~7 times; 53% 1~3 times; 7% none in past week

Quantitative analysis

Quantitative data were collected on users' affective responses and the perceived qualities of the GA. The values for positive affect (PA) and negative affect (NA) were calculated by averaging the responses to the 10 associated descriptors on the PANAS scale (Watson et al., 1988). Internal consistency for PA and NA were at the excellent level (Cronbach's α of .90 for PA and .94 for NA). Besides the two factor distinction, PA can be further partitioned into three components: joy (*excited, proud, enthusiastic*), interest (*interested, strong, determined*) and activation (*active, inspired, alert, attentive*) (Egloff et al., 2003). Based on this partition, the values for joy, interest, and activation were calculated by averaging the respective descriptors. Internal consistency was satisfactory (Cronbach's α = .83; .72; .76 respectively). To examine the nuances of positive affect, it has been decided to include these three components into further analysis. To decide whether negative affect needed partitioning, a principal component analysis was conducted. The results did not suggest the need for further partitioning, which is consistent with the work of Hassenzahl et al. (2010).

Values of the pragmatic quality, hedonic quality and attraction were computed similarly, by averaging the scores of the associated descriptors. Internal consistency was satisfactory for all measures (Cronbach's α = .74; .78; .93 respectively). A Pearson Correlation Coefficient was further calculated to assess the relationship between the perceived qualities and affective responses.

Qualitative analysis

Qualitative data were collected on users' self-reported experiences with the GA. They were analysed following the thematic analysis process outlined by Braun and Clarke (2006). The data were coded in terms of: 1) usage scenarios (what was the GA used for); 2) contexts of use including situational context and social context (where did the experience happen; who was with the participant); 3) devices (which device was used to access the GA); 4) positive factors (what factors contributed to positive affect); and 5) negative factors (what factors contributed to negative affect).

The overall analysis was iterative. To start with, the author of the thesis derived initial coding categories. Next, the author met with two researchers to review the categorization, discuss specific data, and refine the categorisation. Following the final classification, another two researchers assessed a 10% random sample of the data to evaluate the consistency of the final coding scheme. Krippendorff's α (Krippendorff, 2007) and Cohen's κ (Cohen, 1960) were both calculated to validate the inter-rater consistency for the coding categories. Inter-rater agreement was satisfactory to all categories (Krippendorff's α ranging from 0.69 to 1; Cohen's κ ranging from 0.68 to 1). After the agreement was met, the remaining data were coded by the author based on the developed categories.

4.4 Findings

This section presents results in response to the three research questions, i.e. users' experiences with the GA, their affective responses, and the product qualities that influence users' affective experiences.

4.4.1 CA user experiences: scenarios and contexts of use

Scenarios of Use

The thematic analysis has shown four main scenarios of use: S1) requesting basic information; S2) searching for answers; S3) getting recommendations; and S4) accessing external services. While the first three scenarios are all related to information searches, they differ in terms of

how users asked their questions, what they expected from the response, and whether there were follow-up interactions. They also differ in terms of the contexts of use such as the access device and location.

S1: Requesting Basic Information. In this scenario participants used the GA to request basic information. For example, participants used the GA to ‘ask for weather’, ‘find locations’, check ‘news’ or ‘sports updates’, and search for a ‘player’s name’, ‘information about a band’, the ‘population of a city’ and the ‘definition of a slang term’.

The requested information was often a specific fact, and users were generally clear about the information they needed and how to ask for it. It was also easy for users to assess the relevance of answers. As a result, users usually received the expected answers without having to ask follow-up queries.

This study’s data showed that participants expected an accurate output. Moreover, participants enjoyed the experience when the GA proactively provided relevant information without being explicitly asked, for example, a participant stated *‘I was getting ready for work . . . I pulled up the Google Assistant and wished it good morning. In response, it wished me a good morning too. Then it proceeded to tell me the weather, give me details about my commute and play the news program that I had set up. I enjoyed the fact that it gave me all the information that I wanted without me having to pull up a dozen different apps. I can just say “good morning” and it tells me all that information while I’m getting dressed’* (P81).

In this scenario the response was typically presented as text extracts sometimes with images or web-links when necessary. It was found that reading out the answers was generally preferred by participants, for example, *‘I like making it read news to me when I was tired of reading texts’* (P59). However, it was notable that if the answers were not accurate enough, the reading-out feature could cause dissatisfaction. For example, a participant who was looking up information about a city’s population reported: *‘I used a voice command to access it . . . Of course, the first search result was a Wikipedia excerpt and it started to read it aloud. However, population was not in this excerpt. It was a bit annoying, so I had to open Wikipedia page and looked for it myself’* (P126).

S2: Searching for Answers. In this scenario participants used the GA to search for answers, which involved more complex information than the previous scenario and may require further processing of the search results. For example, a participant used the GA to learn about a plant: *‘finding out the uses of a seed produced by a tree ... and how can I turn it into a very good benefit for my home’* (P3), and another to learn about an astronomical event: *‘looking up information about the recent eclipse of the sun . . . the interaction was very positive. It was suggesting what I may be interested in and this made my study fun’* (P109).

The requested information was more complex than facts and often required the user to assess its relevance by making judgments regarding inputs and search results. At times participants needed to alter the search query to receive better results, or to make follow-up queries.

The data showed that to solve their problems participants expected an output that was useful. For example, one participant said, *‘[the GA] gave me a useful response. I was satisfied’* (P102). Moreover, participants enjoyed it when the GA suggested relevant links for follow-up queries. For example, in the instance mentioned earlier where the participant was learning about the solar eclipse, he stated *‘[the GA] was suggesting what I may be interested in’*, and *‘this made my study fun’* (P109).

In this scenario the response often involved the provision of links to webpages, images or videos. Consequently, it was usually difficult for the GA to read out the answers directly.

S3: Getting Recommendations. In this scenario, participants used the GA to get recommendations on places to eat or visit. For example, participants asked for nearby locations such as the *‘nearest restaurants’* (P11) or places with refined requirements *‘a restaurant which serves Italian dishes near my location’* (P91). Other times, participants asked for travel advice: *‘when travelling to a new place I ask the GA for place recommendations’* (P68).

The requested information was often a list of options satisfying users’ requirements. Users then evaluated the options to make a decision. Therefore, there were follow-up actions, such as viewing restaurant details, calling for enquiries, making reservations, or getting directions to the place.

The data showed that participants expected the output to include as much information as possible on the recommended places, for example, open hours, telephone or price. Such information was used to help them make decisions or with future actions. For example, a participant (P141) who *'asked for a Thai restaurant'* with the intention to *'order some takeout'* was expecting a contact number or order link from the response. Another participant shared an experience in which she was satisfied with the recommendation because she received the information she needed: *'I used it to find a coffee shop ... got all the information including price list very simply'* (P164).

In this scenario the response was often presented as a combination of text, images and sometimes locations.

S4: Accessing External Services. In this scenario, participants used the GA to access external services including home devices (e.g. interacting with lighting and TV), telephone services (e.g. making and receiving calls), media services (e.g. playing music), and personal task applications (e.g. checking calendar, reminders, and email).

Differently from the previous three scenarios, users' focus was more on interaction with the services rather than conversation with the assistant. For example, *'I was in the bathroom and heard my phone's notification sound. When I came out (with) my hands wet, I said "OK, Google. Open WhatsApp" and boom! . . . It was very handy.'* (P8) In this example, the GA was used to launch WhatsApp, and there was no further conversation between the GA and the user.

Unlike the previous scenarios, the output was often external services responding to the user. In this scenario participants expected accurate and efficient execution of the command. For example, a participant stated, *'this system seems wonderful to me because I can interact with my electronic devices almost immediately'* (P6).

Contexts of use

Contextual information about the four scenarios including the devices used, the locations of use and the social context is summarised in Figure 25. Smartphone was the dominant device used across all four scenarios. Google Home also had a considerable role in the study. It was

used most frequently in the *accessing external services* scenario (30%) and least frequently in the *getting recommendations* scenario (10%). Smartwatch was not commonly used by participants, and most of its use happened in the *accessing external services* scenario.

The two dominant locations of use were at home and in transit. When the GA was used for *requesting basic information*, the home and in transit took the majority of the cases. Whereas, in the other three scenarios, the workplace and public places appeared commonly as well. In particular, when the GA was used to *search for answers* and *get recommendations*, a considerable number of experiences happened at public places (17.5%). Finally, a conspicuous number of experiences in the last three scenarios happened at workplaces (10%).

The social context was rather similar in the four scenarios. Participants used the GA predominantly alone, followed by uses in the presence of family members and lastly with friends and colleagues.

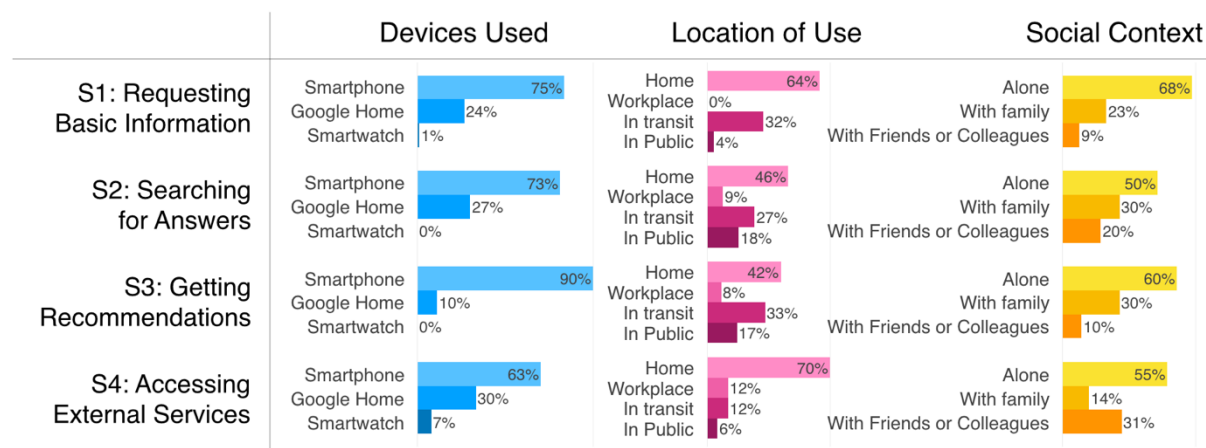


Figure 25. Contexts of use across four scenarios

4.4.2 Affective responses

Participants' affective responses are shown in Table 7. The results showed that the overall positive affect was above 3 (moderately experienced), whereas the overall negative affect was lower than 2 (experienced a little). The emotion *interest* was found to be the main contributor to positive affect, followed by *joy* and *activation*.

To test whether positive and negative affect were correlated with each other, e.g. if they were at the opposite poles of the same dimension, the Pearson Correlation Coefficient calculation was performed. The results showed no relationship between the two ($r=0.07$, $p=.38$). This means that positive and negative affect coexisted but were independent of each other. Thus, they were regarded separately in this study.

Table 7. Overall evaluation of affective experience

Affect	Mean (SD)	Cronbach's alpha
Positive Affect	3.27 (0.93)	$\alpha=.90$
Interest	3.38 (0.99)	$\alpha=.72$
Joy	3.25 (1.14)	$\alpha=.83$
Activation	3.12 (0.97)	$\alpha=.76$
Negative Affect	1.80 (0.90)	$\alpha=.94$

To investigate if the GA triggered different affective responses depending on the scenarios, the five affect evaluators (PA, interest, joy, activation, NA) were calculated for each scenario. A normality test showed that the data were not all normally distributed. Therefore Kruskal-Wallis test was conducted. The results showed that there was a statistically significant difference for PA, interest and joy across the four scenarios ($\chi^2(3,122)=8.18$, $p=0.042$; $\chi^2(3,122)=8.32$, $p=0.039$; $\chi^2(3,122)=8.40$, $p=0.038$ respectively), Figure 26. The difference for activation and NA was, instead, found not to be statistically significant.

Following this, Mann-Whitney U tests were conducted to compare the differences of PA between pairs of scenarios. Significant difference was found between S1 and S2 ($p=.02$) and S1 and S4 ($p=.03$). This showed that participants in the *requesting basic information* scenario received significantly lower positive affect than in the *searching for answers* and *accessing external services* scenarios. No significant difference was found between the other pairs.

The same tests were conducted for interest and joy. Significant difference was found between S1 and S2 ($p=.02$) and S2 and S3 ($p=.03$) for interest; and between S1 and S4 ($p=.01$) for joy. This showed that participants found it more interesting when using the GA to *search for*

answers than to *request basic information* or *get recommendations*; and that participants found it more joyful when using the GA to *access external services* than to *request basic information*. No significant difference was found between the other pairs.

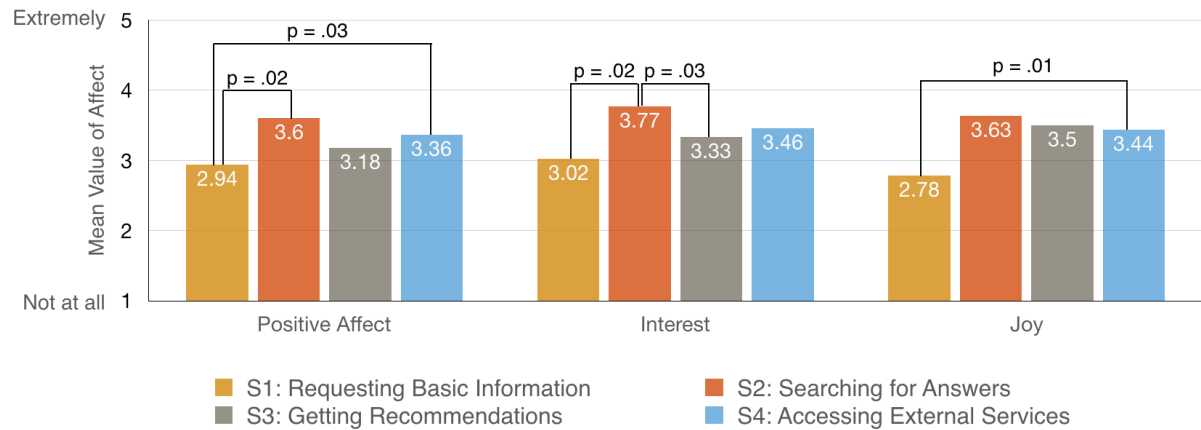


Figure 26. Affective responses in the four scenarios

4.4.3 Correlation between product qualities and affect

Evaluation of product qualities showed that the overall attraction of the GA was rated the highest ($M=1.66$, $SD=1.33$) followed by the pragmatic quality ($M=1.49$, $SD=0.98$) and the hedonic quality ($M=1.23$, $SD=1.22$).

To test whether the evaluation of product qualities had effects on the affective responses, Pearson's r was calculated, Table 8. According to the interpretation of correlation r (Acer et al., 2019), PA was positively correlated with all product qualities; NA was negatively correlated with all qualities except for the hedonic quality. This meant that on the one hand, increasing both the hedonic and pragmatic qualities could increase users' positive affect. Notably, the effect of the hedonic quality was higher than that of the pragmatic quality. On the other hand, among the two, only the pragmatic quality was found to significantly influence negative affect.

Table 8. Correlation between product qualities and affect

Product Quality	Positive Affect	Negative Affect
Hedonic	.47 *	-.07
Pragmatic	.32 *	-.42 *
Attraction	.28 *	-.35 *

* $p < .001$

The next section elaborates on the hedonic and pragmatic product qualities by presenting the underlying factors identified from the thematic analysis.

4.4.4 Factors underlying pragmatic qualities

Factors in relation to the quality of the response content

The factors identified are *helpfulness* and *proactivity*. *Helpfulness*, used here as an umbrella term, refers to the response being accurate, helpful and useful depending on the scenario types. For example, in the *requesting basic information* scenario, participants used the term ‘accurate’ to describe the quality of the GA’s responses to their requests. Whereas in the scenario *searching for answers*, participants used terms such as ‘useful’ and ‘helpful’ to describe how well the GA had solved their problems. Regarding the *getting recommendations* scenario, participants used both ‘accurate’ and ‘helpful’ without significant difference in frequency between the two. In addition, when using the GA for *accessing external services*, participants appreciated how accurately the GA understood a command and how well the command was executed, for example, ‘*I enjoyed how accurately it understood me and executed the task*’ (P150).

Inaccurate or irrelevant answers were found to cause negative experiences. For example, a participant stated, ‘*I asked it to help me find a location on a map. Results were not what I asked for, so I was a little frustrated*’ (P92).

Proactivity, that is predicting and responding to users’ queries, was identified in the first three scenarios only. This may be because in these scenarios, users regarded the GA as a smart search engine and thus expected more information. *Proactivity* was found to be realised by delivering

additional information (i.e. information not directly requested) to the users. Importantly, specifics on the expected additional information could differ in the varying scenarios.

In *S1: Requesting Basic Information*, the additional information was typically offered based on contextual information and the results were not necessarily on the same topic. For example, the participant getting ready for work said to the GA ‘*good morning*’ and was returned information about the weather, the daily commute and the news. These results were all relevant to the specific context of ‘getting ready for work in the morning’, but they covered diverse topics. In *S2: Searching for Answers*, additional information was typically provided on the same topic and was generated based on the search query. For example, the participant who studied the solar eclipse was offered suggestions relevant to his subject of interest. In *S3: Getting Recommendations*, additional information was expected to be directly linked to the search results, for example, restaurant details such as price or reservation links. Generating such information may require the integration of results from different sources such as restaurants or delivery services.

Factors in relation to the quality of the interaction

The factors identified are: *fluidity*, i.e. maintaining a continuous voice interaction; *seamlessness*, i.e. integrating with external services; and *responsiveness*, i.e. shortening the time to obtain a response.

When fluid interaction was broken, a negative experience was likely to happen. For example, most of the frustration happened when the assistant could not understand users. This was often due to the GA’s difficulty in recognising users’ accents or the languages they speak, and the GA’s limitations of understanding complex sentences. Fluidity of interaction was often expected in multi-tasking contexts especially where hands-free was a must. It was also expected when the user was tired of ‘*typing or reading lengthy text*’. In general, participants perceived the interaction with the GA as ‘*easy to use*’, ‘*convenient*’, ‘*effortless*’, ‘*intuitive*’ and ‘*simple*’. However, if the conversation was interrupted due to errors of voice interaction, negative feelings occurred. A robust and reliable technology behind voice interaction was shown to be the foundation for fluidity.

Seamless integration between the GA and other services (either from Google or other service providers) was often appreciated by users. For example, the participants found the GA *'helpful for things like adding events to the calendar and even ask for an Uber car'* (P118). Another participant liked the GA because of the level of integration: *'I like it for its level of integration with all Google applications and the general search service.'* (P164)

Responsive interaction with the GA was valued because it was perceived as saving time. Participants expressed their appreciation for this quality using terms such as *'so fast'*, *'saves time and effort'*, and *'immediately'*. For example, a participant wrote, *'this system seems wonderful . . . because I can interact with my devices almost immediately'* (P6). A fast response was typically expected in all cases, but was especially appreciated when participants were in a rush or in trouble, for example, *'while driving in my regular route, one important road was blocked for some maintenance. [I] was not sure about the alternative route . . . I thought got stuck in some mystery place . . . the assistant said the way very perfectly along with the time to reach home. I had a very positive experience with this virtual assistant'* (P89). The study's data showed that delays in the responses were associated with negative affect. For example, a participant reported getting annoyed when the system was *'slow in answering'* (P78).

4.4.5 Factors underlying hedonic qualities

Besides pragmatic qualities, the findings also showed factors relating to hedonic qualities. These factors are: 1) comfort in human-machine conversation; 2) pride of using cutting-edge technology; 3) fun during interaction; 4) perception of having a human-like assistant; 5) concern about privacy; and 6) fear of causing distraction.

These factors usually do not directly affect the task at hand, which is the key difference between pragmatic and hedonic qualities. For example, errors during voice interaction may interrupt the task, whereas, uncanny feelings such as *'having to speak louder than normal'* (P100) were fine and did not stop the task. However, the hedonic factors were shown to influence how a user felt about the whole experience.

Lack of comfort was caused by the difference between a conversation with a machine and with a real person. It may be due to the way participants talked, for example, *'having to speak very*

clearly and loud' (P157), or the way participants felt, for example, *'talking to no one feels like talking to self'* (P106) or *'cannot forget that I am talking to a robot'* (P29). Lack of comfort also happened if the user was not familiar with the GA, for example, *'I used it at my sister's house and it felt weird. I was used to talking to Siri so it was very different. I was uncomfortable because I wasn't used to it'* (P80).

For some participants, pride of using cutting-edge technology led to positive feelings. They expressed that using the GA was like *'experiencing the future'* (P29). The feeling of knowing, experiencing and learning new things made the participants proud, for example, *'I felt like I was modern. Showing it to someone who had never used it before made me feel like I know something that others don't'* (P158).

Besides saving time and being easy to interact with, the GA was, at times, perceived as *'fun to use'* (P63) and a device which *'breaks boredom'* (P21).

Furthermore, participants also expressed their connectedness to the GA, for example, *'I felt well taken care of'* (P71). In such cases, participants referred to the GA as a real person, for example, *'I feel someone is there to help me all the time. I never feel alone'* (P8), or that *'I felt very positive, like I have a personal assistant'* (P95).

Besides these factors, a few participants mentioned their concern for privacy, for example, *'the truth makes me afraid that Google knows every detail of our lives day by day'* (P162). Some other participants worried that interaction with the GA may be a distraction to the task at hand, especially in the multi-tasking contexts. For example, a participant mentioned *'I tried not to distract myself while driving'* (P58) and admitted not to like it.

4.5 Discussion and Design Implications

This section discusses the main findings and the implications for designing existing and future CAs. The implications are not specific to a particular type of application, rather they are beneficial for positive CA design in general. For example, they could help designers better

understand users' expectations across different scenarios and contexts, and thus design for a positive user experience. More details on the findings and implications are discussed below.

4.5.1 CA user experiences

Scenarios of use: more complex and diverse uses

This study has identified four primary scenarios, which commonly appear among GA users. Consistently with previous findings (Cowan et al., 2017; Luger and Sellen, 2016), the dominant scenario was shown to involve basic information requests such as weather or news updates. The findings also showed new and emerging scenarios which have become more common such as making more complex searches, getting place recommendations and accessing external services. The growing use of GA in complex and diverse scenarios may indicate that its reliability, familiarity and trust to users have increased, compared to what was reported in previous works such as the one by Luger and Sellen (2016). In their work (2016), the authors reported that users were reluctant to use CAs for complex or socially sensitive tasks such as making calls or sending long emails, and that users would not trust a CA in these circumstances. The findings presented in this chapter, however, showed that phone calls were one of the major uses, and users indicated enjoying the benefits brought by access to external services.

Contexts of use: more ubiquitous uses

Porcheron et al. (2017) have stated that the use of CAs is expanding towards more social and collaborative contexts, and they have encouraged the HCI community to explore the uses of CAs in everyday real-life settings. In agreement with Porcheron et al., this study has shown growing ubiquity of CA uses as well. Besides home and car being the dominant locations of use, workplaces and public settings such as street, park and café have also been identified as common use settings. Findings reported in this chapter have shown that public settings appear frequently in scenarios where users ask for recommendations, e.g. asking for places to eat and visit. Public settings also appear frequently when people use the GA to solve their problems, often by conducting complex searches. The social context is expanding too, from private settings towards social settings with family, friends and colleagues being present. The findings have shown that about half of the uses happened when users were alone; the other half were with people around. In line with Cohen et al. (2016) and Porcheron et al. (2017), the evidence

that the social context is evolving sheds new light on the diversity and ubiquity of GA use, and this finding invites future research to study conversations within multi-user settings.

Implications for design

In his experience design theory, Hassenzahl (2010) has proposed that design should start with *why* (i.e. clarifying the needs and emotions involved in an experience), and then proceed with *what* (i.e. functionality) and *how* (i.e. ways to realise the functionality). The scenarios and contexts identified in this research along with the associated emotions can help designers understand the *why* of CA experience. More specifically, designers could use the types of scenarios and contexts emerged in this study to understand the needs of users. For example, the findings have shown that when the CA is used for *requesting basic information*, users expect the response to include additional information which could be helpful for the activity that they are engaged in.

4.5.2 Affective responses

Findings from this study have shown that GA users experienced more positive than negative affect. This finding, however, disagrees with results from previous studies (Avula, 2017; Luger and Sellen, 2016; Vtyurina et al., 2017) where it was reported a big gap existed between user expectations and the practical realities of use, and that satisfaction was generally low. This contradiction may be explained in two ways. First, CAs have been significantly developed and improved. By the time previous studies were conducted, the technology investigated in this research was not as developed as it is now. The present study (conducted in 2017) may have benefited from a more reliable technology support, thus obtaining more positive experiences. Second, users' familiarity with the GA has increased. Thus, they are more aware of what the agent can offer and what to expect from it.

The investigation of the sub-components of positive affect has shown that interest is the most salient emotion experienced by participants, followed by joy and activation. This may be explained by the emotional design theory (Yoon et al., 2012) which states that interest is stimulated by the appraisal of novelty-complexity (*'a product must be appraised as novel and/or complex to be interesting'*) and coping potential (*'the degree to which one appraises oneself to*

have sufficient skills, knowledge, and resources to deal with an event'). In the context of the present study, it is likely that the GA was considered as a novel product, due to the young age of CAs in general. This may also be because the natural language interaction has made it so intuitive to use that the required coping skills are generally low, and thus the coping potential is high. Novelty as a motivation to use CAs has been found in recent research (Luger and Sellen, 2016), for example, people are motivated to use CAs because they are curious about the CA, or that they simply want to play with them. However, it is worth noting that such novelty and curiosity may decrease when people become more familiar with the agents, thus causing a loss of interest (Yoon et al., 2012). In fact, such effect is already evidenced in this study' data, for example, participants engaged in the *requesting for basic information* scenario received significantly lower interest than those engaged in more complex scenarios. This is probably because requests such as asking for weather were no longer novel to users.

Implications for design

Two approaches may be useful to maintain a positive experience level. The first approach involves increasing the complexity level of tasks, while keeping the coping potential high, for example, by introducing challenging tasks. This approach is grounded in the belief that increasing complexity could stimulate interest (Yoon et al., 2012). This is also evident in the finding that when using the CA to *search for answers*, users experienced significantly higher level of interest than in the other scenarios. The second approach consists of increasing the level of joy and activation. This could, for example, be achieved by introducing more playful interactions between the product and the user (Desmet, 2012; Fredrickson et al., 2008). In the findings it was observed that users experienced significantly higher level of joy when they used the GA to *access external services* compared to *request basic information*. This may indicate that joy was elicited through the interactive experiences with external devices. The approaches are further supported by the activation theory (Scott Jr, 1966) that a certain level of activation is necessary for effective functioning and that such activation can be stimulated by novelty, complexity, variation and uncertainty.

4.5.3 Factors influencing affective responses

The quantitative results have shown that increasing both pragmatic and hedonic qualities could significantly improve positive affect. This result is consistent with previous studies (Hassenzahl et al., 2010), where a correlation between product qualities and positive affect is identified for interactive technologies. Previous work (Hassenzahl, 2003) has suggested that the design of interactive technologies could benefit from considering both pragmatic (task-related aspects) and hedonic (task-unrelated aspects) qualities. This is because both aspects substantially contribute to the overall appeal of a system (Hassenzahl et al., 2001). Findings presented in this chapter show that this suggestion is valid for the design of CAs as well.

Pragmatic factors

With regard to the pragmatic factors, Zamora (2017) has found that users expect a high-performing, smart and easy-to-use agent. The study presented in this chapter has shown that the GA has met some of these expectations. For example, the high-performing quality was evidenced by the GA being helpful; and easy-to-use evidenced by its interaction being fluid, seamless and responsive. Proactivity of CAs has also been proposed in the literature (Cohen et al., 2016), specifically, future CAs have been suggested to be capable of recognising user attentions or goals and actively responding to such attentions, which supports the findings presented in this chapter. Importantly, this chapter's findings contribute to the literature by validating the statistical connection between the discussed factors and affective responses: the pragmatic-related factors would significantly contribute to positive affect if satisfied, but would significantly cause negative affect if not. This suggests that reinforcing such factors in design would improve users' positive experiences and reduce negative ones.

Hedonic factors

Hedonic factors are less discussed in the CA literature compared to pragmatic ones. In the paper by Cohen et al. (2016), it has been asked whether and how a CA could recognise users' emotions; and if users can be in multiple emotional states simultaneously with varying degree of intensity. This chapter's study responds to their work answering that users' emotions may differ across scenarios depending on the tasks they perform and the contexts they are in. The

findings also show that multiple emotions could coexist with different intensity levels. Not only different types of positive emotions coexist, but positive and negative emotions could also be present simultaneously. In addition, similar to that of pragmatic factors, the study presented in this chapter contributes to the literature with the validation of the statistical link between hedonic factors and affective responses: hedonic factors such as comfort, pride and fun during use, and the perception of having a real assistant can significantly contribute to positive affect. Positive affect can also be improved if concerns for privacy and distraction are reduced.

Implications for design

The identified pragmatic and hedonic factors have the potential to be used as guidelines and benchmarks in the design and evaluation of experiences with CAs. Specifically, to provide helpful and proactive answers, designers could offer additional information or links to help users proceed with their activities. To deliver fluid interactions, designers could focus on enabling robust voice interaction, as this can help reduce frustration due to weak comprehension. To seamlessly integrate CAs with external services, designers could anticipate users' preferences for external services and launch them accordingly. To increase the responsiveness of CAs, designers could attempt to address the waiting time, for example, by explaining to users why an answer cannot be delivered immediately. With regard to hedonic factors, to reduce discomfort when talking to an agent, designers could introduce onboarding processes or tutorials, for example, educating users that they do not need to speak extra loud or slow with the agents. To introduce fun interactions, designers could create opportunities to break boredom or make tasks more playful. To develop CAs with the traits of a human assistant, designers could design CAs with caring personalities. Finally, to reduce concerns for privacy and distraction, designers could attempt to increase user trust.

4.5.4 Limitations

This study adopted the critical incident method to collect users' self-reported experiences. One limitation of this approach is that recalled memories may be inconsistent with interactions observed in process. For the purpose of understanding the experiences of users this method is adequate, since this study is primarily concerned with subjective experiences as reported by users. Additionally, the method is typically criticised as participants may have not invested

adequate time in reporting rich information. This limitation was mitigated by asking more in-depth questions in the survey requiring specific details on the reported experiences.

4.6 Conclusions

This study contributes to the literature on conversational agents by extending our understanding of user's affective experiences. Specifically, quantitative evaluations of the affective responses and product qualities were performed; and a qualitative analysis of users' experiences with the GA was conducted which describes four primary usage scenarios and the contributing factors to affective responses. It has been found that the overall experience was positive with *interest* being the dominant contributor followed by *joy* and *activation*. The use of CAs has become more ubiquitous, and CAs are adopted in increasingly diverse scenarios and context when compared to previous findings. Moreover, it has been shown that the varying scenarios and contexts could lead to users' different affective responses. Furthermore, a set of pragmatic and hedonic factors are identified which were shown to correlate with users' affective responses. Finally, design implications are presented, which help designers to reinforce the factors that contribute to positive experiences and mitigate the factors causing negative experiences.

Chapter 5 Designing Positive Experiences with Conversational Agents

5.1 Motivation

Bringing positive experiences to users is one of the key goals when designing and developing conversational agents (CAs) such as Alexa, Google Assistant (GA) and Siri. Yet there is still a discrepancy between user expectations and their experiences, part of which is due to a lack of understanding regarding users' underlying needs for positive experiences and the absence of guidelines for designing and evaluating CAs. Self-determination theory (SDT) has been shown helpful to facilitate the design of interactive technologies that lead to positive user experiences. However, SDT has not yet been employed in the context of CAs. Hence, the research presented in this chapter aims to apply SDT to the development of design implications and guidelines for CAs. This was achieved in three phases. First, I applied SDT to in-depth interviews to explore the basic human needs of competence, autonomy and relatedness. Second, I synthesised the results of the interviews into a set of ten guidelines. Third, I evaluated the guidelines by surveying 189 participants. The guidelines recommend how to educate users about the capabilities of CAs, design the conversations between CAs and users, deal with situations when CAs malfunction and design CAs for engagement overtime.

CAs such as Alexa, GA and Siri have become progressively integrated into our lives, as evidenced by their increased use in homes and in sectors such as education, healthcare, e-

commerce and business. As much as computers, the internet and smartphones have impacted our life and society in recent decades, CAs are joining the stream of technology revolution (Reddy, 2018a, 2018b). Their emergence is inevitably shaping our behaviours and everyday experiences. We begin our days with mindful morning routines facilitated by CAs [e.g. users can establish and manage routines with Google Assistant (Google, 2020)]. We join conference calls set up by CAs [e.g. companies can utilise Alexa for business operations (Amazon, 2020a)]. What is more, students can participate in group discussions moderated by CAs (Winkler et al., 2019), and families can play games and have fun with CAs (Beirl et al., 2019).

The fact that CAs are changing our personal, professional and social lives can both help and hinder our wellbeing. On the one hand, CAs pose risks because the consequences of technological revolution are not always positive, similar to how smartphones may become sources of distraction or cause poor-quality sleep (Sarwar and Soomro, 2013). This reminds us of the need to design CAs responsibly to reduce their potential negative impact. On the other hand, CAs provide opportunities because the pursuit of happiness largely benefits from the acquisition of positive experiences on a day-to-day basis (Hassenzahl et al., 2013; Lyubomirsky et al., 2005b). As CAs are becoming ubiquitous, there is a clear need to understand how they should be designed. In the HCI literature, there is increased interest in designing products and interactive technologies to enhance positive experiences and psychological wellbeing (e.g. Calvo and Peters, 2014; Desmet and Hassenzahl, 2012; Desmet and Pohlmeier, 2013; Hassenzahl et al., 2013). However, CAs have not yet been considered in this body of work as they have only recently become popular. As such, we have yet to figure out how to design CAs to create positive and meaningful experiences that ultimately improve our wellbeing.

SDT, one of the foundational theories in positive psychology, has been shown to facilitate the design of positive experiences (Hassenzahl et al., 2013; Jansen et al., 2017; Peters et al., 2018). SDT is a theory of human motivation which suggests that people become self-determined and motivated to grow when their needs for competence, autonomy and relatedness are fulfilled (Ryan and Deci, 2000). Considering the fulfilment of these psychological needs when design could result in substantial benefits, including but not limited to increased user engagement, positive user experiences and human flourishing (Peters et al., 2018). However, this theory has not yet been applied in the context of CAs. It is unknown how users perceive and what they

expect from CAs in relation to these three needs as well as how such needs could be enhanced through interactions with CAs.

Additionally, most design implications and recommendations for CAs are distributed throughout different publications (e.g. Chaves and Gerosa, 2018; Fast et al., 2018; Graesser et al., 2017; Luger and Sellen, 2016; Yang et al., 2019) and are rarely presented explicitly as actionable guidelines. This could limit the application of these findings in design practice (Amershi et al., 2019). Expressing these findings as heuristics or guidelines, on the other hand, has shown to be helpful in facilitating the design and evaluation of products, e.g. Nielsen's (1995) usability heuristics and Amershi et al.'s (2019) artificial intelligence (AI) design guidelines. Amershi et al.'s (2019) guidelines have not only become useful resources for the design of AI-infused products but also inspire and enable future researchers to further develop principles for human–AI interaction. However, there are still no such guidelines for CAs in the academic community. Nevertheless, the growing number of articles that focus on how to design CAs in public domains, such as blogs [e.g. (Babu, 2019; Black, 2019)] and organisations' best practices [e.g. (Amazon, 2020b; Google, 2019; Microsoft, 2019)] imply that such guidelines are necessary.

To fill these gaps, the studies presented in this chapter aim to apply SDT to develop insights and actionable guidelines to facilitate the design of positive and meaningful user experiences with CAs. This was achieved through three phases.

Phase 1: Apply SDT to understand user expectations and to inform CA design.

- RQ1: What are users' perceptions and expectations regarding competence, autonomy and relatedness?
- RQ2: What aspects of CAs support or hinder these needs?

This is achieved through semi-structured interviews with 14 participants, specifically, unpacking what the three psychological needs—competence, autonomy and relatedness—mean to CA users and how to design for these needs (Section 5.3).

Phase 2: Derive guidelines from findings in Phase 1.

- RQ3: How can CAs be designed to meet users' needs for competence, autonomy and relatedness?

This is achieved by consolidating and synthesising the findings from Phase 1 into ten actionable guidelines, following a rigorous process outlined by Amershi et al. (2019) (Section 5.4).

Phase 3: Evaluate the guidelines in terms of their value to users' experiences.

- RQ4: How important are the guidelines to improving overall user satisfaction with CAs?

This is achieved by surveying 189 participants and conducting an initial empirical evaluation of the guidelines from the perspective of CA users (Section 5.5).

5.2 Related Works

5.2.1 Self-determination theory (SDT) and its implications for design

SDT (Ryan and Deci, 2000) provides a framework for the study of human motivation. It identifies three innate needs, namely competence, autonomy and relatedness. The fulfilment of these needs will motivate the self to seek optimal function and growth. More details on SDT can be found in Section 2.1. This section focuses on the literature of how SDT has been applied to inform design practices.

One of the many design implications of SDT resides in the notion that the basic needs of competence, autonomy and relatedness are mediators, which can be tweaked to improve the experience. They could be used as inspirations or criteria to adjust and evaluate the design (Calvo and Peters, 2014; Peters et al., 2018). For example, Jansen et al. (2017) used SDT to develop engaging digital coaches to help users achieve their fitness goals. In their study, SDT was applied to prepare and analyse user interviews and gather insights on how to increase the three needs through the digital coach. In Karapanos et al.'s (2016) study, SDT was applied to evaluate wearable activity trackers to improve product satisfaction. The evaluation asked whether the product increased the feeling of mastery (competence), provided meaningful choices (autonomy) and facilitated the connection between the user and others (relatedness). In this way, the specific features of the product were measured against the satisfaction of psychological needs and adjusted accordingly to improve the user experience (Peters et al., 2018).

Previous research has shown that the sense of competence can be enhanced by offering optimal challenges, positive feedback or opportunities for learning (Peters et al., 2018). Specific ways of achieving this may, however, differ depending on product types. This can be explained by the notion of ‘technology specific’, meaning that a given technology is more suitable for certain activities and, thus, more readily supports certain values while rendering those activities (Friedman et al., 2002). However, despite competence being a universal need, the ways of fulfilling it should be considered independently of the particular products that are designed. For example, in video games, a sense of competence can be reflected in the controls being ‘intuitive’, meaning that the controls should be easily mastered and not interfere with one’s gaming experience (Ryan et al., 2006). Competence can also be reflected in the perceived difficulty or novelty of the game, suggesting that designs should offer new difficulty levels that promise opportunities for learning (Lomas et al., 2017; Peters et al., 2018).

The sense of autonomy can be affected by system capability, complexity, misrepresentation and fluidity (Friedman, 2010; Friedman et al., 2002; Friedman and Nissenbaum, 1996) in software systems. Friedman (2010) explains that user autonomy can be undermined if the system does not provide the necessary capabilities to help the user realise their goals. A loss of autonomy may also happen when the user is given inaccurate information about the system or that the system does not adapt to the user’s change of goals over time. Similar to those of competence, such aspects may differ across different system domains. For example, in the design of games, the feeling of autonomy can be improved by providing users with sufficient choices and options (Ryan et al., 2006) or by enhanced personalisation (Rigby and Ryan, 2011). Beyond the interface level, autonomy can also be facilitated by technology augmenting the user’s abilities to pursue personal goals and values, such as assistive technologies, behaviour change technologies or productivity tools (Peters et al., 2018).

The feeling of connectedness can be enhanced by the product facilitating social interaction (e.g. communication tools enabling long-distance connection to friends and family) or the product playing a symbolic role (e.g. Coca-Cola reminding us of a childhood family dinner, thus connecting us closer to our family) (Yang et al., 2017). The first way concerns the ‘communication’ function of a product, which enables us to interact or communicate with other people. The majority of research has focused on the study of communication tools and

social media and how such technologies can be designed to support relatedness. For example, Sheldon et al. (2011) discuss how the different affordances of technology, such as videos or emojis, can influence social connection. They further suggest that designs should be meaningful and satisfy genuine relatedness rather than the mere semblance of connection. The second way concerns the ‘symbolic’ function of a product. This function reminds people of their past memories with others, which evokes the feeling of connectedness. For example, food often reminds people of happy times together with their loved ones, and a family car could be a symbol of love because of the many family trips together in the car (Yang et al., 2017).

As discussed earlier, our needs for competence, autonomy and relatedness can be fulfilled in various ways, depending on the product type, the context of use or even the user’s personal attachment to that product. This suggests the need to further examine these needs within the context of CAs.

5.2.2 Designing CAs

In this section, relevant works on CA design are reviewed. I obtain findings not only from the literature regarding CAs but also from a broader spectrum of research on interaction design and AI design. Since a CA is also an AI product and a digital system, I believe design insights from these domains can also contribute to the design of CAs.

Within the scope of interaction design, Nielsen’s (1994a) ten usability heuristics are no doubt one of the most influential design guidance. According to Nielsen, ‘they are called heuristics because they are broad rules of thumb and not specific usability guidelines’ (Nielsen, 1994a). These heuristics have since been applied successfully to guide the design and evaluation of digital systems. An accepted approach in HCI is to take a general set of principles and tailor them for use in evaluating a specific application (Nielsen, 1994b; Yanco et al., 2004). Although originally generated for UI design, the heuristics have been tailored and applied to guide the user-centred design and evaluation of various products, including but not limited to video games (Pinelle et al., 2008), web applications (Scott and Neil, 2009), online education (Ebner and Holzinger, 2007) and e-commerce websites (Chen and Macredie, 2005).

Within the scope of human–AI interaction, the effort to develop design guidance for intelligent interfaces began 20 years ago. In his paper, Horvitz (1999) proposes design principles for integrating automation with direct manipulation interfaces, such as considering uncertainty about a user’s goals, allowing for efficient invocation and termination, employing socially appropriate behaviours for agent–user interaction and continuing to learn through observation. In recent years, the number of studies regarding various AI design topics continues to increase, for example, transparency and trust (Kulesza et al., 2015; Rader et al., 2018; Ribeiro et al., 2016; Weld and Bansal, 2018), personalisation (Deuschel and Scully, 2016; Findlater and McGrenere, 2004; Gajos et al., 2006), predictability and accuracy (Gajos et al., 2008).

Most recently, Amershi et al. (2019) derived 18 guidelines from previous works. These guidelines serve to help designers who work in the AI domain design and evaluate AI-infused systems (Amershi et al., 2019). Such guidelines are timely and a necessary complement to the general UI guidelines due to the unique characteristics of AI technologies that differentiate human–AI interaction from traditional user interface interaction. In addition to increasing efficiency, automated systems may have unpredictable behaviours and be disruptive or untrustworthy. Therefore, the traditional UI guidelines may not be fully applicable to AI systems, and new guidelines may be needed. To facilitate design practice, Amershi et al.’s (2019) 18 guidelines have been organised based on the different phases of user interaction: ‘initially’, ‘during interaction’, ‘when wrong’, and ‘over time’. This way, each subset of guidelines can focus on a specific process of the interaction.

Within the scope of CAs, although the academic community has not yet provided specific guidelines, there has been a long tradition of study regarding the design of intelligent agents. Norman (1994) posits that the main challenges of designing intelligent agents are not technical but social, that is, how people interact with and perceive agents. This argument is still relevant today. Despite major improvements in natural language processing (NLP) and machine learning (ML) technologies compared to 20 years ago, there is still a significant discrepancy between users’ expectations and actual experiences with CAs (Luger and Sellen, 2016); how this discrepancy can be remedied remains unknown.

Norman (1994) also highlights the following factors to consider when designing intelligent agents: 1) the user’s feeling of control, i.e. ensuring that the user is in control of the system and

comfortable with the agent's automated actions; 2) the accuracy of expectations, i.e. accurately depicting what the capabilities of the agent to minimise false hopes; 3) privacy concerns, i.e. easing the disturbing thoughts of many individuals that intelligent agents may have access to their personal information and financial activities; 4) human-agent interaction, i.e. providing satisfying interactions with the user so that they feel comfortable, natural and in control. Note that each factor is a challenging task, and future research is required to answer many of the underlying questions. For example, many questions have yet to be answered regarding human-agent interaction, e.g. what is the appropriate form of interaction between users and the agent; how the user should instruct the agent; and how the agent should respond to the user. Nevertheless, at a high level, this work outlines four important areas regarding the design of intelligent agents: the feeling of control, the accuracy of expectations, privacy concerns and human-agent interaction.

In recent years, with the proliferation of CA applications such as Siri, Alexa and GA, the body of work pertaining to the design of CAs has begun to grow (e.g. Candello et al., 2019; Chaves and Gerosa, 2018; Fast et al., 2018; Graesser et al., 2017; Huang et al., 2018; Luger and Sellen, 2016; Winkler et al., 2019; Yang et al., 2019). Some works have centred on human-agent conversations. For example, Porcheron et al. (2018) suggest that CAs deliver resourceful responses through voice interaction. Resourceful responses could include cues about what the system was doing, why it was being done, and what was likely to be done next (Dourish and Button, 1998). Providing such cues would facilitate users' interactions with their CAs. Whereas, when the CA does not respond (i.e. silence), the state of the system remains unknown to the user (Porcheron et al., 2018). Myers et al. (2018) have studied how users overcome obstacles during voice interaction. Specifically, they summarised four types of obstacles—NLP errors, unfamiliar intent, system errors and failed feedback—and found that users handle these obstacles differently. Users speak louder or slower when they encounter NLP errors, whereas they are more likely to quit, settle (accept the flaw) or restart when they encounter the other types of obstacle.

Other works have considered modalities of human-agent interaction other than voice conversations. For example, graphical user interaction exists in smartphone CA interactions, and this may differ from voice interaction with a smart speaker. Considering these various

interactions requires a focus on diverse contexts of use, such as different places (e.g. in a car, at home, at a workplace and in public) or different devices (e.g. smart speakers, smart phones, smart watches and TVs) (Yang et al., 2019). Cowan et al. (2017) have suggested switching between modalities when the context changes. For example, screen-based interaction should be minimised when moving into contexts that require hands-free operation. Moreover, researchers have provided suggestions to improve the fluidity and seamlessness of interactions, especially when integrating with third-party services (Cowan et al., 2017; Yang et al., 2019). This is because failing to do so often interrupts users' hands-free operation, thus causing negative emotions, such as frustration.

Design recommendations have also been made that focus on revealing system adequacy and limitations (Luger and Sellen, 2016) to help users establish accurate perceptions of CA intelligence. Such perceptions are often affected by how the system presents itself and information to the user, for example, the interfaces through which users interact with the system and in what ways the system delivers information to users (Cassell, 2000). This suggests that intelligence and limitations of CA systems be conveyed through these interactions.

In spite of all the academic research, an increasing number of articles regarding design conversational agents are being seen in the public domain (e.g. Amazon, 2020b; Babu, 2019; Black, 2019; Google, 2019; Microsoft, 2019). This implies an urgent demand for practical design guidance in addition to research insights.

5.2.3 Research gaps

This analysis of the literature highlights two gaps and thus the focus of my research. First, despite being a mature theory of motivation and human flourishing, SDT has not yet been explored in the context of CAs. The successful utilisation of SDT to design engaging user experiences, e.g. in game design (Ryan et al., 2006) and behaviour change technologies (Jansen et al., 2017) suggests an opportunity to apply this theory to the field of CAs.

Second, most of the CA design implications described in academic papers are not expressed as actionable guidelines, which limits their usefulness to be used in real-world design practice. The value of articulating guidelines is present in such examples as usability heuristics (Nielsen,

1995) and guidelines for human–AI interaction (Amershi et al., 2019). However, the existing guidelines may not be adequate for CAs because they are intentionally designed to be general rather than specific (Amershi et al., 2019). Since CAs have a unique form of interaction (i.e. conversational and voice interaction) that is different from other applications, specialised guidelines are needed. The conversational interface of CAs presents new challenges and opportunities for designers, necessitating the provision of guidance regarding the design of conversational experiences.

The studies presented below address the two gaps. Specifically, SDT is applied to inform the creation of conversational experiences that satisfy users’ psychological needs of competence, autonomy and relatedness. A set of guidelines are then developed and evaluated based on the empirical insights into SDT as applied to CAs.

5.3 Phase 1: Applying SDT to Inform the CA Design

This phase aims to understand users’ perceptions and expectations of the needs of competence, autonomy and relatedness and how the design of CAs may support or hinder their fulfilment.

5.3.1 Method

Semi-structured interviews were conducted in early 2019. All interviews were carried out online via Zoom, and were audio-recorded. Each session took approximately 60 minutes.

Participants

Fourteen participants were interviewed (six were male, eight were female; aged between 24 and 50; 10 undergraduates, four postgraduates; 11 from Europe, one from Asia, two anonymous). Participants were recruited through a professional service platform (respondent.io). The goal was to recruit CA users of any type (e.g. Alexa, Google Assistant, Siri or Cortana). They were selected based on demographic data and their general experience with CAs: the type of CA they use most frequently (if more than one), as well as the duration and frequency of use within the past week. Among the 14 participants, there were seven Alexa users, six Google Assistant users and one Cortana user. Table 9 summarises the information. The participant-information-sheet

including the consent form was sent to each participant prior to the study. Signed consent form was collected before each interview session starts. Participants were each paid \$15.00 for taking part.

Table 9. Participants' information

P#	Age	Gender	CA type	Duration of use	Frequency of use
P1	28	F	Google Assistant	1–3 yr.	Daily
P2	49	F	Alexa	1–6 mo.	Every other day
P3	37	M	Alexa	1–3 yr.	Daily
P4	24	M	Alexa	6–12 mo.	Daily
P5	34	F	Alexa	1–6 mo.	Daily
P6	34	F	Alexa	6–12 mo.	Daily
P7	26	F	Google Assistant	1–3 yr.	Every other day
P8	26	F	Alexa	1–6 mo.	Daily
P9	36	M	Google Assistant	1–3 yr.	Daily
P10	38	M	Google Assistant	1–3 yr.	Daily
P11	37	M	Google Assistant	1–3 yr.	Daily
P12	50	F	Cortana	1–6 mo.	Every other day
P13	25	M	Alexa	1–3 yr.	Daily
P14	43	F	Google Assistant	1–6 mo.	2–3 times a week

Note: participants were randomly assigned a number for analysis purpose.

Study Design

I first warmed up the interview session by asking the participants general questions about their CA, for example, the devices they use, why they bought them, and what they often used them for. I then asked focused questions around the three needs. Questions were informed and adapted from Peters et al. (2018), who describe how needs can be examined in technology-based experiences. For example, the satisfaction of needs can be assessed by asking whether ‘the user feels capable of using technology’ (competence), whether ‘technology provides the user with useful options and choices’ (autonomy) and whether ‘technology makes the user feel

connected to other people' (relatedness). Therefore, to explore competence, questions were asked around the user's capability of and effectiveness in using the agent (e.g. 'To what extent do you feel capable of using the CA and why?'). To explore autonomy, questions were asked around the user's feeling of control and flexibility (e.g. 'How much control do you think you have over the agent?' and 'How much flexibility do you have in your conversations with the agent?'). Concerning relatedness, questions were asked around the feeling of connectedness to other people and belongingness to the community (e.g. 'To what extent does the agent make you feel connected to other people?' and 'What are your thoughts on the agent connecting you with the communities that you are in?').

Data Analysis

Following an iterative thematic analysis, the interview data were transcribed and coded. The analysis involved two researchers. Researcher 1 (the author of the thesis) performed the main analysis guided by the six phases outlined in Braun and Clarke (2006), and Researcher 2 was invited to evaluate the codes and themes throughout the analysis until a consensus was reached on their appropriateness. With the goal of answering the two research questions (RQ 1 and RQ 2), the data were analysed and coded in terms of the user's perceptions and expectations of each of the three needs as well as the aspects of the CA that may support or hinder the needs. After multiple rounds of coding, the codes were condensed into larger, overarching themes. Finally, connections were established between the themes, which led to the synthesis presented below.

Next, I present the key findings around what the three needs mean for CA experiences and design implications.

5.3.2 Competence in the CA and implications for its design

The results show that the users' sense of competence was often affected by (a) how much they thought they had made full use of the CA capabilities and (b) how effectively they communicated with the CA.

Making full use of the CA capabilities

One reason that prevented the participants from feeling competent was that they felt they did not know all the CA capabilities, in their own words, '*not using the CA to the fullest*': '*[I don't feel I'm fully capable] because I feel I got a lot more to discover in its functionality... I know there's more out there that I haven't touched yet*' (P5) or '*I haven't really looked into anything other than what I use it for*' (P4). In general, the participants felt they only knew and used the basic functions of the CA or the ones they were already familiar with. This could be due to the fact that they were not trained to use the CA: '*I know it can set alarms and play music, so I use these functions. I don't know what else I can do with it. I haven't been given this knowledge*' (P1).

The feeling of incompetence (in this case, having insufficient knowledge of the CA capabilities) was also likely caused by how the participants had discovered and learnt the capabilities. Often, the participants had discovered new skills or capabilities by surprise: '*For a long time, I didn't know it [Alexa] can give definitions of words. Once, I asked the definition of a word, and it responded with a really good answer. I was like, "Wow, I should do this more often"*' (P13).

Other times, the participants had discovered new uses online or from their friends: '*We played games with it [Alexa] over Christmas, like music quizzes. We didn't even know these existed. Someone at work told me, so we gave it a try*' (P5). The fact that new capabilities kept emerging made the users feel that they did not know about all the things the CA was capable of.

Despite the available resources online, the participants reported having little interest in approaching these resources actively, as this was often perceived as a huge effort, and the motivation to learn was low: '*[I don't need to learn new skills] there's nothing I can't do by myself with my phone or laptop, and it's not going to take that long*' (P12). There was some exception though but only at the beginning or prior to purchasing, for example, through the product's welcome tour or online tutorials: '*[I] went through the commands that the app showed me or asked [the CA] what new things it could do*' (P6). After the initial stage (for a week or two), such learning became unexciting.

As a result, some participants appeared to have had resigned to the fact that they should only use the basics of the CA. Others, however, wished for a fast and easy way to gain an overview

of the CA capabilities. This way, they could better understand what they already knew versus what was still out there. For example, P13 said: *‘I think I know the basics quite well. But for advanced features, I don’t know that much because I don’t really get told them. I would like to have prompts saying, “Have you considered trying that?” or “Did you know you can do this or that?”’*. P8 had a similar expectation: *‘I would expect a skill list of all the things it can do’*.

Not only does the extent of a user’s knowledge of the capabilities of CA affect their feeling of competence, but it could also affect their engagement with the CA. Knowing more about what the CA can do may encourage the user to use it more often: *‘When I realised what I could actually do with the assistant, I thought I would’ve have used it more’* (P14). In other words, the user’s mere use of the basics and limited learning of new capabilities may lead to diminished engagement.

It is important to note that setting realistic expectations is crucial when introducing new capabilities. In the first few interactions with a CA, over-promising or failing to live up to the user’s expectations may eventually decrease their engagement:

It was a little bit at odds with what we were expecting before we got it. I thought it could do many things around the house. The versatility and understanding were what we expected. But now it’s much less than what we thought it was before we got it. At first, I was asking for anything to see what would happen. But now I’ve just kind of resigned myself to the basic functions. (P8)

Summary (a). As shown above, the users’ knowledge of the CA capabilities is a key determinant of their sense of competence; it is also essential to their overall engagement with the CA. However, the information above shows that the CA users still think that they lack a full picture of what the CA can do. It also highlights their limited motivation for learning new capabilities actively, given the existing approaches (e.g. through online resources or CA apps). The results also show that when introducing new capabilities, it is important to be realistic about what they can do and keep up to the promises. The user will likely stop using a new capability if it does not meet their expectations. This finding has three implications for the CA design. The first implication highlights in-context education, which involves introducing users relevant capabilities from within the conversation when that capability may be needed; this reduces the

effort required for learning from outside resources. The second implication provides an overview of the CA capabilities, ideally highlighting what the user has and has not tried. The third implication sets realistic expectations for the user and keeps up to the promises.

Communicating effectively with the CA

The participants felt less competent when effective communication was hindered. There are a few reasons why this happened. It could be due to a lack of robustness in voice recognition: *‘Sometimes it mishears me or can’t pick up what I say. Once I asked for a specific album by a specific artist, it didn’t give me what I had asked’* (P10). This could also be due to the inability to interpret complex sentences (e.g. the ability to retrieve or keep context like in human conversations): *‘When I ask a question, it doesn’t understand the context correctly. It just gives an unrelated answer. So, I have to try again’* (P11). The participants appeared to have discovered solutions to these two issues. For example, they had learnt that they needed to speak clearly and loudly in a quiet place: *‘I feel I have to speak slowly and clearly for it to understand me’* (P9). They also had learnt to only ask very specific and structured questions: *‘We have to be very specific about the questions we ask’* (P8). P11 also mentioned, *‘You have to be careful about how you structure your questions’*. The participants were aware of the fact that talking to a CA was not the same as talking to a human being: *‘You can’t ask a question like you’re speaking to a normal person. If you don’t get the right answer, you have to restructure your question’*.

Another reason that may hinder effective communication is that the responses from the CA are often too robotic, lacking conciseness and specificity:

I once asked about the sweetness of a new type of blueberry. It responded with an excerpt from Wikipedia. But that’s not what I wanted. A human wouldn’t do that. A human would just tell me how sweet it is. What I wanted was something more concise, not a scientific description. The same goes for films. (P1)

This participant was expecting a more human-like response, a short and direct answer rather than a search result. Unlike the previous two issues, the participants did not offer any solutions as they hardly had any control over the responses from the CA.

Regarding the way the participants asked questions and the responses they received, as evident above, the users' conversations with the CA were somehow shaped and restricted by it. The users had to ask questions in a certain way to obtain the answers they needed. In almost all cases, the users could not control what to include in the response and how that response had to be presented. The only way to change the responses involved rephrasing the questions. In general, the participants were tolerant of such constraints because they expected the CA to be no more than a machine in its infancy: *'I understand that... I think it's still not completely natural. It's not a conversational language like you and I are having now'* (P10); *'I guess the technology is quite new. The voice technology is not there yet'* (P9).

However, a lack of attention to these issues may pose risks in the future. First, future engagement could decline. Users will be unwilling to use more advanced features: *'I often use it [Google Assistant] for dictation. But for anything related to the long form of writing, I would rather do it myself because it just can't work'* (P7). Similarly, P8 had discovered that the CA had much less understanding than she had expected; therefore, she had ended up using only the functions that worked well: *'...versatility and understanding were what we expected. But now it's much less than what we thought it was ... now I've just kind of resigned myself to the basic functions'* (P8).

Second, users may have less confidence in the CA, precluding the accomplishment of more advanced tasks. For example, this comment concerns shopping via the CA:

I will always have to double-check. If I ask it to buy a film ticket, I wouldn't just give it the details and presume it's going to do it. I would still feel I need to watch over what it's doing; double-check that it's gone to the right place. It doesn't understand the context.
(P7)

P11 and P12 expressed the same concern: *'If I wanted to order groceries, I probably wouldn't trust it enough to get the right results'; 'I won't trust it 100% to write and send an email'* (P12).

Third, it may affect young children who are learning how to communicate. As mentioned above, the participants had learnt to speak to the CA in a certain way to obtain the answers they needed. Such way of speaking requires being specific, direct and not always polite: *'You need to*

be quite direct at it like, “Show me this.” You feel very unnatural because you want to be polite saying “Please” and “Thank you” to it’ (P7). She said that she had learnt such a way of speaking from the CA itself:

I think I have learnt how to do it. There are words that it prefers. Words like ‘would you’ won’t work. You need to say, ‘Play music’ or ‘Find me this.’ Instead of saying ‘Can you find me an Indian restaurant?’, you say, ‘Find me an Indian restaurant.’

This shows that the participants had managed to seek solutions to their problems through trial and error. They eventually had adjusted themselves to the way of talking that worked. During this process, the system (i.e. the CA) was teaching, or at least shaping, a learning style which worried P7: *‘If you had a child, that would be a problem. We don’t want them to talk to people like that in the real world’.*

Summary (b). Having effective communication with the CA is key to the users’ feeling of competence. However, communication was often hampered for three reasons: (1) a lack of robustness in voice recognition, (2) weakness in the interpretation of complex questions and (3) responses being too robotic rather than being concise and to the point. Ineffective communication may have three negative consequences. First, it may decrease user engagement, meaning that users may eventually only use the capabilities that they are familiar with. Second, it may impinge on user trust, meaning that users may be reluctant to use the CA for more advanced tasks (e.g. shopping). Finally, it may introduce new behaviours – children may mimic the way they talk to the CA in the real world. The findings in this section have four implications for the CA design. First, the robustness of voice recognition should be improved to eliminate the need for a slow and clear talk. Second, the automatic retrieval of contextual information should be improved to reduce the need for specificity for every query and increase the opportunity for a more natural way of speaking. Third, more human-like responses need to be provided; these should be concise and straightforward. Finally, CA designers should take responsibility for eliminating the negative impacts of externalities on users. CA designers need to appreciate the fact that CAs are used by all age groups, and they can potentially shape how people (especially young children) talk to each other.

5.3.3 Autonomy in the CA and implications for its design

The results show that the users' sense of autonomy was often reflected by their (a) having control over the conversation, (b) having a personalised experience and (c) having control over their data.

Having control over the conversation

'Control to me means how I ask the CA a question, and how it responds to me' (P14). The interaction between the user and the CA often consists of two parts: asking questions and receiving responses. For the users, having a high sense of autonomy meant being flexible in the way they asked questions and received the expected responses. However, two factors limited the sense of autonomy when, first, the users did not have sufficient flexibility in how they could ask questions, and, second, when the users had no control over what responses they could receive. Sometimes responses came unpredictably and inconsistently. In other words, the interaction was often driven by the CA rather than the users. To achieve a high sense of autonomy, the users expected flexibility in the way they asked questions and expected predictable and consistent responses. The participants also welcomed the idea of being able to customise the questions and responses.

Asking questions. Flexibility was often restricted because the users often had to adapt to the CA's way of operation to obtain what they wanted. They often had little control over how they could use the CA:

Because companies decide how the CA works, not me. For example, if you have a couple of alarms on and want to change the time of one, you have to cancel the alarm and set up a new one. It has to be done in this way because it's engineered in this way. I feel like I don't have much control over that because this is not really how I want her to work.
(P8)

Natural conversation was also said to be limited. The users were not able to talk freely to the CA as they tend to do to a human being: *'I don't feel completely flexible about the way I ask*

questions] because it has to be structured. You can't ask a question like when you are speaking to a normal person' (P11).

Receiving responses. The participants complained that they had no control over the responses: *'[I don't think I have enough control] because the CA doesn't always give me the response I expect'* (P9). Sometimes, the responses were not as expected and often came unpredictably. On other occasions, the responses to the same query asked before were inconsistent. Both of these examples were frustrating experiences: *'Often it comes with a surprise. I think I need more control because I often cannot get what I want'* (P1); *'You ask the same thing three days in a row; it will have three different ways of doing it. I feel like it's not quite consistent'* (P7). Inconsistency is not uncommon. P9 also said that receiving inconsistent results made him feel less in control of the CA: *'There were times I asked it to play a song, and it said, "You don't have your assistant connected to your TV," but other times it understood and played the song'*. Most participants thought that the CA was acting independently of them. Additionally, not providing sufficient explanation for the CA's behaviour can lead to a feeling of powerlessness: *'It [Alexa] is so itself. It's doing whatever it wants. If we ask it to turn on the TV, it doesn't do it, and we don't know why'* (P6). As shown in this example, providing explanations for the CA's behaviour (e.g. why the CA cannot do what it's asked to do) can be very helpful in times when an error occurs.

Customising questions and responses. One way to address the above issues is to allow users to decide how they want to ask questions and what responses they wish to receive. The concept of 'routine' is one useful example. The concept of routine is introduced in Google Assistant, Alexa and Siri (named shortcut). The idea is to allow the user to set up a trigger word or customised command for a routine (e.g. 'good morning') and define what actions to receive in response to that command. For example, when the user says, 'Good morning,' the CA would start playing the news, followed by the weather forecast and the schedule of the day.

Some participants mentioned that they had used this feature and found it useful in the following ways. First, since it gives the user options to customise responses, it increases the chance of obtaining expected and consistent answers: *'It's quite valuable because I see a lot of potential in terms of getting consistent results'* (P1). The user can set up their favourite actions, their order and, even more specifically, what news resources they wish to include. Second, the notion of routine allows the user to adapt the use of the CA to their own lifestyle, thus using

the CA in accordance with their own values. The participants had experimented with or started to plan applying the routine to many aspects of their lives. For example, the routine could make this participant's day more productive: *'I would use it for scenarios like starting my workout playlist. And when I start to work, it could know me well and play a different playlist. I listen to the piano while working'* (P12). An evening routine could make this participant's evening more relaxing:

If you can customise a prompt, it could be something very specific to get that going; this is definitely valuable to me. I will use it when cooking. When I say, 'Good evening,' it could start my evening cooking routine with music. That would be really nice. (P8)

However, the routine option works best when there is a sequence of actions related to diverse capabilities. This idea is also valid when applied to a single capability, meaning that the user can customise the trigger word and responses for a particular capability. This way, the control is pushed towards the user's end. For example, this is what P5 said about her daughter using the CA when doing her homework:

She would like to learn synonyms, so she will ask a lot like, 'What's another word for happy?' If she can define the question herself, say, 'It's homework time,' then when she says, 'Happy,' Alexa will automatically suggest alternative words for happy instead of the meaning of happy.

Summary (a). The users' sense of autonomy was reflected by whether they had control over their conversation with the CA, specifically, concerning how they asked questions and what responses they received. Currently, such a sense of control is limited, and the interaction is more driven by the CA rather than the user. To be more specific, the user feels they have limited control over how they can ask questions. This is likely the case for two reasons. First, the usage of the CA is often engineered by the manufacturer, leaving the user no other alternatives. Second, because of the limitations of technology, the user is not able to talk the way they do to a real person. Moreover, the user feels they have no control over how the CA responds. This could be due to a lack of robustness in the responses, yielding inconsistent and unexpected results, and a lack of sufficient explanation for the CA's unpredictable behaviour. These conditions have three implications for the CA design, namely (1) providing users with options

to customise their conversations with the CA, as shown by the routine feature; (2) considering adding explanations for the CA's responses, especially when things go wrong; and (3) improving the robustness of the natural language processing technologies to better understand the human language.

Having a personalised experience

The sense of autonomy manifests itself in having personalised experiences, which is made possible by an intelligent CA. This means that, among others, the CA learns about the user over time and can provide responses consistent with their preferences:

There's a song I want to listen to, and there are different versions. Each time I ask Alexa to play that song, I have to specify which version I would like to listen to. Since I'm always asking the same thing every single day, Alexa should know by now that I want this version of the song. (P6)

However, in reality, CAs are still making independent decisions in most cases without considering the user's preferences and habits: *'But now when I say the name of that song, Alexa still plays whatever it wants' (P6)*. This is not uncommon. Most participants thought their CA was not intelligent enough to provide personalised responses: *'Everything is input manually rather than automatically' (P10)*.

A perceived balance between control and intelligence is worth noting. To many participants, 'control' means the CA does what it is told to. On the one hand, a user with more control over the CA could lower the CA's level of intelligence. On the other hand, users wish for some form of personalisation which requires the CA becoming intelligent and making decisions on their behalf: *'I think having more control over it means lowering its intelligence level and letting it do what I want it to do. But my less control means a more intelligent CA hiding more details from me' (P1)*. Control and personalisation may be in conflict with each other, and balancing them is challenging, especially in cases where people's personal preferences change over time. For example, this participant was disappointed with the CA not noticing a change: *'I don't think it's learning. Sure it can notice some pattern. But humans are always doing things slightly off. I often*

drink coffee for breakfast, but sometimes I drink tea' (P7). Despite this challenge, this finding may suggest that when not sure about the answer, the CA should ask the user for confirmation.

Summary (b). A higher sense of autonomy for users is contributed by the user having a personalised experience. The participants were expecting the CA to learn about their preferences and deliver tailored results. However, to this date, they have not had the feeling that their CAs were taking their needs and preferences into consideration when delivering responses. This highlights two implications for the CA design: (1) improving the intelligence level of the CA and (2) seeking confirmation whenever the CA is not confident enough about automatically delivering personalised results.

Having control over data

The sense of autonomy is also largely affected by whether the user has control over their data. Most participants talked about their concerns: *'I don't feel like I've got any control over it. I'm sure it's listening in the background and spying on me'* (P5); *'I don't know whether she's listening all the time, even if she's not responding to any commands. That's my major concern'* (P6).

A lack of control over data leads to diminished trust. Some participants, for example, had decided that they would not put a CA speaker in the house because they did not trust it enough:

I don't have Google Home speaker in my house because I don't trust that I have total control of it. (P7)

It's the reason I don't have Google or Alexa at home because, you know, there's always this conspiracy that they're listening to you all the time. At the same time, it's in everyone's home, phone and laptop. There's no way to get away from this software. (P12)

Other participants would switch the power off if they were concerned about their privacy: *'If you don't want Alexa to be involved, you switch it off'* (P2).

There were also participants who had accepted this situation and admitted that this was part of what they had bought: *'I don't like the idea that it's collecting data on me, listening to my*

conversations... But I guess it's just part of what I paid for' (P4). Despite this, they expected some transparency:

Ideally, I would like to see exactly what has been set up. At the moment, it gives you a history of what you asked. It would be good to see what data have been sent to Amazon to see how they deal with the data and how the algorithms work. (P3)

Summary (c). Concerns over whether, when and how data are collected and used tend to impinge on the users' sense of autonomy. Not addressing this issue could lead to low trust and engagement with the CA. This has an implication for the CA design, meaning that users should have more control over their data or, at least, access to a transparency channel to allow them to view and manage their data.

5.3.4 Relatedness in the CA and implications for its design

When asked whether the CA had made them feel connected to other people, very few answers were in the affirmative. One common reason is that hardly any functionality supports communication between people, nor is connecting with other people the main motivation for using the CA: *'In terms of connections like talking to people, it doesn't make me feel more connected'* (P8). P2 did not feel so either. Like many other participants, she was not expecting this: *'No, and I don't expect this. I wouldn't use it because I have my phone ... I don't need Alexa to connect to these things. I don't think Alexa is built for that'*.

Although social functions are not fully available in (or may not be designed for) current CA systems (until the date of this study in early 2019), the data revealed three roles that CAs may play in supporting relatedness. It is worth noting that the participants had mixed views on these roles. In the following section, I present these roles in detail, elaborating on both the CA's benefits and the users' concerns.

CA as a communication tool (messaging and calling between individuals)

CA could be used as a communication tool to send messages and make calls or video chats. For example, Alexa has a 'Drop' feature that allows users to talk to their contacts who also have the Echo device: *'I've used the Drop feature once, which is good. I can call others who also have the*

Amazon Echo' (P3). The value of CA resides in the voice control, which makes it easier and faster to launch the communication channel.

Other than this, the participants found little value in using the CA as a communication tool. Three reasons were cited. First, they would not consider switching from the tools they were already using: *'I think I would rather text or call. I doubt I would have the desire to use Google Assistant to message or make a call. I don't think that's something I will change what I do now'* (P14). P5 did not consider this either because this was not why she had bought the CA: *'This is not the reason we got Alexa, to be honest. Especially for family, I'd much rather have that personal connection. If I want something, I'd ask them'*.

Another reason concerns the robustness of the system: *'I would not be quite confident about asking the CA to make phone calls. Because a lot of my friends don't have regular English names, and it would probably not recognise their names correctly'* (P11).

Furthermore, many smart speakers lack a visual interface, which makes the CA less helpful in messaging. Sending messages via voice is less interactive because it is difficult to send emojis and other visual elements: *'I probably won't use it for communication. I would use text messaging and the phone because it's easier to send funny messages and select images through text apps rather than voice'* (P10).

Summary (a). The participants were found to attach little value to the use of the CA for communication. There are three reasons for this. First, the participants have no motivation for switching from their existing tools. Second, technology is not robust enough to provide sufficient trust. Finally, the CA device often lacks a visual interface, making it less useful for sending messages. These findings suggest that these issues need to be addressed before and during the implementation of social-related functions. For example, it is worth considering (1) the distinguished values that CAs may bring compared with traditional communication tools, (2) ways to gain users' confidence in utilising social functions on CAs and (3) ways to eliminate the limitations brought by the lack of visual interface.

CA as a voice interface to social channels (interacting with groups and communities)

Although most participants were reluctant to use the CA for individual communication, they did see value in connecting to social channels via their CA, especially when it was about receiving news updates from groups, organisations or communities. This means that the user interacts with their social channels through the CA (e.g. listening to community news and posting messages to group channels). The voice interface of the CA makes interactions, such as posting and commenting, easier, thus increasing engagement. This is especially helpful when the user needs to stay active in their groups. For example, when at work, *'it can connect to my slack, so I can ask it to read my last message or reply to my last message by saying...'* (P13). This also benefits parents by allowing them to stay active in their children's school community: *'The school has a Facebook group. If using the assistant, I may communicate more in the group.'* (P14).

Moreover, the CA has the potential to pre-process information before delivering it to the user. Being an interface between the community and the user, the CA can help filter out redundant or irrelevant news. In the study, a mum of two mentioned that she often receives the same notification from the school multiple times (her children go to the same school). Worse than that, the notifications not only come to the school app but also by email, text message and perhaps other platforms (e.g. the Facebook group). CA as an interface to the school channel has the potential to filter out these redundant notifications: *'...there's so much information. We have the school app, emails and sometimes text messages... We parents do get a lot of the same information. If you have more than one child, you get the same information many times...'* (P14).

It is worth noting the users' concerns. First, the users did not adequately trust the CA for posting their comments on social channels, largely due to a lack of confidence in its robustness: *'My worry would be if I was having a conversation in a house and somehow the CA picked up something randomly in the background, transcribed it and put it on the social media, I would be uncomfortable with that'* (P10). Some participants shared their concern of misspelling: *'I think I'd be worried about misspelling the words in that case'* (P8). Since this regards the user social profile, users, in general, want to be 100% sure before any action is taken: *'I would need to be 100% confident about what I say and 100% sure it goes on the right platform'* (P10).

Second, the users were concerned about accessing social channels in shared environments, such as the family. Often the CA is shared by the family. The users did not think it was appropriate for their children to listen to their social interactions. Moreover, a social account usually belongs to one individual. It is hard to use one shared device for all adults in the family: *'It's a family device. I don't really want my daughter to access my social media. Plus, my husband and I have separate social media accounts. We've got different interests, so different things come on our news feeds, and not all of our friends are mutual'* (P5).

Third, the users were uncomfortable about sharing data. In the case of social accounts, not only are the users' data accessible to the CA, their friends' and family's data may be revealed as well. The participants found this intrusive and unsettling:

No, I wouldn't like it at all. To me, it's really intrusive because that means the assistant can access my Facebook account or other accounts. That would allow the assistant to read and learn about my friends. They haven't given any permission for that. (P6).

Lastly, there were concerns about the lack of a visual interface. This undermines the usefulness of interactions, for example, for showing a picture and other visual elements, as well as providing feedback or confirmation messages such as *'your comments are being posted'* (P14).

Summary (b). The results illustrate the value of using the CA as an interface to group or community news for two reasons. First, the audio interface makes the interaction easier, and thus it helps the user stay active in the group if they want to. Second, as a smart interface, the CA has the potential to pre-process the information, filtering out unwanted or duplicate notifications as defined by the user.

Data from this study reveal four concerns. The first concern is the lack of a robust technology making it less trustworthy to take action on the social media on behalf of the user. The second concern is about the user's unease about having interactions with social channels in a shared environment, such as the family. The third concern is about intrusiveness and the CA's access to information about the user's friends or family. The final concern is about the lack of the visual interface on some CA devices, undermining the usefulness of interactions.

Regarding the values and concerns, it is worth considering the following implications. First, the CA is recommended to ask for permission before launching its social-related features, as these features may appeal to some, but not all, participants. Second, CA designers are advised to address the above concerns before and during the development of such features. It is also worth determining the extent to which the values outweigh the concerns before implementing any of the features related to communication.

CA as a facilitator of social activities

CAs can also support relatedness by facilitating fun and engaging social activities. This allows family members or friends to bond with each other. For example, using the CA to play games with family members helps parents to bond with their children: *'The only thing that has something to do with connection is that we use it to play games. Together we try to get an answer to the game'* (P5). Another example is that talking to the CA was found to break the ice between people or to invoke an interesting conversation: *'That would be a social thing; like "Showing what GA can do" could be the topic of a conversation with friends when they're visiting'* (P11). This study has also showed that the use of the CA allows parents to help their children do their homework and family members to play with the CA and have fun. As a new interactive technology, CA has many benefits, which raise the question of how we can design CAs to support social interactions among family members and friends and enhance their connectedness.

Summary (c). Although CA may not have intentionally been designed as a facilitator of social activities, this finding highlights CAs' implicit values and opportunities associated with social activities alongside their primary functions. These benefits give more prominence to 'designing experiences' than 'designing products'. In other words, the design of the CA should begin with contemplating the experiences it can create, followed by concentration on designing product functionality. As the data show, CAs have the potential to enrich social interactions and bring additional social benefits. It is, therefore, useful to be aware of such benefits and, if possible, turn them into explicit designs in the future.

5.4 Phase 2: Deriving Design Guidelines

This phase aims to translate the findings from Phase 1 into design guidelines.

5.4.1 Method

First, I consolidated the implications from Phase 1 and organised them into four categories based on the following phases of user interaction, as identified by Amershi et al. (2019) – ‘initially’, ‘during interaction’, ‘when wrong’ and ‘over time’. Specifically, I summarised all the findings from Phase 1, which resulted in 13 implications. I then filtered out the implications that pertain more to technology advancement than design, such as ‘improve the robustness of voice recognition’, ‘improve the intelligence of CA’ and ‘improve natural language processing technology’, resulting in ten implications. Subsequently, I clustered the implications into the four abovementioned categories. Next, I translated the implications into actionable design guidelines following the guidance outlined in Amershi et al. (2019): ‘written as a rule of action; containing about 3-10 words and starting with a verb; accompanied by a one-sentence description that qualified or clarifies any potential ambiguities; not contain conjunctions’. Finally, the guidelines were discussed, reviewed and iterated by me and another researcher until an agreement was reached.

Note that relatedness was considered differently than the other two needs and was not taken into account in the creation of guidelines. There are two main reasons for this decision. First, unlike competence and autonomy, relatedness depends heavily on particular features of the product, that is, features that allow users to communicate or interact with one another. However, such features were not commonly seen in CAs when the study was conducted. Second, capabilities linked to relatedness were not always expected in CAs. Findings from Phase 1 showed that participants had little motivation to use CAs for social purposes. Most often, participants had concerns other than positive perceived value. Considering relatedness different than the other two needs is not uncommon. For example, in Peng et al. (2012), relatedness was excluded for similar reasons. Despite of this, as the development of social capabilities in CAs is still in its infancy, I believe it is useful to discuss the possible roles and opportunities for CAs to support relatedness and the concerns users may have (see Section

5.3.4). These insights could inform the design of CAs' social functions and the development of associated guidelines in the future.

Of the resulting guidelines, the first six were developed from implications relevant to competence and the other four from implications relevant to autonomy. However, instead of grouping them into two categories based on the needs, they are organised based on the four interaction stages discussed earlier. There are two reasons for this: 1) despite competence (or autonomy) being the primary need that is fulfilled in one experience, the two needs often coexist. As such, designers are encouraged to achieve a balance of both needs instead of emphasising one over the other which may result in one need being overlooked. 2) Presenting guidelines in line with the interaction stages (as shown in the section below), as opposed to needs, provides more structured instruction that is thus more helpful for designers.

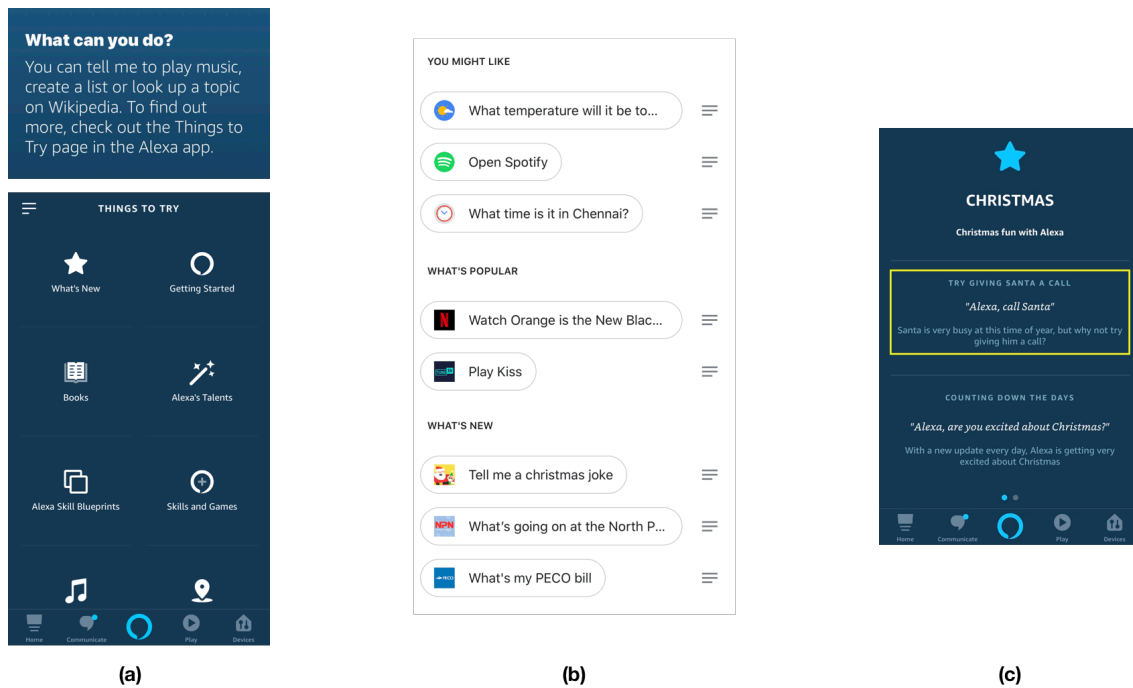
5.4.2 Design guidelines for CAs

Table 10 presents a summary of the guidelines. Each guideline contains an actionable suggestion followed by a sentence describing the goal of the guideline. For example, G1 suggests that the CA should provide a personalised overview of its capabilities, and the goal is to give the user a comprehensive understanding of what the CA can do as well as what capabilities have and have not been explored by the user. All guidelines are discussed in detail later.

Table 10. Design Guidelines for CAs

Initially	G1: Provide a personalised overview of CA capabilities. Update the user about the capabilities of the CA, which capabilities have been explored and which have not been explored.
	G2: Provide in-context education. Make it convenient for the user to discover new and relevant capabilities.
	G3: Reveal how well the CA can perform when introducing new capabilities. Help the user have an accurate expectation of the CA's capabilities.
During interaction	G4: Learn from conversational context. Make sure the user does not need to repeat information during the conversation.
	G5: Provide succinct responses. Make it easy for the user to retrieve information.
	G6: Talk politely. Encourage polite and socially appropriate conversation.
When wrong	G7: Provide an explanation regarding why the CA cannot complete a task. Help the user understand the current system status.
Over time	G8: Learn from conversations over time. Help the user obtain a personalised experience.
	G9: Provide opportunities for customisation. Allow the user to customise the commands and responses.
	G10: Provide opportunities for user data management. Allow the user to view and manage their personal data.

G1–G3 concern educating users about the CA’s capabilities. Relevant examples are presented in Figure 27.



(a) When asked ‘What can you do?’, Alexa points the user to the ‘things to try’ page. (b) ‘Explore what’s new’ page on the GA app; it shows categories of things to do. (c) When asked ‘Alexa, call Santa’, Alexa is supposed to connect the user to Santa, but in the first few trials, users heard ‘I can’t find the name “Santa” in your contact list’ and experienced disappointment.

Figure 27. Examples of G1 to G3

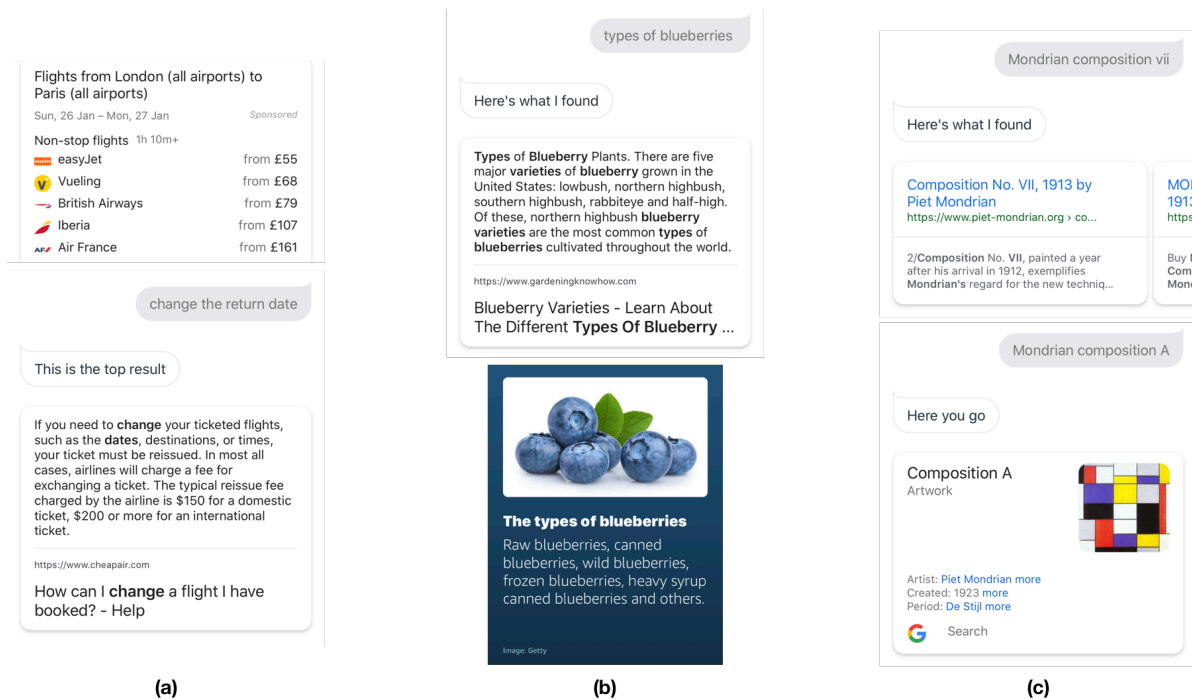
G1. Provide a personalised overview of CA capabilities: update the user regarding the CA’s capabilities, which capabilities have been explored and which have not been explored. Given the fast-growing number of CA capabilities (e.g. ‘tell jokes’ is one capability; ‘play podcasts’ is another example of capability), users need a way to access an overview of these capabilities, ideally highlighting what they are already familiar with, what is new and what seems relevant to them. In current CAs, available capabilities are often organised into categories on a summary page, such as ‘things to try’, Figure 27 (a). A page like this helps the user understand what they can do with the CA. However, CAs currently do not provide a holistic and personalised view of their capabilities, which, if achieved, could be more useful compared to the current approach. Specifically, this research suggests making the summary page more informative. For example, the categories could be reordered or tailored according to the user’s usage history and

preferences instead of using generalised categories; a dashboard could also be helpful comparing what the user has already tried to the entirety of the CA's capabilities.

G2. Provide in-context education: make it convenient for the user to discover new and relevant capabilities when needed concurrently with the flow of actions. More specifically, in-context education means introducing new capabilities during the conversation when needed. For example, the CA may recommend cooking-related capabilities while the user is asking about dinner ideas. In current CAs, new capabilities are often introduced through a 'what's new' page, Figure 27 (b). Unlike in-context education, this approach requires the user to exit their ongoing conversation with the CA and find the 'what's new' page themselves. In other words, the key difference regards when and how that capability is introduced. This guideline involves the CA recommending new capabilities to the user within the conversation as needed.

G3. Reveal how well the CA can perform when introducing new capabilities: help the user have an accurate expectation of the CA's capabilities. This means that the CA should not exaggerate what it can actually do. For example, during the Christmas season, Alexa introduced the skill 'call Santa', Figure 27 (c). However, the first few trials failed as Alexa responded with *'I can't find the name "Santa" in your contact list'*. Although it worked eventually, users' initial excitement had already been replaced by disappointment. This guideline suggests that, when introducing new capabilities, it is important to anticipate users' expectations and ensure that they are met.

G4–G6 concern the conversations between the CA and the user. Relevant examples are presented in Figure 28.



(a) After a conversation with GA about 'flights to Paris', the user wanted to change the return date; however, they had to repeat the conversation to do this. (b) When asked for 'types of blueberries', GA replied with a search result (top); Alexa replied with a direct answer (bottom). (c) When asked about an artist's name and painting, sometimes GA replies with search results (top) and other times with a direct answer (bottom); the answers often come randomly and inconsistently.

Figure 28. Examples of G4 to G6

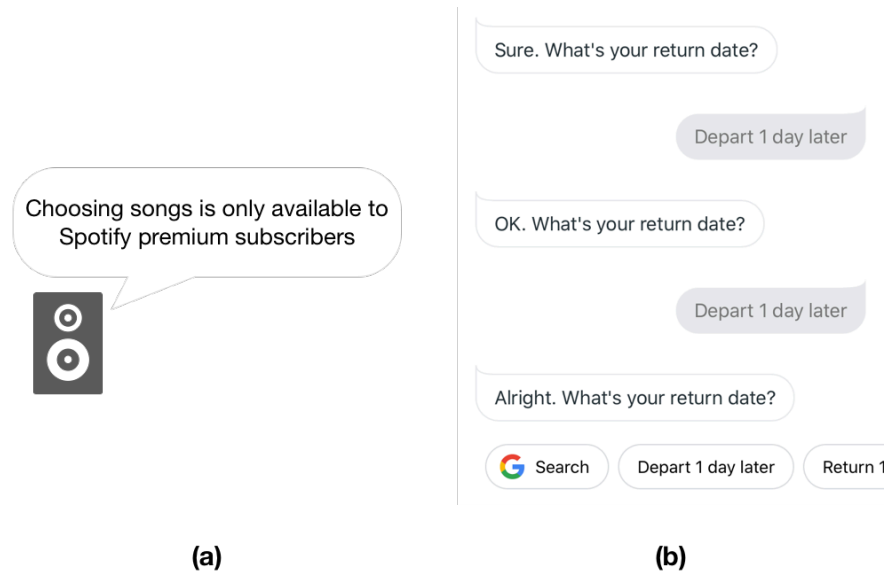
G4. Learn from conversational context: remember and replay information previously shared in the conversation. Maintaining the flow of conversation is key to effective communication, which requires the CA to understand the conversational context. For example, if a user asked to book a flight and later wanted to change the return date, the user should not have to repeat the flight information, Figure 28 (a). In conversation design, it becomes challenging when the conversation jumps between multiple sub-topics, which is common in human communication. A user, for example, may ask about a flight to Paris, get distracted by the attractions and then ask about the Louvre museum. After the 'distraction', the user may go back to the 'flight booking' topic. In this case, the CA should be able to pick up on previous information to complete the original task.

G5. Provide succinct responses: make it easy for the user to retrieve information. In cases where responses are in the form of search results, current CAs have different forms of

presentation. Sometimes, the CA gives a short briefing with the search link. Other times, it provides a direct answer, Figure 28 (b). It has also been noticed that such forms of presentation are often inconsistent, Figure 28 (c), and there is no option enabling the user to choose the form that better suits their needs. When making such design choices, this guideline suggests that the ultimate goal should be to help the user retrieve useful information easily through approaches such as succinct and concise answers; the decision on whether showing or hiding search links in a response could be made by collecting user feedback regarding their preferred form.

G6. Talk politely: encourage polite and socially appropriate conversation. This guideline concerns the negative influence that CAs may have on the way we talk, especially young children. It has been found that it is not uncommon for users to speak to CAs in a commanding fashion, for example, ‘Alexa, do this’ and ‘Alexa, stop’. In fact, users have been implicitly instructed by CAs to speak this way because CAs understand the command better when talking directly. Although adults are generally fine with this, the study from Phase 1 shows that CAs are often shared among family members, and children are increasingly exposed to CAs or are CA users themselves. In the study, parents raised concerns about the potential negative externalities of CAs. This guideline suggests considering designs that discourage and eliminate such debatable influences.

G7 concerns how to deal with situations when the CA system malfunctions. Relevant examples are presented in Figure 29.

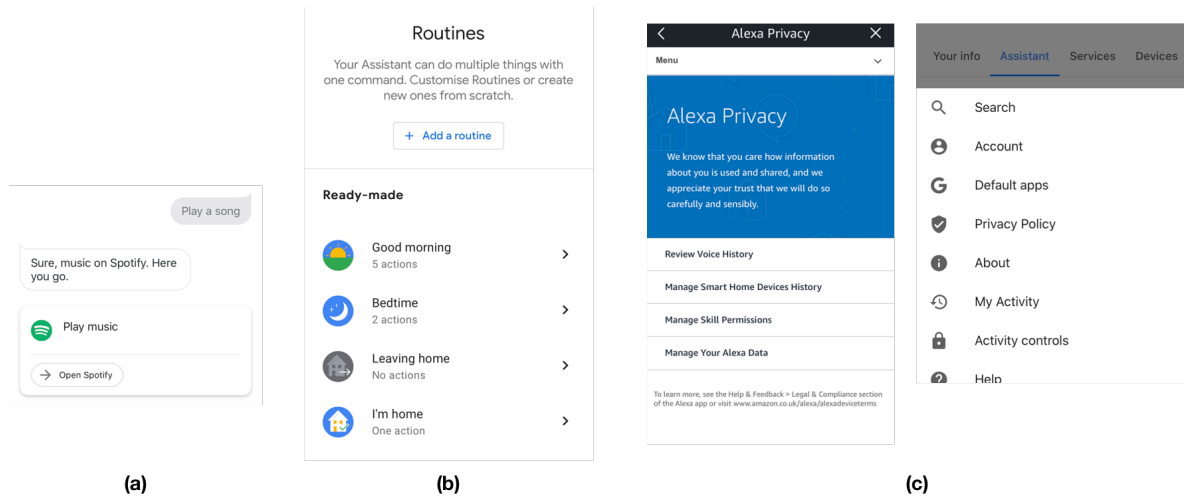


(a) Google Home explained why it could not play the song. (b) Something went wrong with GA as it kept repeating the question 'What's your return date?' and offered no explanation.

Figure 29. Examples of G7

G7. Provide an explanation regarding why the CA cannot complete a task: help the user understand the current system status. There are many reasons CAs cannot complete certain tasks, including system settings or technical limitations. Regardless of the reason, it is beneficial to provide users with explanations regarding any malfunction. Providing such explanations, for example, explaining why the CA cannot complete a task, Figure 29 (a), helps the user make sense of and resolve the current situation. A lack of explanation, conversely, may frustrate the user, Figure 29 (b).

G8–G10 concern the design and long-term use of CAs. Relevant examples are presented in Figure 30.



(a) Music can be personalised through the service provider (e.g. Spotify) rather than the CA; screenshot from GA app. (b) Through the routine feature, users can customise the trigger phrase and actions to respond; screenshot from GA app. (c) Users can find privacy policies in CA apps; Alexa app settings page (left); GA app settings page (right). However, these pages were not easy to find.

Figure 30. Examples of G8 to G10

G8. Learn from conversations over time: behave intelligently to personalise users' experiences. In current CAs, some of the content can be personalised through service providers. For example, when a CA is asked to play a song, it is the media service (e.g. Spotify) that provides personalised music to the users based on data from that service platform, Figure 30 (a). According to the findings from Phase 1, however, CAs provide few personalised experiences (except for the basics, such as location and voice). Participants reported that they did not feel the CA was learning from their past conversations.

G9. Provide opportunities for customisation: allow the user to customise the commands and responses. This means giving users the ability to customise their conversations with the CA, for example, defining how they ask questions and how they want the answers to be presented to them. In current CAs, the 'routine' feature offers such opportunities, Figure 30 (b), although its primary intention is to combine multiple actions into one. This guideline suggests customisation within the action. For example, in most CAs, the user can customise the news resource list so that when the command 'play news' is launched, the CA only plays news from that list. This concept may also apply to other scenarios.

G10. Provide opportunities for user data management: allow the user to view and manage their personal data. The goal is to provide users with transparency on the data, for example, whether and when their data is collected and how it is used. Current CAs provide some form of data management. For example, users can find the privacy policy or activity history in the apps, Figure 30 (c). However, these could be designed to be more easily accessible, as the findings from Phase 1 showed that most participants did not know such features' existence.

5.5 Phase 3: Evaluating Guidelines

This phase aims to evaluate the guidelines in terms of their perceived importance and value to the overall user experience.

5.5.1 Method

A survey study was conducted. It was implemented using Qualtrics and distributed on the Amazon Mechanical Turk platform. A total of 200 participants were recruited for this study. They were regular users of any type of CA, including, but not limited to, Alexa, Google Assistant, Siri and Cortana. This was controlled through screener questions at the beginning of the survey. Specifically, participants were asked the question: which virtual assistant do you use? They were given choices including 'I do not use a virtual assistant' and a list of product examples such as Alexa, Google Assistant and Siri. Participants were told ineligible for the study if they had not used a virtual assistant. They were not able to go back or access the survey again to alter their choice. Passing the screener question brought participants to the consent page. Upon collection of their consent, participants entered the main body of the survey. The following data were collected in the main body: 1) the users' overall satisfaction with the CA, 2) the extent to which the guidelines have been followed or violated in the CA and 3) the perceived importance of the guidelines. The average task duration for each response is 4 min 24 seconds. Participants were given incentives (at an average rate of \$10/hour) as acknowledgement of taking part.

Survey Design

The survey contained five sections. The first section collected participants' consent and background information on their usage of CA, including the type of CA, the device used and the duration and frequency of use.

The second section asked the following question to assess the users' overall attitudes about and experiences of the CA: *'Overall, how satisfied or dissatisfied are you with your virtual assistant?'* A seven-point semantic differential scale from 'extremely dissatisfied' to 'extremely satisfied' was used. This question was borrowed from HaTS, an empirically validated survey largely used for measuring users' attitudes and experiences with products (Müller and Sedley, 2014).

The third section assessed the extent to which each of the guidelines had been applied or violated by the CA. For each guideline, the description was first presented; then the participants were asked to rate their CA on a five-point scale from 'strongly disagree' to 'strongly agree'. The description was slightly rephrased from the guideline description to better suit the participants' circumstances. For example, the guideline, 'provide in-context education' was changed to 'it helps me discover new and relevant capabilities.' This is because the primary audience of the design guidelines are product designers, whereas the participants are usually the end-users.

The fourth section collected information on the users' evaluation of the importance of the guidelines. For each guideline, it was asked, *'Overall, to what extent is [the guideline] important in making your experience better?'* A five-point scale from 'not at all important' to 'extremely important' was used.

The fifth section collected the users' demographic data, such as gender, age and education.

Data Analysis

I first cleaned the data set by removing the responses that were invalid (e.g. incomplete responses or responses that had the same answer for all questions). After the cleaning process, 189 valid responses remained. The participants' information is summarised in Table 11. Using the cleaned data set, I performed the following analysis. First, the users' evaluation of the

importance of the guidelines was calculated. Second, for each guideline, the extent to which it had been violated or applied in the CA was calculated. Lastly, Pearson's r was calculated between the violation and application of the guidelines and the users' satisfaction with the CA.

Table 11. Participants' Information

Age	22% age 18-24; 46% age 25-34; 17% age 35-44; 8% age 45-54; 7% age 55 and older
Gender	51% male; 49% female
Education	19% postgraduate; 68% undergraduate; 13% high school
Duration of use	19% > 3 yr.; 28% > 1-3 yr.; 29% 6-12 mo.; 21% 1-6 mo.; 3% < 1mo.
Frequency of use	42% daily; 29% every other day; 27% 1-3 times; 2% none
CA types	49% Google Assistant; 33% Alexa; 16% Siri; 2% Cortana
Devices	44% used one device; 56% used two or more devices Details: 65% smart phone; 44% smart speaker (without screen); 42% laptop; 20% tablet; 11% TV; 6% watch; 4% smart display (speaker with screen); 3% in-car system

Next, I present the key results of the users' evaluation of the importance of the guidelines, their application in the current CAs and their correlation to overall user satisfaction.

5.5.2 Perceived importance of guidelines

The data shows that, overall, most participants considered the guidelines important to improving their experience, Figure 31.



The numbers in the graph represent the number of participants who selected each choice (N=189)

Figure 31. Participants' evaluations of the importance of the guidelines

Most participants (approximately 77%) considered G1 (Provide a personalised overview of CA capabilities) and G2 (Provide in-context education) important for improving their experience, with G2 ($M=0.97$; $SD=0.8$) having a slightly higher average score than G1 ($M=0.86$; $SD=0.8$). This means that it is beneficial for the user to have a comprehensive understanding of the CA's capabilities as this makes the user feel more competent (discussed in Phase 1). It is equally important to increase the discoverability of new capabilities, allowing the user to locate relevant ones easily. While introducing new capabilities, setting realistic expectations becomes crucial. As shown, G3 (Reveal how well the CA can perform when introducing new capabilities) was considered important to 79% of the participants (19% were neutral; only 2% indicated it was unimportant). This is in agreement with the interview findings from Phase 1 that participants may feel disappointed and less competent if the CA left users with expectations that were not in line with its capabilities.

G4 (Learn from conversational context; $M=1.07$; $SD=0.81$) and G5 (Provide succinct responses; $M=1.23$; $SD=0.70$) received the highest average score among all guidelines. Both are related to the actual conversations users have with CAs. This finding implies that an effective conversation (specifically, one that is fluent and natural) with the CA is the key to a better user experience.

Participants rated G6 (Talk politely) as less important compared to G4 and G5. One explanation may be that the concern regarding politeness is mostly evident among parents who

share the CA with their children, whereas most survey respondents may not fall into this category. G7 (Provide an explanation regarding why the CA cannot complete a task) was considered important by most participants (68%). Consistent with the interview findings, this means that it is beneficial if the user understands the CA's malfunction and, more importantly, can figure out how to resolve the issues.

G8 (Learn from conversations over time) had the lowest average score ($M=0.37$; $SD=1.23$). This guideline is about providing personalised experience based on past conversations. There are three possible reasons for this low score. First, current CAs are not yet proficient in learning and personalisation, thus resulting in negative first impressions with users. Second, users had not benefitted from such personalisation, so they were more likely to give it a neutral rating. Third, users may have concerns regarding privacy and data sharing, which in turn lowered their expectations. G9 (Provide opportunities for customisation) and G10 (Provide opportunities for user data management) were also considered important by most participants (approximately 75%). In line with the interview findings from Phase 1, this result highlights the importance of providing users with sufficient control (in terms of the customisation of conversations) and transparency (in terms of user data that is created and shared over time as users interact with the CA).

5.5.3 Guideline application/violation and relation to user satisfaction

After learning about the importance of the guidelines, the next aim is to understand the extent to which they have been applied or violated in current CAs and how this correlates with users' overall satisfaction with CAs.

Application of the guidelines in current CAs

It has been found that all guidelines were somewhat applied in existing CAs, although not to their full extent, Figure 32, thus indicating room for improvement.

Of the guidelines, G5 (Provide succinct responses) is the most extensively applied. All CAs are generally able to have basic conversations with users and provide relevant responses if asked properly. The gap may be caused by inaccurate responses when commands are not structured

as expected or because responses are too robotic and less natural (e.g. more like search results than human answers).

G6 (Talk politely) and G7 (Provide an explanation regarding why the CA cannot complete a task) are applied least extensively. Regarding G6, this may reflect the interview findings where the CA favours direct commands (e.g. 'tell me the weather') and may struggle with polite wording (e.g. 'would you please...'). Although improvements have been made to improve how CAs respond to polite wording, users may still be encouraged to use simple and direct commands. Regarding G7, this indicates that responses such as 'sorry, I don't understand' are still common, and users are told neither how nor why the CA malfunctioned. Instead, the user is expected to figure out the problem themselves.

The rest of the guidelines sit in between (having a score from 0.6 to 0.86, indicating somewhat applying the guidelines). Users are usually given an overview of CA capabilities during the welcome tour or initial setup. New capabilities can be found in mobile apps, but the user is required to learn about these capabilities in advance rather than in the moment when the capability is needed. In terms of conversations, CAs may sometimes struggle to maintain the flow of conversation and may lose conversational context easily. In terms of the experience over time, users can experience some amount of personalisation (e.g. location or music), transparency and control (e.g. through settings in the mobile app). However, these could be developed further, for example, by making the settings easier to discover (most participants in the interview study did not know that such settings exist).

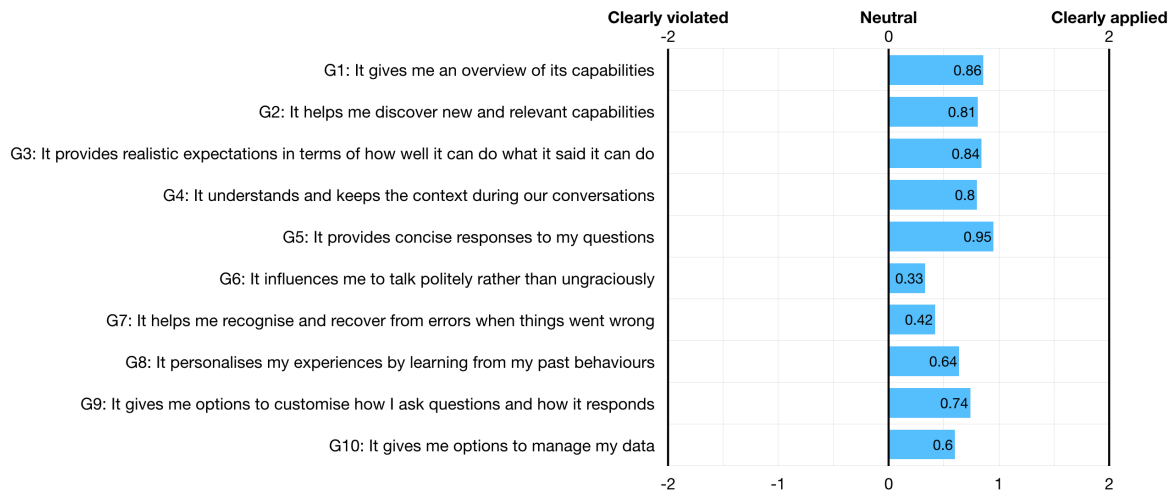


Figure 32. Application (or violation) of the guidelines in existing CAs

Correlations between guideline application and user satisfaction

The results show that all guidelines are positively correlated with user satisfaction. All correlations are statistically significant, Table 12. It is worth noting that G6 (Talk politely) showed the least correlation with user satisfaction. Similar to the explanation in the previous section, this may be because G6 was more of a concern for participants who have young children at home who also use the CA; conversations with the CA may have a long-term influence, especially on younger generations. This result further strengthens the interview findings and the importance of guidelines, highlighting the benefits of articulating the guidelines and the value of applying them in the design of CAs.

Table 12. Correlation between guideline application and overall user satisfaction with CAs

	G1	G2	G3	G4	G5	G6	G7	G8	G9	G10
	M=0.86 SD=0.8	M=0.81 SD=0.9	M=0.84 SD=0.8	M=0.80 SD=0.8	M=0.95 SD=0.8	M=0.33 SD=1.1	M=0.42 SD=1.0	M=0.64 SD=1.0	M=0.74 SD=0.9	M=0.60 SD=0.9
Satisfaction with CAs	.34**	.38**	.41**	.32**	.39*	.15**	.24**	.28**	.30**	.27**

**p<.01, *p<.05; N=189

5.6 Discussion

SDT has been applied to gain insight into designing CAs for competence, autonomy and relatedness. Ten design guidelines have been further developed based on the empirical results. The evaluation study has validated the perceived importance of the guidelines in terms of their value in improving overall user satisfaction. In this section, I contextualise the key findings within the existing literature and discuss future research to support the design of CAs.

To help explain how technology supports or undermines people's basic psychological needs, Peters et al. (2018) have proposed the Motivation, Engagement and Thriving in User Experience (METUX) model. This model describes six spheres of experiences (i.e. adoption, interface, task, behaviour, life, society) that allow researchers and practitioners to analyse the impact of technology from multiple perspectives.

Looking at this research's findings from the lens of the six spheres, it has been found that competence, autonomy and relatedness are affected differently in multiple spheres of experiences. Competence is often affected at the adoption, interface and task level. For example, this study shows that people set certain expectations for the CA before purchasing. If the actual experiences do not meet their expectations, the sense of competence is likely to drop. In the interface and task spheres, competence is primarily affected by the effectiveness of the use. Autonomy, on the other hand, is found to be affected across all spheres. For example, in the interface and task spheres, autonomy is affected by users' control and flexibility of the CA conversation. In the behaviour sphere, autonomy is influenced by whether the CA can adapt to the user's daily habits and provide tailored services. In the life and society spheres, autonomy is dominantly related to privacy and transparency of user data. The impact on relatedness is also reflected in multiple spheres, mostly at the behaviour, life and society level. For example, if social related features (e.g. communication and social media functionality) were to be introduced in CAs, one major concern among CA users is the feeling of intrusiveness, as the CA might have access to not only their own personal data but also the data of their social circles.

Next, I discuss the three needs in more detail below.

5.6.1 Competence and autonomy in CAs

This research shows that the fulfilment of competence and autonomy entails different implications for CAs compared to other product categories. This supports the earlier argument that, although the needs listed are universal, the specific methods of realising them should be individualised according to product category.

Competence is determined by how well users think that they have made full use of a CAs' capabilities and how effectively they can communicate with their CAs. While previous research shows that competence is usually affected by factors such as optimal challenges, positive feedback and learning opportunities (Lomas et al., 2017; Peters et al., 2018; Ryan et al., 2006), in the case of CAs, the sense of competence could be supported or hindered by the discoverability of CA capabilities (e.g. how a CA introduces new and relevant capabilities to the user) and the quality of the conversation (e.g. understanding complex sentences and maintaining the flow of conversation). These factors are attributed to the distinctive characteristics of CAs. Therefore, it is recommended that they be carefully considered in addition to the general factors outlined in previous research that were discussed earlier.

Autonomy is determined by how much control users have over their personal data and the conversations with CAs as well as how well the experiences are tailored to their habits and preferences. To support autonomy, this research suggests that designers of CAs should consider providing customisation options, data management controls and methods of personalisation. These implications are in line with prior research, in which providing users with sufficient options (Ryan et al., 2006) and improved personalisation (Rigby and Ryan, 2011) has shown to enhance user autonomy; but the implications presented in this chapter concern more specifically about CAs compared to the previous works. The concept of personalisation is also discussed by Friedman (2010), although she refers to it as system fluidity. Friedman points out that users' goals often change over time, and, therefore, it has been suggested that, to support user autonomy, systems should take into account such changes and provide mechanisms through which users can tailor their systems (Friedman, 2010; Laurel, 1997; Malone et al., 1995).

5.6.2 Relatedness in CAs

Unlike competence and autonomy, users have mixed expectations for relatedness. In other words, relatedness is not always expected of CAs. Nevertheless, the findings identify three roles that CAs may play to enhance this need. The first role is similar to a traditional communication tool, but made available on CAs, for example, the user could make phone calls through CAs. Such features have started to appear in CA products in the past two years, such as Google Duo and Alexa Drop. Both of these allow CA users to make video calls with contacts who have the same CA product. The second role is acting as a smart voice interface to social media, for example, users could create and post tweets not from the Twitter app, but from the CA. And the third role is acting as a facilitator of social activities.

Through the first two roles, the CA adds value via its voice interface and its potential for intelligence. Specifically, the voice interface makes hands-free use possible and makes the interaction easier and more engaging overall. In agreement with Luger and Sellen (2016), hands-free use has been identified as one of the major reasons people use CAs.

Furthermore, the potential for intelligence allows the CA to provide a ‘smart interlayer’ between the user and social media channels, assisting with tasks such as filtering irrelevant and duplicate notifications. Despite the fact that social channels make people more connected to one another, constant notifications have long been reported as disruptive to users’ focal tasks (Sahami Shirazi et al., 2014). Even worse, they may cause stress due to information and communication overload (Lee et al., 2014; Ragu-Nathan et al., 2008; Westermann et al., 2015). Turning off notifications altogether is not always an ideal solution as this could cause users to miss important and urgent notifications. The second role (i.e. CA as a smart voice interface to social channels) may benefit from the intelligent characteristic of CAs and offer new solutions to this issue. Instead of providing fixed notification controls (e.g. on/off) (Mashhadi et al., 2014), the CA could act intelligently to detect duplicate and redundant information and even automatically take actions (e.g. mark as read or delete) if permitted by the user.

Despite the benefits of these two roles, users expressed their concerns which are the main reasons they would rather not expect relatedness-relevant features appear in CAs. The first concern regards the user’s lack of trust in using CAs for social purposes, for example, CAs are

not robust enough for such advanced tasks; it is intrusive to share social data with CAs. The second regards the lack of motivation, because some CAs do not have visuals, making them less useful for social interactions. The third is a lack of comfort, for example, some participants feel uncomfortable using CAs for social purposes in a shared environment (e.g. at home). The lack of readiness of CAs' social functions is understandable. The concerns discussed here again verify and emphasise important factors such as trust and privacy concerns in the design of intelligent agents (Cohen et al., 2016; Norman, 1994). To improve users' confidence in automation and the acceptability of new technologies, Norman (1994) has highlighted the following technical and social requirements, which could be useful for the design of CAs: 1) the technical requirement is to 'devise a computational structure guaranteeing that from the technical standpoint, all is under control'. 2) The social requirement is to 'provide reassurance to the user that all is working according to plan'.

The third role of CA to enhance relatedness is the facilitation of social activities. This is often seen among families in which CAs help parents have fun times with their kids or in social gatherings where the CA 'breaks the ice' or makes the gatherings more entertaining. This role aligns with the concept of possibility-driven design (Desmet and Hassenzahl, 2012) where opportunity is sought to facilitate a positive experience, and this opportunity may not necessarily have direct link to the product's primary functionality. For example, the main purpose of an art print may be to decorate a person's home, but it may also serve to start a conversation during a friend's visit. The function of facilitating social activities becomes especially relevant as we see CAs predominantly being used in homes (Yang et al., 2019) and increasingly used by family members. For example, children are becoming a promising CA user group (Druga et al., 2018; Lovato and Piper, 2015), and families' interactions with human-like agents are increasing (McReynolds et al., 2017). In the literature, similar social values of CAs have mostly been studied in terms of the presence of virtual agents as human companions, for example, as children's intelligent toys (Druga et al., 2018) or family's friends (Purinton et al., 2017). This finding adds new scenarios to the general discussion on this topic, and more importantly, it suggests new opportunities to design for relatedness and highlights the challenges and user concerns which may prevent the successful realisation of the social values.

5.6.3 Design guidelines

The guidelines, developed on the basis of SDT, provide practical support for CA designers. This work contributes to the existing CA literature by articulating the key guiding principles relevant to the needs of competence and autonomy. Furthermore, it offers an initial set of CA guidelines to be used in the academic community, which encourages future research to build on this work and, thus, the development of a more complete set of guidelines. With regard to the broader AI design field, this work complements the existing AI design guidance by offering specialised guidelines for CAs. These were created in response to the request to develop domain-specific guidance by Amershi et al. (2019), who explain that the AI guidelines in their work were developed to be general and that some of them may not directly apply to systems that lack graphical user interfaces, such as voice-based virtual assistants. Therefore, additional specialised guidelines are needed for this particular product type (Amershi et al., 2019).

In this section, I first discuss how the proposed guidelines can support conversation design. Then, I compare three sets of guidelines: the proposed CA guidelines in this study, the AI design guidelines (Amershi et al., 2019) and the UI design heuristics (Nielsen, 1994a). These three sets were formed based on three design scopes, i.e. CA design, AI design and interaction design, respectively. Through this comparison, I discuss what has remained constant across the three scopes and what is new.

CA guidelines

The guidelines proposed in this research are specialised for CAs and focus on conversation design – the type of interaction that distinguishes CAs from other types of product. G4 and G5 directly concern the design of intuitive and effective conversations with a focus on learning from conversational context and providing an easy way to retrieve information from responses. These guidelines can impact conversation design and help make the conversational search more effective. Prior research has found that users' preferences are split between direct answers and the provision of search results (Vtyurina et al., 2017). This research proposes enabling users to choose between these options based on their own preferences, as seen in G5.

More importantly, this issue could be further addressed by giving users the control needed to make decisions according to their own preferences, as suggested by G9, i.e. providing options that allow the user to customise how they want the answers to appear. This could not only improve how satisfied users are with the responses but also eliminate inconsistent and unpredictable responses, which are common causes of user frustration.

Moreover, this research highlights designing politeness within CA conversations. As G6 describes, CAs should be designed to discourage demanding and ungracious conversations. This acknowledges the fact that CAs play an increasingly prevalent role in family lives, and, in that setting, young children are frequent users of CAs (Beirl et al., 2019). Although CAs show potential to enrich family activities (Beirl et al., 2019), this research identifies that parents are concerned about the negative impact CAs may have on their children, especially the way they address other people in real life. G6 responds to this concern by encouraging responsible conversation design.

Conversational experiences could be further improved if CAs were to recommend relevant capabilities to users based on the detection of their needs in the context of conversations, as described in G2. Specifically, G2 proposes to provide in-context education, that is, to proactively anticipate user needs for certain capabilities and introduce them when needed. While G2 focuses on when a capability may be introduced to the user, G1 focuses on providing a holistic overview of all the capabilities and ideally augment the overview with personalised information, such as capabilities that the user is already familiar with and new capabilities. Such an overview is beneficial because, unlike other systems, where capabilities are often fixed (or rarely change), the capabilities of CAs are expanding rapidly, with new services added every day. The discoverability of these services thus becomes essential to users' experiences.

It is equally important to consider assisting the user in establishing accurate expectations regarding CAs' performance of the capabilities, as described in G3. This guideline is in line with the notion of 'misrepresentation of the system': Friedman (2010) explains that the user's autonomy may decrease when they are provided with inaccurate information that leads to false hope of the system. In CAs, this could be mitigated by conveying system intelligence and limitations (Luger and Sellen, 2016).

Conversation may be interrupted due to system errors or limitations. To deal with such situations, G7 suggests providing explanations to the user when the CA malfunctions. Importantly, unlike systems with graphical interfaces, CAs may need to explain to the user through the voice interface. It is, therefore, worth considering how such an explanation could be delivered (e.g. consider whether it is sufficient to simply turn text into speech).

This research shows that, over time, a user's overall experience can be improved if CAs are capable of learning about user habits from past conversations, as described in G8, and allowing users to control and manage their data, as described in G10. Specifically, G8 suggests that CAs should be able to learn from past conversations in order to provide experiences tailored to each user. Meanwhile, G10 suggests the data that has been collected and how that data was utilised should be made transparent to the user, who should also be able to control and manage this data. Providing such control is crucial as participants' fears regarding privacy and data permanency are among the main reasons preventing them from engaging further with CAs (Cowan et al., 2017).

Comparing three sets of guidelines for CA, AI and UI design

Table 13 shows the comparison between the proposed CA guidelines and existing guidelines in other fields, i.e. AI and UI design guidelines. It reveals three groups: 1) guidelines that are relevant to all three fields (coloured green), 2) guidelines that mainly apply to intelligent applications – AI and CA applications (coloured blue), and 3) guidelines that are mostly specific to CAs (coloured orange). I discuss the three groups in detail below.

Table 13. Comparing CA guidelines to AI and UI guidelines

	CA guidelines (This thesis)	AI guidelines (Amershi et al., 2019)	UI guidelines (Nielsen, 1994a)
Initially	G1: Provide a personalised overview of CA capabilities	Make clear what the system can do	
	G2: Provide in-context education		
	G3: Reveal how well the CA can perform when introducing new capabilities	Make clear how well the system can do what it can do	
During interaction	G4: Learn from conversational context	Show contextually relevant information	
	G5: Provide succinct responses		
	G6: Talk politely	Match relevant social norms	
When wrong	G7: Provide an explanation regarding why the CA cannot complete a task	Make clear why the system did what it did	Help users recognise, diagnose and recover from errors
Overtime	G8: Learn from conversations over time	Learn from user behaviour	
	G9: Provide opportunities for customisation	Provide global controls	User control and freedom
	G10: Provide opportunities for user data management		

First, regardless of application types (whether they be UI, AI or CA applications), the design principles related to handling system errors (G7) and providing user controls (G9 and G10) are consistently relevant. In the UI guidelines, Nielsen writes about ‘help[ing] users recognise, diagnose, and recover from errors’ (Nielsen, 1994a). When transferring this principle to AI applications, CAs included, the emphasis has been put on explaining why the system did what it did, as the AI guideline writes, ‘make clear why the system did what it did’ (Amershi et al., 2019). This is largely due to the unpredictability of AI applications. Therefore, transparency and visibility with regard to the system status (in this case, why the system malfunctioned)

could help the user make sense of the situation, thus increasing their feeling of control (Norman, 1994).

The other principle that remains relevant is ‘user control and freedom’ (Nielsen, 1994a), although the actual types of control (e.g. what to control and how to control it) could vary largely and are often dependent on the applications. For example, for AI applications, the control should allow the user to ‘customise what the AI system monitors and how it behaves’ (Amershi et al., 2019). In the case of CAs, controls are further categorised into two types. The first pertains to the control of conversations, specifically, how the user instructs the CA, and how the CA responds (G9). The second pertains to user data management, specifically the management of personal data collected by the CA over time (G10).

The second group of guidelines are specifically applicable to intelligent applications (i.e. AI and CA applications), not necessarily to traditional UIs. They are related to revealing system capabilities and limitations (G1, G3), the effectiveness and social norms of human-agent interactions (G4, G6) and personalisation (G8). Despite the fact that the five guidelines share similarities with some of the AI guidelines, they are more specific about CAs than the AI guidelines and thus provide additional informative instructions regarding CA design. For example, G1 concerns the similar issue to what the AI guideline entails, ‘make clear what the system can do’. However, instead of a general statement, G1 specifically emphasises the ‘personalised overview’ of what the CA can do. This is important to CAs, as previous studies have consistently shown that many users are not aware of the capabilities of their CAs (Luger and Sellen, 2016; Yang et al., 2019). This could result in users feeling overwhelmed by unknown capabilities (Luger and Sellen, 2016), and it could decrease users’ sense of competence, according to the findings in this research. The contrast between generalisation and specialisation applies also to the other four guidelines (i.e. G3, G4, G6, and G8). For example, G3 is aligned with the AI guideline on revealing ‘how well the system can do what it can do’, but it stresses helping users establish accurate expectations of the CA when introducing new capabilities to them.

Finally, the guidelines related to the discoverability of CA capabilities (G2) and the design of CA responses (G5) apply primarily to CAs and they have not been mentioned in previous AI and UI guidelines. Both guidelines concern issues that are specific to CA products. For example,

as the number of CA capabilities continues to grow, their discoverability becomes a challenge which G2 aims to address. In the case of G5, it focuses on another challenge that typically occurs in conversations between users and CAs: how to provide human-like responses to users.

5.6.4 Limitations and future work

First, when evaluating the guidelines, the focus has been put on end-users instead of designers. Therefore, the study was designed to examine the perceived importance of the guidelines and their relation to improving user experience. Intentionally emphasising end-users as a first step allows this research to first gain insights into the importance and relevance of the guidelines before moving forward to evaluate their practicability. This is because, end-users are better at giving feedback regarding the value the guidelines can bring to their experiences, whereas designers may focus more on how to easily and effectively apply the guidelines. Despite of this, I acknowledge that evaluation only from the perspective of end-users is a limitation, and future work is needed to evaluate these guidelines from the perspective of design experts, i.e. to investigate how these guidelines can be applied in design processes.

Second, these guidelines were developed from the perspective of SDT, and thus, they might not be comprehensive. An approach informed by a different theory or one that uses a synthesis of literature, similar to those of Amershi et al. (2019), might result in different guidelines. I consider the development of guidelines an ongoing process. Through this work, I hope to encourage more research like this to contribute practical guidelines for designers and developers in order to create intuitive and effective CAs.

5.7 Conclusions

Building on SDT, I researched how CAs can be designed to meet users' basic psychological needs, in particular, competence, autonomy and relatedness. I first gained insights into users' perceptions of the three needs through interviews and suggested design implications based on these insights. I then transformed the design implications into practical guidelines and evaluated the perceived importance of the guidelines through a survey study. I discussed how this research contributes to the fields of AI and CA design. Overall, this research contributes

design implications and guidelines informed by SDT to provide practical support to CA designers to help create positive CA experiences.

Chapter 6 General Discussion and Conclusions

This chapter initially summarises the main findings from the studies presented in the previous chapters and then highlights how the overall aim and objectives were achieved by providing knowledge and design support to assist the design of happiness and well-being. Next, it moves on to the discussion points that have been organised as follows. Firstly, the theoretical model developed on the basis of well-being science, how it has informed this research and how it could benefit other researchers and designers is discussed. Secondly, how this thesis has extended existing positive design literature by providing empirical insight into the well-being supportive experiences is discussed. Thirdly, how this thesis expands the existing understanding of CA experiences by examining the emotional responses and the associated influencing factors is discussed. Fourthly, CA experiences are discussed from the perspective of the three needs: competence, autonomy and relatedness, together with implications and guidelines on how to design for these needs. At the end of the chapter, the limitations are discussed, future works are outlined and the thesis' conclusions are presented.

6.1 Summary of Research Findings

A summary of the main findings is presented as answers to the five objectives, Figure 33.

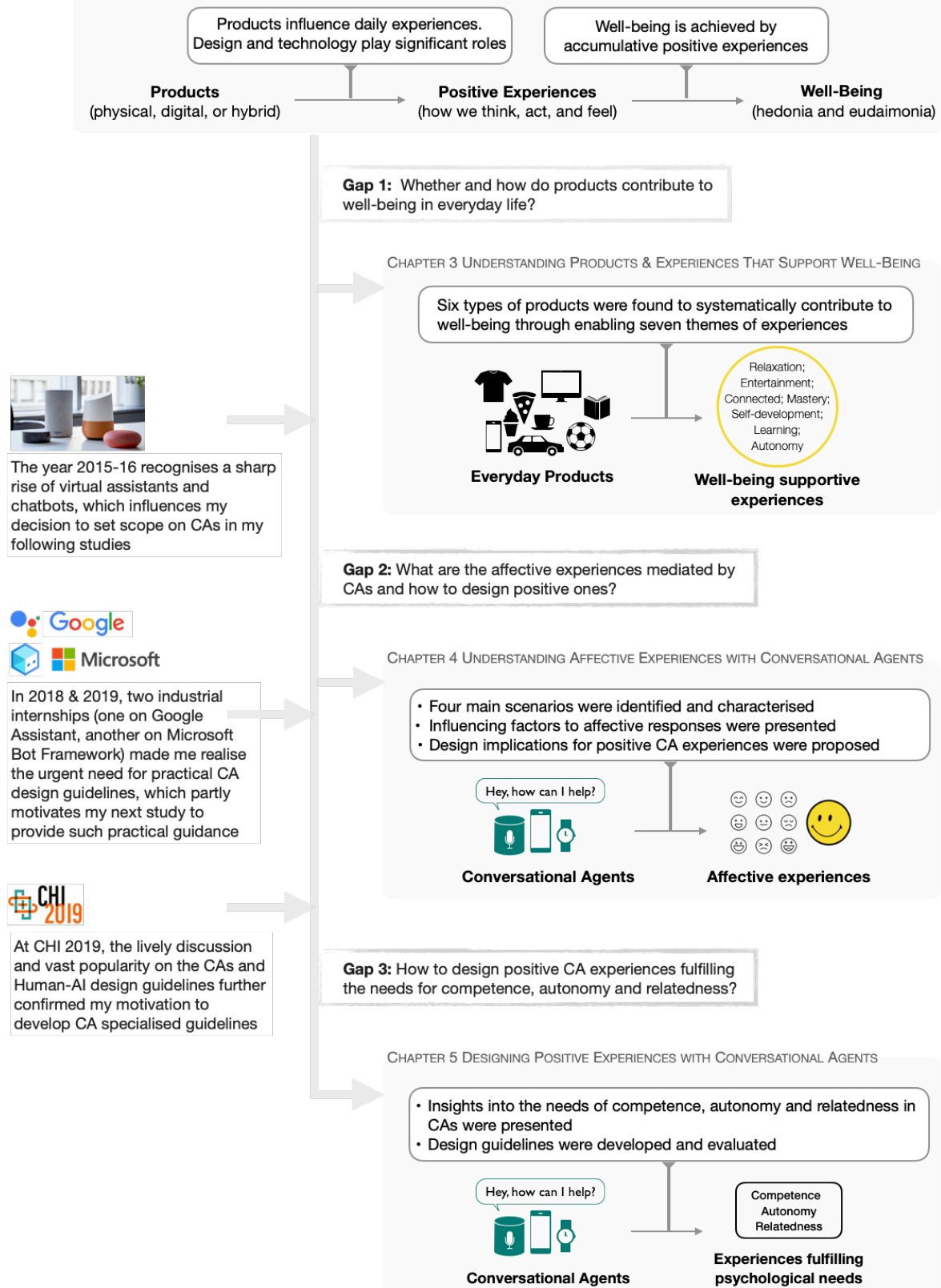


Figure 33. Summary of research findings

Objective A. *Undertake a critical review of the state of the art on well-being science and associated design and technology practice, as well as conversational AI developments.*

This objective was achieved by reviewing three bodies of literature in the areas of positive psychology, HCI and human-AI interaction, which is presented in **Chapter 2**. The key learning from positive psychology is that well-being is achieved by having a steady inflow of positive experiences. During positive experiences, people's psychological needs, such as competence, autonomy and relatedness, are fulfilled and this leads to positive feelings, thinking and behaviours. Products, technology in particular, play a significant role in shaping our daily experiences. The literature review shows two ways in which the design of products and technology can contribute to positive experiences. One way is through supporting existing well-being strategies such as positive interventions. The other is through augmenting otherwise ordinary daily experiences with positivity. The above learnings are synthesised into a theoretical model that is presented in Chapter 2.

Further reflecting on the positive design and technologies literature, a lack of empirical evidence on the everyday well-being supportive experiences was identified. Such empirical insights are needed to strengthen the relatively abstract design frameworks and approaches proposed in prior works. Reflecting on the CA literature, a gap in exploring CA experiences from the perspective of well-being, including both hedonic and eudaimonic aspects, was identified. Exploration from a view of well-being, for example affective responses and SDT, is needed to help design positive CA experiences. What is more, practical design guidance is lacking but needed to further support CA design practices.

Objective B. *Investigate whether and how products support well-being in everyday life.*

This objective was achieved through an empirical research study investigating the well-being supportive products and experiences reported by users, which is presented in **Chapter 3**. Participants reported six types of everyday products as contributing to their happiness and well-being. These products are: digital devices (e.g. computers, smartphones, games and TVs), food (e.g. favourite meal, coffee, tea and chocolate), vehicles (e.g. cars and motorbikes), clothing and accessories (e.g. vintage dresses, shoes and makeup), books (e.g. favourite book and bible) and sports equipment (e.g. a football). Of all of these, digital devices dominate the reported product types at 49% due to their hybrid functionality and ubiquitous features. This

result also reinforces the significant impact that technology has on well-being, which further motivates me to focus my next studies on the exploration of how new technologies can be designed to improve well-being.

These products support well-being by creating seven themes of experiences, including hedonic experiences (i.e. *relaxing* and *entertaining* experiences), during which people get rest, relive stress and receive joy, as well as eudaimonic experiences (i.e. *connecting to loved ones*, *mastering an activity*, *learning new knowledge*, *developing self-image* and *doing things freely*), during which people establish meaningful social relationships, develop their self-identity, achieve personal growth and gain competence and autonomy. Products play two roles in creating these experiences. Firstly, they may carry reflective meanings from the person's past experiences, so they facilitate a current positive experience through reminiscing. For example, a gift may remind a person of their friends or a souvenir may remind a person of a memorable vacation. Secondly, they are enablers that make a positive experience possible. For example, a car enables a person to drive freely and a phone enables people to talk even if they are far away from each other. Together, these insights suggest ways in which products can be designed to support well-being.

Objective C. *Investigate the affective experiences mediated by CAs and how to design positive experiences.*

This objective was achieved via an empirical research study examining 171 CA users' experience reports and the emotions elicited during those experiences, which is presented in **Chapter 4**. Four primary CA usage scenarios have been identified: requesting basic information, searching for answers, getting recommendations and accessing external services. Beyond common tasks such as checking the weather and setting reminders, this research's findings demonstrate the more complex and diverse uses of CAs, such as helping the user to solve a problem at hand, suggesting tailored recommendations or even acting on behalf of the user to control external devices. These findings indicate users' increasing trust in agents, but at the same time, puts greater responsibility on the shoulders of CA designers and engineers to provide reliable and trustworthy services to users. In addition to the diversity of use, the contexts of use have also become more ubiquitous. The findings show increasing use in settings outside of the home, such as in workplaces, public places or cars. Correspondingly, about half

of the time a CA is used in a social context. This implies the significance of studying CAs in multi-user settings and shared contexts.

Regarding affective responses, this research's findings show that overall, CA users feel more positive emotions than negative ones. Specifically, *interest* is the most salient emotion experienced by participants, followed by *joy* and *activation*, which could be explained by the novelty of CA products and people's curiosity towards them, as well as the interactivity and engaging experiences brought by interactions with CAs. Moreover, emotions are elicited differently across scenarios. For example, participants receive significantly more joy in the *accessing external services* scenario than the *requesting basic information* scenario. Similarly, participants find *searching for answers* and *getting recommendations* significantly more interesting than *requesting basic information*. This finding further confirms the above explanation that the level of interactivity and engagement affects the elicitation of *interest*, *joy* and *activation*.

Affective responses are influenced by both pragmatic (task-related) and hedonic (task-unrelated) factors. Specifically, pragmatic factors include those relating to the quality of the response content, i.e. being helpful and proactive, as well as those relating to the quality of interactions, i.e. maintaining a continuous and fluid voice interaction, integrating seamlessly with external services and being responsive to user requests. Hedonic factors include participants' comfort in having human-machine conversation, their pride of using cutting-edge technology, fun of use during the interaction, perception of having a human-like assistant, concern about privacy and fear of causing distraction. The findings suggest that the design of CAs can benefit from considering both types of factors as they provide a statistically significant contribution to positive emotions.

Objective D. *Explore how to support the fulfilment of people's psychological needs (i.e. competence, autonomy and relatedness) with CAs.*

This objective was achieved via an in-depth interview study exploring the Self-Determination Theory within the context of CAs, which is presented as phase 1 in **Chapter 5**.

In CA experiences, users' sense of competence is often affected by 1) how much they think they have made full use of the CA's capabilities and 2) how effectively they can communicate with

the CA. In the study, participants consistently considered themselves as lacking a full picture of what the CA can do. And there is no easy way to quickly gain such an overview, especially with new capabilities increasing rapidly. In addition, having effective communication with the CA is another key factor concerning the sense of competence. This study shows that effective communication is often blocked by the lack of robustness in voice recognition and CAs not being able to understand complex sentences or talk naturally. Ineffective communication can lead to negative consequences such as decreased user engagement and user trust and should be addressed in design.

Autonomy is often reflected in the user 1) having control of the conversation (how they ask questions and what responses they receive and how), 2) getting a personalised experience and 3) having control over their data. The study shows that user autonomy is limited because conversations are more often driven by the CA not by the user (e.g. unpredictable responses), which suggests that more controls and customisation options should be provided to the CA user. What is more, user autonomy is also limited by CAs not delivering sufficiently personalised responses, as well as a lack of transparency and control over user data, which is collected and generated during interactions with CAs.

Relatedness is not always expected in CAs due to its dependency on specific functionality as in communication tools. Participants reported little expectation to see such functionality embedded in CAs, partly due to a lack of trust in the technology and privacy concerns. Despite this, a few exceptions were found, which suggests two new opportunities for CAs to support relatedness, in addition to the traditional communication functions. The first opportunity resides in the CA acting as a voice interface for public social network channels (e.g. forums, interest groups and local communities). Instead of using a website, users interact with their channels through CAs (e.g. getting news from these channels or posting comments to threads). CAs have two advantages over traditional applications: 1) the voice interface makes interaction more convenient and interactive, thus more engaging, and 2) CAs have the potential to pre-process information, for instance filtering out unwanted or duplicate notifications as defined by the user. Importantly, the following two concerns should be addressed first and foremost: users' discomfort with interacting with social channels in a shared environment, such as with family, and the intrusiveness of CAs having access to information relating to the user's social

groups. The second opportunity for CAs to support relatedness is acting as a facilitator of social activities. Unlike the previous opportunity, this approach does not require it to implement social functions, but instead, it creates an environment for people to bond and socialise, for example family members playing games with CAs.

Objective E. Develop design guidelines to provide practical support for CA designers.

This objective was achieved by translating the research insights from Objective D into practical design guidelines, followed by an evaluation study validating their importance to and value in improving the overall user experience, which is presented as phase 2 & 3 in **Chapter 5**. Ten guidelines were developed and evaluated. Specialised for CAs, these guidelines focus on the design of conversations – the type of interaction that distinguishes CAs from other applications.

To improve the conversational experience, G1-G3 focus on educating users about new and existing CA capabilities. Specifically, G1 suggests ways of providing a holistic overview of what the CA can do. G2 proposes providing in-context education by recommending relevant capabilities to the user during the conversation based on the detection of their intents. G3 points out the importance of helping the user to establish accurate expectations of what the CA can do and how well it can perform. G4 and G5 directly concern the design of intuitive and effective conversations, suggesting that CAs should learn from conversational contexts and provide concise and succinct responses to users. G6 highlights the importance of designing politeness within CA conversations and discouraging demanding and ungracious dialogue. This guideline recognises CAs' increasing impact on family life, especially young children, and it aims to reduce the negative effects that CAs may have by encouraging responsible design of CAs. G7 provides guidance on how to handle conversation interruptions caused by system errors, suggesting ways in which users can be provided with explanations. Moreover, users can benefit from having more personalised experiences and more control over their conversations with CAs and their personal data. Specifically, to provide more tailored experiences, G8 advises that CAs should learn user habits from past conversations over time. To eliminate inconsistent and unpredictable responses, G9 suggests offering controls and options that allow the user to customise certain details of the responses. Lastly, G10 recommends providing users with sufficient controls for data management.

6.2 Discussion

In this section, I contextualise the key findings within the existing literature and discuss the contributions of this work to the HCI field.

6.2.1 A model for well-being design

One key differentiation between positive technologies and others is the theoretical foundation that positive technologies are based upon (Calvo and Peters, 2014). In the case of positive technologies, they have drawn on theories such as SWB (Diener, 2000), PWB (Ryff and Keyes, 1995), SDT (Ryan and Deci, 2017), PERMA (Seligman, 2018) and other applied psychological research (Layous and Lyubomirsky, 2013; Sheldon et al., 2012; Sheldon and Lyubomirsky, 2004) to develop new ideas, design approaches and evaluation metrics to support well-being. Undoubtedly, psychological well-being research has offered a large body of work and insights that are helpful to other disciplines, including design and technology. However, it is never easy to effectively apply them in design practice. Due to the complexity and large volume of research available, it is unrealistic for designers to thoroughly review this knowledge during the design practice. The gap between well-being science and design practice prevents effective incorporation of well-being theories and thus is a barrier to creating positive designs. This could benefit from having an effective model or framework that provides a concise synthesis of well-being research and explains that knowledge in design language.

Prior works, such as the Positive Design framework (Desmet and Pohlmeier, 2013), have attempted to address this gap. The framework states that positive designs should aim to achieve all three well-being components: pleasure, personal significance and virtue. To assist design practice, this framework describes other considerations along with the three components, for example utilising the possibility-driven approach and considering personal fit and active user involvement. However, the three components proposed in the framework only loosely describe well-being at a high level, overlooking some essential aspects of well-being. For example, comparing it to the PERMA (Seligman, 2018) and SDT (Ryan and Deci, 2017) theories, well-being aspects such as engagement and positive relationships, competence and autonomy are not included in the framework, at least not explicitly. Yet, it has been argued that explicit

distinction of these well-being aspects is necessary because they could be independent of each other and pursued separately (Seligman, 2011).

Conversely, the Positive Computing framework (Calvo and Peters, 2014) provides a more comprehensive overview of well-being theories, along with useful strategies and evaluation methods and metrics. However, aiming for an overarching framework for the overall positive computing domain, it is set within a much larger scope than what this thesis covers. As such, this framework includes factors that are out of the scope of this thesis (e.g. the transcendent or extra-personal factor) and overlooks details that are necessary for the scope of this thesis (e.g. connections between the theories, synthesis of the insights from within the theories and implications for design).

In need of a theoretical foundation that fits the scope of this thesis, a well-being design model was developed based on a review of positive psychology (see Section 2.1.3). This model has informed and guided this research in a number of ways and it could potentially help other researchers and designers. Firstly, the model suggests that design should set the goal of creating positive user experiences. This is because positive experiences are essential means to sustainable well-being. Consequently, this thesis has been centred around understanding and designing positive experiences with products. For example, people's happy experiences are examined in Chapter 3 and positive CA experiences are explored in Chapter 4 and Chapter 5. Secondly, the model assisted the identification of unexplored areas in the literature. Specifically, it outlines two ways of designing positive experiences: through supporting dedicated activities and rejuvenating non-dedicated activities with positivity. This view was taken to analyse how CAs have been previously studied to support well-being. This enabled the identification of the fact that the second means was largely unexplored in the literature, which motivated the undertaking of studies reported in Chapter 4 and Chapter 5 to fill this gap. Thirdly, this model motivated the use of the SDT approach in an effort to develop design support for CAs. This model describes positive experiences as those that satisfy people's psychological needs. It further suggests that design should support this needs fulfilment. In light of this, the SDT theory (Ryan and Deci, 2000) was explored and its effectiveness in supporting positive design was discovered. Thus, the SDT approach was applied for the studies presented in Chapter 5.

6.2.2 Well-being supportive experience themes

Designers aspire to design products that promote their users' well-being. But the challenge is how this can be done. Considerable progress has been made by design literature to equip designers with effective methods and insightful theories, such as those by Desmet and Hassenzahl (2012), Desmet and Pohlmeier (2013), Hassenzahl (2010), Jordan (2002) and Norman (2005) to name a few. This work starts with emotional design approaches that go beyond product functionality to focus on eliciting positive emotions from products, for example Jordan's pleasure design framework (Jordan, 2002) and Norman's three levels of emotional design (Norman, 2005). Emotional design was then expanded by approaches such as those proposed in positive and experience design theories (Desmet and Hassenzahl, 2012; Desmet and Pohlmeier, 2013; Hassenzahl, 2010; Pohlmeier, 2012) which have demonstrated what positive design is and how to achieve it; however, they are often limited to a conceptual and broad level, lacking actionable and descriptive information relating to specific contexts of use. These limitations may be due to the way in which these theories (e.g. Desmet and Hassenzahl, 2012; Desmet and Pohlmeier, 2013; Pohlmeier, 2012) were generated: many of them emerged using a deductive-oriented approach (top-down approach), meaning they were developed from the analysis of established theories (e.g. well-being theories) instead of empirical data (Creswell and Clark, 2007). This indicates that these design theories may have overlooked the perspective of users as they are not based on empirical evidence.

To mitigate this effect, in this thesis, the inductive-oriented approach (bottom-up approach) was followed, which involves *'using participants' views to build broader themes and generating theories interconnecting the themes'* (Creswell and Clark, 2007, p. 23). To start with, a survey study using the critical incident method was conducted to collect people's experiences with products that contribute to their well-being. Following this, seven well-being supportive experience profiles were derived from a rigorous process of coding and identifying themes that amplify dimensions of well-being valued by users.

This study contributes empirical evidence and insights into what and how products can help promote well-being. Specifically, six categories of products are reported and seven well-being supportive experience themes are identified (see Chapter 3). Unlike previous works, these experience themes were generated via the examination of empirical data on users' perspectives.

Furthermore, unlike the relatively broad experience descriptions in prior literature, this study provides detailed descriptions for each experience theme, including personal meaning (why the experience contributes to a person's well-being), activities (what is the core behaviour taking place in the experience), contexts (what is the core context when the experience happened) and product roles (how is the product involved in the experience), together with examples from participant reports. These details give designers more insightful information, which could support design practice more effectively.

Altogether, the findings could benefit design in the following ways. First, they inspire the exploration of new opportunities in early design phases. For example, multiple links between products and the experience themes are identified; thus, designers can explore the possibility of creating new links or strengthening existing ones. Second, they stimulate creativity and help designers brainstorm new ideas and design solutions in middle design phases. For example, two roles that products play in creating a well-being supportive experience, namely enabler and carrier of reflective meanings, are identified. For each role, multiple examples from empirical data are provided and designers can use this as guidance or a source of inspiration for applying these roles in their own design contexts. Third, they help with the evaluation of existing designs in late design phases by assessing to what extent the existing work can support well-being. For example, the experience profiles presented in the findings can serve as ultimate design goals and can be compared with during evaluation. Mapping existing designs to these experiences can help designers identify gaps and opportunities so that they can make adjustments.

6.2.3 Affective CA experiences and how to design positive ones

The ubiquity and increasing popularity of CAs over the past five years indicates the large impact that CAs may potentially have on our lives, including our well-being. However, the opportunities regarding how CAs can support well-being have only been partially explored. Most prior work has created CA applications that are dedicated to supporting well-being related activities, such as supporting e-healthcare or positive interventions and behaviour change. For example, CAs can serve as a virtual dietitian for diabetic patients (Fadhil and Gabrielli, 2017) or support fitness training (Kocielnik et al., 2018), nutrition (Graf et al., 2015), meditation (Shamekhi and Bickmore, 2015) and reminiscing (Nikitina et al., 2018). Although these applications are still in their infancy and can only support simple scenarios, they

demonstrate the promising benefits that CAs can bring to such scenarios. This is evidenced by CAs providing tailored experiences and enabling natural and intuitive interactions (Fadhil and Gabrielli, 2017).

However, besides dedicated well-being applications, the exploration of active positive design for non-dedicated CA applications (i.e. rejuvenating CA experiences with positivity regardless of system functionality) is missing in the CA literature. This thesis contributes to the field by providing in-depth insights into and design implications for positive CA experiences from both hedonic and eudaimonic perspectives: affective experiences (see Chapter 4) and the psychological needs of competence, autonomy and relatedness (see Chapter 5), respectively. The affective experiences of CAs are discussed in this section, and the three psychological needs are discussed in the following sections.

To start with, users' affective responses to their CA experiences are examined. From this, it is learnt that emotions are elicited differently depending on the scenario. Specifically, scenarios with a higher level of complexity and interactivity are found to stimulate more positive emotions, such as interest and joy. In light of this, this thesis applies emotional design knowledge [e.g. design for interest (Yoon et al., 2012), joy and other positive emotions (Desmet, 2012)] to inform the positive design of CAs. Specifically, it suggests introducing complexity and playfulness to CA interactions and it stresses the importance of having a balanced amount of complexity. Referring to the Flow Theory (Csikszentmihalyi, 1997), an optimal amount of complexity should introduce enough challenge so that users stay engaged in the task but not too much to make them feel incompetent.

Besides emotions, it is also important to consider the diverse contexts of use. This is because the way in which people are using CAs and their acceptance of this technology is changing rapidly. For example, in 2017, it was reported that people were reluctant to use CAs in public places because of social embarrassment (Cowan et al., 2017). However, over the last three years, we have started to see use cases emerging in settings such as cafés (Candello et al., 2018), local landmarks (Acer et al., 2019), schools and workplaces (Amazon, 2020a). This shift indicates people's growing confidence in the new technology and thus increased acceptability. More importantly, even more diverse scenarios and contexts of use in the future are foreseen. This thesis sheds new light on the different types of scenarios and contexts of use that need to be

considered. For example, it suggests considering contextual factors such as devices, locations and social contexts and that it would be beneficial to ask questions such as: will people interact with the CA through voice or text, where would people use the CA and will people use the CA individually or share it with others.

Finally, this thesis identifies a set of pragmatic and hedonic factors that could influence affective responses. The pragmatic factors suggest the need for a helpful, proactive and responsive agent with fluid and seamless interactions. In addition, the findings highlight a set of hedonic factors that, if addressed successfully, could significantly improve users' affective responses. These factors concern users' expectations of a human-like assistant, comfort and fun in use, as well as concerns over privacy, trust and distraction from primary tasks. Some of these factors strengthen existing arguments, for example they support the goal of developing a high-performing, smart and easy-to-use agent (Zamora, 2017), and confirm the importance of privacy concerns and its relevancy to today (Cohen et al., 2016; Norman, 1994). Others open up new perspectives, for example the need to ease users' fear of distraction when multi-tasking. This suggests an opportunity to borrow insights from mobile distraction research, such as that of Choudhary and Velaga (2017), Nathan et al. (2018) and Wijayarathna et al. (2019), to inform CA design.

6.2.4 Design for competence with CAs

Competence is not only related to how well the user can perform the current task, as discussed in Przybylski et al. (2010), Ryan et al. (2006) and White (1959), it also concerns what the user knows about the system's capabilities. This is particularly relevant for CAs, due to the fact that many CA systems (e.g. Google Assistant, Alexa) play the role of a service platform where the user has access to external services. For example, from a CA, the user can listen to news from the BBC, play music from Spotify or order food from Uber Eats. The number of services¹² (and thus the capabilities of the CA) is growing rapidly: as this report (Liu, 2019) shows, the number

¹² 'Services' may be referred to by other terms, depending on the CA: in the case of Google Assistant, they are called 'apps' or 'actions'; in the case of Alexa, they are called 'skills'.

of Google Assistant services in the United States increased by 147% within just one year from 2018 to 2019, to a total of 4,253 services.

The acceleration in CA capabilities makes it difficult for the user to gain a clear picture of what the CA can do. Even in 2016, when the number of services was much lower than today, users reported feeling overwhelmed by the unknown potential of CAs (Luger and Sellen, 2016). This thesis shows that such a feeling of ignorance could decrease a user's sense of competence. This is because competence is affected by how much the user knows about the CA's capabilities. In particular, the findings demonstrate that users expect to gain an overview of all available capabilities and of efficient ways to access relevant capabilities as necessary. In response to this, design implications are provided to support the discoverability of CA capabilities. For example, instead of simply showing categories of 'things to do', the overview of capabilities could be improved by adding personalised information, for example, highlighting what users have already tried and what they have not.

Finally, this thesis has provided guidelines to support design for competence (Section 5.4). These guidelines provide suggestions for educating users about what the CA can do, improving the discoverability of new and relevant capabilities, as well as ways to design effective human-agent conversations.

6.2.5 Design for autonomy with CAs

The sense of autonomy is found to decrease where the user has limited control over the conversations with CAs. For example, participants reported that their CAs often respond inconsistently and unpredictably, leaving them with little control of how the conversation will happen. On the other hand, users expect to have human-like conversations with CAs, as this is more natural and familiar to them (Cho et al., 2019; Cowan et al., 2017). However, this inherently increases the chances of CAs behaving independently and unpredictably (Porcheron et al., 2018), thus increasing users' sense of lack of control. This contradiction may be addressed by differentiating between two conversational purposes: transactional and social (Eggins and Slade, 2005; Schneider, 1988). In conversations with transactional purposes (e.g. seeking answers or requesting information), consistency and accuracy in CA responses are expected from users. Therefore, it is worth considering providing users with more control in

such conversations. Conversely, in conversations with social purposes (e.g. perceiving the CA as a friend or a guru), unpredictability may add enjoyment to the user's experiences (Lehman and Leite, 2016). Therefore, such scenarios may benefit from more human-like conversation.

User autonomy is also affected by level of personalisation. It has been found that users expect personalisation to be applied to their behaviours and everyday life, for example, through CAs learning and adapting to users' daily habits and routines. This points to another key question in the design of CAs: how to design the human-agent relationship. In previous works, it has been shown that people were resistant to build relationships with CAs beyond the level of 'strangers' or 'casual acquaintances' (Clark et al., 2019). However, findings from this thesis contradict that argument, as a higher level of personalisation inevitably implies a closer relationship than that between strangers or acquaintances. In such cases, more information is shared and more common ground established, as described in the linguistic literature (Johnstone, 2018). Importantly, given that improved personalisation is often based on the user sharing more data with the agent, this raises security risks and privacy concerns. It is, therefore, vital to consider how to balance the level of personalisation with potential risks and concerns.

Finally, to support design for autonomy with CAs, this thesis offers guidelines for achieving this objective (Section 5.4). These provide guidance on adding transparency to the system's status when errors occur and on providing tailored services over time, as well as suggestions regarding providing users with controls to customise conversations and manage their data. These guidelines help increase user autonomy, by allowing users to gain flexibility and control over their interactions with CAs.

6.2.6 Design for relatedness with CAs

In the literature, there is little discussion around the topic of relatedness with CAs. Existing research has mostly explored the social roles of CAs with particular types of use cases, for example, supporting the elderly (Sabelli et al., 2011), playing with children (Druga et al., 2018; McReynolds et al., 2017) and helping people with disabilities (Pradhan et al., 2018). However, the social functions of CAs within people's everyday life and how relatedness can be supported have not been adequately explored. This thesis contributes to this topic by identifying users' expectations and concerns with regard to the social roles of CAs in their daily lives.

The findings show that CA users' expectations of relatedness are mixed. This is connected to the readiness of the technology (e.g. not yet incorporating mature social-specific features), the shortcomings of (or lack of) visual UIs (e.g. not all CA devices have screens, which makes it inconvenient to use visual elements such as emojis, which are popular in social interactions (Fadhil et al., 2018)), the awkwardness of having social interactions in a shared environment (e.g. talking to a CA speaker about Facebook news feeds when families are around), as well as privacy concerns (e.g. the intrusiveness of a CA accessing information about a user's social circles).

Despite users' concerns and the high dependency on technological developments, the findings stress a design direction that does not introduce these extra concerns, i.e. the CA playing a role in facilitating social activities, for example, strengthening parent-child relationships by participating in family bonding activities. In recent years, this direction of design has started to emerge in studies that explore CAs providing companionship to individuals (Lopatovska and Williams, 2018), supporting teamwork in schools (Xiao et al., 2019), relieving employee anxiety in workplaces (Kimani et al., 2019) and providing entertainment to family members (Jones and Ackerman, 2018; Sciuto et al., 2018). These studies have all touched upon the social effects of CAs from different perspectives. However, they have not explicitly linked these effects to the user's sense of relatedness. This thesis has articulated the value of the roles that CAs may play, and proposed that if such social functions are successfully applied, CAs could indirectly help improve social relationships between people and thereby increase their sense of relatedness.

6.3 Limitations

In addition to the limitations of the individual studies presented in the corresponding chapters, there are three additional points that apply to the thesis as a whole.

Social factors of well-being

Although findings from the thesis sometimes touch upon social factors, most of the discussions around design for well-being focus on individual factors, i.e. those that can be experienced within the self and do not necessarily require the presence of others. For example, most of the

well-being supportive experience themes (e.g. relaxing, mastering an activity, developing self-image, learning new knowledge) identified in Chapter 3 can be pursued through individual efforts. Accordingly, designs aiming to support such experiences are centred around supporting individual efforts, rather than facilitating social settings. Similarly, in the research on CAs presented in Chapter 4 and Chapter 5, the focus is mainly on the individual uses of CAs.

Despite topics such as, relatedness, considerations of multi-user settings and shared-use contexts, have been covered in the thesis, it has not yet been explored thoroughly how CAs may facilitate social settings to support well-being. For example, how might CAs be used in workplaces to support employee well-being? How might CAs strengthen family relationships? Although this is beyond the scope of this thesis, as this research progresses, the significance of these topics becomes more evident, revealing the urgent need for further research.

Ethical AI

Another limitation of this research is the lack of in-depth discussion on topics related to ethical AI (e.g. privacy, security, data transparency and control), which is particularly critical for CA design. Although this decision was made intentionally, due to the scope of the thesis, I acknowledge this as a limitation and discuss its importance here. In their proposal on the future of personal assistants, Cohen et al. (2016) call for the HCI community to become involved in discussions on ethical issues, for example, how to balance the trade-off in the provision of personal data in exchange for better-performing software, how to prevent the misuse of personal data, and how to protect children in their interactions with CAs.

It is encouraging that industry and policy makers are working together to tackle such issues, and progress has been made in the past five years. For example, in terms of policy, the EU data regulation law GDPR has been introduced, aimed at protecting user information (Goddard, 2017). The Institute of Electrical and Electronics Engineers (IEEE) has outlined principles to ensure that AI systems are built to respect ethical considerations, as seen in the IEEE Global Initiative on AI Ethics (Chatila et al., 2017). In industry, Microsoft has launched an ethical AI initiative, proposing six responsible AI principles, including fairness, reliability and safety, privacy and security, inclusiveness, transparency, and accountability ('Responsible AI

principles from Microsoft', 2020). With CAs such as Google Assistant, Amazon's Alexa and Apple's Siri, users can find privacy policies within the CA mobile apps and users now have more options for data control (e.g. opt in or out of certain services that require user data).

Despite this progress, concerns are still growing, especially as technologies such as facial recognition advance rapidly: new concerns and ethical issues arise in tandem. Having said that, the ethics of AI is an ongoing topic that needs careful attention throughout the design and development process. This thesis has discussed this topic at several points, when concerns have arisen from participants. For example, in Chapter 4, it was found that concern over privacy is a factor that leads to a negative experience. In Chapter 5, lack of sufficient control and of transparency regarding user data were found to decrease user autonomy. The ethical issue is also a major reason why the integration into CAs of social-related features is not welcomed by users. Due to the scope of this research, deeper insights into these issues have not been provided. This is acknowledged as a limitation of this research. Greater awareness of ethical issues is called for in future CA studies.

Personal assistants vs. chatbots

A third limitation is that most of the empirical evidence is collected from CAs such as Google Assistant, Alexa and Siri, i.e. 'personal assistants', rather than 'chatbots'. The reasons have been provided in Section 2.3. Briefly, personal assistants and chatbots differ in terms of task diversity, ubiquity and variety of modality. Therefore, the focus on personal assistants offers the opportunity to explore more diverse user experiences including a variety of scenarios, contexts (e.g. locations and devices of use) and interaction styles (voice and text-based interactions). Despite the distinctions, the line between the two types is blurring. Chatbots can ultimately become people's personal assistants. Similarly, a virtual assistant can be a collection of bots each of which taking different responsibilities.

That said, the findings from this study are generally applicable to CAs of any type, and the value of the findings could potentially increase in future as the line between chatbots and personal assistants is further blurred. However, I acknowledge that the findings may have overlooked some use cases that are specific to chatbots. For example, chatbots are often domain-specific, and they may heavily depend on a particular professional knowledge base, e.g. a financial

advisor bot needs to acquire financial knowledge. How to interact with users to provide professional assistance may differ from providing general assistance in daily life. I therefore highlight this limitation and invite future research to develop more complete design guidance for CAs.

6.4 Future Work

Outlined below are three areas for future work to address the limitations discussed above and utilise the contributions of this thesis to further positive CA research.

- Widen the scenarios of CAs and well-being studied to include social settings such as the workplace and family. This has particular promise for CAs, because of their universal characteristics. In particular, further explore how CAs might support relatedness. This topic has emerged from the part of this study exploring SDT (competence, autonomy, relatedness) in CAs; findings on relatedness show promising insights. Despite users' lack of readiness to accept social-related features in CAs, the findings imply possibilities. Such opportunities as well as the corresponding challenges are highlighted in Section 5.3. But realising that this could be a larger topic, more research is needed to: 1) experiment with new ideas around supporting social relationships through CAs, and 2) address the associated privacy and ethical concerns.
- Explore the various topics around ethical AI (as discussed above). Importantly, future research is needed to explore how to address users' privacy concerns, not only from the technological perspective, but also from the design perspective. Research is also needed to address design for inclusiveness and fairness with CAs, taking into consideration different user groups, their particular needs and how best to support these.
- Further develop and refine the guidelines for CAs, taking into consideration factors such as the different CA types (e.g. chatbots, personal assistants), the range of domains (e.g. CAs in healthcare, finance, travel), shifting between different modalities (e.g. voice-based assistants, text-based assistants), and multi-user settings and shared contexts (e.g. CAs shared by family, CAs in the workplace). The importance of these areas has emerged as this research has progressed and is growing as the conversational AI industry develops. Addressing these factors can help inform and advance the

development of CAs and conversational AI in general. In addition, further evaluation of the CA guidelines should be undertaken, with experts and through design activities. In this thesis, the guidelines' perceived importance is tested with CA users; however, their usefulness and effectiveness have not yet been evaluated with design experts. Despite testing with end users is equalled in importance by early phases of evaluation, follow-up studies are needed for evaluation from other perspectives.

6.5 Conclusions

It is evident that design and technology, especially in the rapidly growing field of conversational agents, can have significant impact on individuals' well-being. This impact is often generated through user experiences shaping how we think, feel and behave. Acknowledging such potential, the positive design and technologies field has called for the intentional consideration of well-being to be integrated into the design process, so that products and technologies, regardless of their primary functions and purposes, can support well-being through careful design. However, this has not yet become common practice, due to the lack of support and practical design guidance.

This thesis has aimed at providing such support and design guidance. I first set the objective of investigating some successful examples (e.g. well-being supportive products and experiences), asking why and how they support well-being. The findings provide the routes and means by which these products contribute to well-being. Inferred from these findings, as well as influenced by the recent development of CAs, I then focused the research on the investigation of CAs, asking how we might design them to support well-being. In response to this, I first investigated affective experiences with CAs (e.g. what emotional responses users have, and what are the influencing factors of those responses). I then investigated CA experiences through the lens of SDT theory: specifically, through understanding users' expectations and perceptions regarding requirements for competence, autonomy and relatedness. Combining the findings of these investigations, I provided implications for designing positive CA experiences, as well as for experiences satisfying the three psychological needs. Finally, recognising an urgent need for more practical design guidance, I derived ten design guidelines for CAs, aiming to provide practical support to CA designers. Overall, this PhD research

contributes essential knowledge and design support to the aspiration to design for well-being, particularly with regard to CAs.

References

- Acer, U.G., van den Broeck, M., Kawsar, F., 2019. On Hyper-local Conversational Agents in Urban Settings, in: Proceedings of the 5th ACM Workshop on Mobile Systems for Computational Social Science. pp. 1–4.
- Adams, S.K., Kisler, T.S., 2013. Sleep quality as a mediator between technology-related sleep quality, depression, and anxiety. *Cyberpsychology Behav. Soc. Netw.* 16, 25–30.
- Afzal, S., Dempsey, B., D’Helon, C., Mukhi, N., Pribic, M., Sickler, A., Strong, P., Vanchiswar, M., Wilde, L., 2019. The Personality of AI Systems in Education: Experiences with the Watson Tutor, a one-on-one virtual tutoring system. *Child. Educ.* 95, 44–52.
- Amazon, 2020a. Alexa for Business – empower your organization with Alexa. Amaz. Web Serv. Inc. URL <https://aws.amazon.com/alexaforbusiness/> (accessed 1.14.20).
- Amazon, 2020b. Designing for Conversation. URL <https://developer.amazon.com/ask-resources/guided/conversational-design-workshop#/> (accessed 4.3.20).
- Amershi, S., Inkpen, K., Teevan, J., Kikin-Gil, R., Horvitz, E., Weld, D., Vorvoreanu, M., Fournay, A., Nushi, B., Collisson, P., Suh, J., Iqbal, S., Bennett, P.N., 2019. Guidelines for Human-AI Interaction, in: Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems - CHI ’19. Presented at the the 2019 CHI Conference, ACM Press, Glasgow, Scotland Uk, pp. 1–13. <https://doi.org/10.1145/3290605.3300233>
- Argyle, M., 2013. The Psychology of Happiness. Routledge.
- Arhippainen, L., Tähti, M., 2003. Empirical evaluation of user experience in two adaptive mobile application prototypes, in: MUM 2003. Proceedings of the 2nd International Conference on Mobile and Ubiquitous Multimedia. Linköping University Electronic Press, pp. 27–34.
- Assembly, U.G., 2011. Resolution adopted by the General Assembly. 65/309. Happiness Holist. Approach Dev. N. Y. NY U. N.
- Avula, S., 2017. Searchbots: Using Chatbots in Collaborative Information-seeking Tasks, in: Proceedings of the 40th International ACM SIGIR Conference on Research and Development in Information Retrieval, SIGIR ’17. ACM, New York, NY, USA, pp. 1375–1375. <https://doi.org/10.1145/3077136.3084155>
- Ayobi, A., Marshall, P., Cox, A.L., 2016. Reflections on 5 years of personal informatics: rising concerns and emerging directions, in: Proceedings of the 2016 CHI Conference Extended Abstracts on Human Factors in Computing Systems. pp. 2774–2781.
- Baber, C., 1993. Developing interactive speech technology, Interactive speech technology: human factors issues in the application of speech input/output to computers. Taylor & Francis, Inc., Bristol, PA.

- Babu, R., 2019. The conversational designer's guide to AI assistants [WWW Document]. Medium. URL <https://uxdesign.cc/the-conversational-designers-guide-to-ai-assistants-by-ruben-babu-6aa45de578f0> (accessed 12.4.19).
- Baier, Daniel, Rese, Alexandra, Röglinger, Maximilian, Baier, D., Rese, A., Röglinger, M., 2018. Conversational User Interfaces for Online Shops? A Categorization of Use Cases., in: ICIS.
- Baltes, P.B., Staudinger, U.M., 2000. Wisdom: A metaheuristic (pragmatic) to orchestrate mind and virtue toward excellence. *Am. Psychol.* 55, 122.
- Baumeister, R.F., Newman, L.S., 1994. How stories make sense of personal experiences: Motives that shape autobiographical narratives. *Pers. Soc. Psychol. Bull.* 20, 676–690.
- Beirl, D., Yuill, N., Rogers, Y., 2019. Using voice assistant skills in family life.
- Bhumiratana, N., Adhikari, K., Chambers IV, E., 2014. The development of an emotion lexicon for the coffee drinking experience. *Food Res. Int.* 61, 83–92.
- Bickmore, T., Cassell, J., 2001. Relational agents: a model and implementation of building user trust, in: *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. pp. 396–403.
- Bittner, E., Oeste-Reiß, S., Leimeister, J.M., 2019. Where is the bot in our team? toward a taxonomy of design option combinations for conversational agents in collaborative work, in: *Proceedings of the 52nd Hawaii International Conference on System Sciences*.
- Black, H., 2019. What is Conversation Design, and How to Design Your Chatbot [WWW Document]. Medium. URL <https://medium.com/swlh/what-is-conversation-design-and-how-to-design-your-chatbot-3754f04ab1e7> (accessed 12.4.19).
- Blessing, L.T., Chakrabarti, A., 2009. *DRM: A design research methodology*. Springer.
- Boaler, J., 2013. Ability and mathematics: The mindset revolution that is reshaping education, in: *Forum*. pp. 143–152.
- Boehm, J.K., Lyubomirsky, S., Sheldon, K.M., 2012. The role of need satisfying emotions in a positive activity intervention. Unpubl. Raw Data.
- Braun, V., Clarke, V., 2006. Using thematic analysis in psychology. *Qual. Res. Psychol.* 3, 77–101.
- Brennan, S.E., 1990. Conversation as direct manipulation: An iconoclastic view.
- Brill, T.M., Munoz, L., Miller, R.J., 2019. Siri, Alexa, and other digital assistants: a study of customer satisfaction with artificial intelligence applications. *J. Mark. Manag.* 35, 1401–1436.
- Bryant, F.B., Smart, C.M., King, S.P., 2005. Using the past to enhance the present: Boosting happiness through positive reminiscence. *J. Happiness Stud.* 6, 227–260.

- Cacioppo, J.T., Berntson, G.G., 1999. The affect system: Architecture and operating characteristics. *Curr. Dir. Psychol. Sci.* 8, 133–137.
- Calvo, R.A., Peters, D., 2014. *Positive computing: technology for wellbeing and human potential*. MIT Press.
- Calvo, R.A., Peters, D., 2012. Positive Computing: Technology for a Wiser World. *interactions* 19, 28–31. <https://doi.org/10.1145/2212877.2212886>
- Canbek, N.G., Mutlu, M.E., 2016. On the track of artificial intelligence: Learning with intelligent personal assistants. *J. Hum. Sci.* 13, 592–601.
- Candello, H., Pinhanez, C., Pichiliani, M., Cavalin, P., Figueiredo, F., Vasconcelos, M., Do Carmo, H., 2019. The Effect of Audiences on the User Experience with Conversational Interfaces in Physical Spaces, in: *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems - CHI '19*. Presented at the the 2019 CHI Conference, ACM Press, Glasgow, Scotland Uk, pp. 1–13. <https://doi.org/10.1145/3290605.3300320>
- Candello, H., Pinhanez, C., Pichiliani, M.C., Guerra, M.A., Gatti de Bayser, M., 2018. Having an Animated Coffee with a Group of Chatbots from the 19 th Century, in: *Extended Abstracts of the 2018 CHI Conference on Human Factors in Computing Systems*. ACM, p. D206.
- Carter, T.J., Gilovich, T., 2012. I am what I do, not what I have: the differential centrality of experiential and material purchases to the self. *J. Pers. Soc. Psychol.* 102, 1304.
- Carter, T.J., Gilovich, T., 2010. The relative relativity of material and experiential purchases. *J. Pers. Soc. Psychol.* 98, 146.
- Casais, M., Mugge, R., Desmet, P.M.A., 2016. Using symbolic meaning as a means to design for happiness: The development of a card set for designers 18.
- Cassell, J., 2000. *Embodied conversational agents*. MIT press.
- Cassell, J., Pelachaud, C., Badler, N., Steedman, M., Achorn, B., Becket, T., Douville, B., Prevost, S., Stone, M., 1994. Animated conversation: rule-based generation of facial expression, gesture & spoken intonation for multiple conversational agents, in: *Proceedings of the 21st Annual Conference on Computer Graphics and Interactive Techniques*. ACM, pp. 413–420.
- Cassell, J., Thorisson, K.R., 1999. The power of a nod and a glance: Envelope vs. emotional feedback in animated conversational agents. *Appl. Artif. Intell.* 13, 519–538.
- Chatila, R., Firth-Butterfield, K., Havens, J.C., Karachalios, K., 2017. The IEEE global initiative for ethical considerations in artificial intelligence and autonomous systems [standards]. *IEEE Robot. Autom. Mag.* 24, 110–110.
- Chaves, A.P., Gerosa, M.A., 2018. Single or Multiple Conversational Agents?: An Interactional Coherence Comparison, in: *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*. ACM, p. 191.

- Chen, S.Y., Macredie, R.D., 2005. The assessment of usability of electronic shopping: A heuristic evaluation. *Int. J. Inf. Manag.* 25, 516–532.
- Cho, M., Lee, S., Lee, K.-P., 2019. Once a Kind Friend is Now a Thing: Understanding How Conversational Agents at Home are Forgotten, in: *Proceedings of the 2019 on Designing Interactive Systems Conference*. pp. 1557–1569.
- Choudhary, P., Velaga, N.R., 2017. Modelling driver distraction effects due to mobile phone use on reaction time. *Transp. Res. Part C Emerg. Technol.* 77, 351–365.
- Clark, L., Pantidi, N., Cooney, O., Doyle, P., Garaialde, D., Edwards, J., Spillane, B., Gilmartin, E., Murad, C., Munteanu, C., 2019. What makes a good conversation? challenges in designing truly conversational agents, in: *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*. pp. 1–12.
- Cohen, J., 1960. A coefficient of agreement for nominal scales. *Educ. Psychol. Meas.* 20, 37–46.
- Cohen, P., Cheyer, A., Horvitz, E., El Kaliouby, R., Whittaker, S., 2016. On the future of personal assistants, in: *Proceedings of the 2016 CHI Conference Extended Abstracts on Human Factors in Computing Systems*. ACM, pp. 1032–1037.
- Compton, W.C., Smith, M.L., Cornish, K.A., Qualls, D.L., 1996. Factor structure of mental health measures. *J. Pers. Soc. Psychol.* 71, 406.
- Cowan, B.R., Pantidi, N., Coyle, D., Morrissey, K., Clarke, P., Al-Shehri, S., Earley, D., Bandeira, N., 2017. What can i help you with?: infrequent users' experiences of intelligent personal assistants, in: *Proceedings of the 19th International Conference on Human-Computer Interaction with Mobile Devices and Services*. ACM, p. 43.
- Creswell, J.W., Clark, V.L.P., 2007. *Designing and conducting mixed methods research*.
- Csikszentmihalyi, M., 1997. *Finding flow: The psychology of engagement with everyday life*. Basic Books.
- Csikszentmihalyi, M., Graef, R., 1980. The experience of freedom in daily life. *Am. J. Community Psychol.* 8, 401–414.
- Cuijpers, P., Smit, F., 2004. Subthreshold depression as a risk indicator for major depressive disorder: a systematic review of prospective studies. *Acta Psychiatr. Scand.* 109, 325–331.
- Cutts, Q., Cutts, E., Draper, S., O'Donnell, P., Saffrey, P., 2010. Manipulating mindset to positively influence introductory programming performance, in: *Proceedings of the 41st ACM Technical Symposium on Computer Science Education*. pp. 431–435.
- Danielescu, A., Christian, G., 2018. A Bot is Not a Polyglot: Designing Personalities for Multi-Lingual Conversational Agents, in: *Extended Abstracts of the 2018 CHI Conference on Human Factors in Computing Systems*. ACM, p. CS01.

- Deci, E.L., Ryan, R.M., 2012. Motivation, personality, and development within embedded social contexts: An overview of self-determination theory. *Oxf. Handb. Hum. Motiv.* 85–107.
- Deci, E.L., Ryan, R.M., 2008. Self-determination theory: A macrotheory of human motivation, development, and health. *Can. Psychol. Can.* 49, 182.
- Deci, E.L., Ryan, R.M., 2000. The "what" and "why" of goal pursuits: Human needs and the self-determination of behavior. *Psychol. Inq.* 11, 227–268.
- Delle Fave, A., Massimini, F., 2000. Living at home or in institution: adolescents' optimal experience and life theme building. *Paidéia* 10, 55–66.
- Demirbilek, O., Sener, B., 2003. Product design, semantics and emotional response. *Ergonomics* 46, 1346–1360.
- Denecke, K., Tschanz, M., Dorner, T.L., May, R., 2019. Intelligent conversational agents in healthcare: Hype or hope? *Stud. Health Technol. Inform.* 259, 77–84.
- Desmet, P., Hassenzahl, M., 2012. Towards Happiness: Possibility-Driven Design, in: Zacarias, M., Oliveira, J.V. de (Eds.), *Human-Computer Interaction: The Agency Perspective, Studies in Computational Intelligence*. Springer Berlin Heidelberg, pp. 3–27. https://doi.org/10.1007/978-3-642-25691-2_1
- Desmet, P., Hekkert, P., 2007. Framework of product experience. *Int. J. Des.* 1.
- Desmet, P.M.A., 2012. Faces of Product Pleasure: 25 Positive Emotions in Human-Product Interactions. *Int. J. Dsign* 6, 1–29.
- Desmet, P.M.A., Pohlmeier, A.E., 2013. Positive Design: An Introduction to Design for Subjective Well-Being. *Int. J. Des.* 7, 5–19.
- Deuschel, T., Scully, T., 2016. On the Importance of Spatial Perception for the Design of Adaptive User Interfaces, in: 2016 IEEE 10th International Conference on Self-Adaptive and Self-Organizing Systems (SASO). IEEE, pp. 70–79.
- Diefenbach, S., Kolb, N., Hassenzahl, M., 2014. The "Hedonic" in Human-computer Interaction: History, Contributions, and Future Research Directions, in: *Proceedings of the 2014 Conference on Designing Interactive Systems, DIS '14*. ACM, New York, NY, USA, pp. 305–314. <https://doi.org/10.1145/2598510.2598549>
- Diener, E., 2000. Subjective well-being: The science of happiness and a proposal for a national index. *Am. Psychol.* 55, 34–43. <https://doi.org/10.1037/0003-066X.55.1.34>
- Diener, E., Biswas-Diener, R., 2008. *Rethinking happiness: The science of psychological wealth*. Malden Blackwell Publ.
- Diener, E., Biswas-Diener, R., 2002. Will money increase subjective well-being? *Soc. Indic. Res.* 57, 119–169.

- Diener, E.D., Emmons, R.A., Larsen, R.J., Griffin, S., 1985. The satisfaction with life scale. *J. Pers. Assess.* 49, 71–75.
- Dourish, P., Button, G., 1998. On "technomethodology": Foundational relationships between ethnomethodology and system design. *Hum.-Comput. Interact.* 13, 395–432.
- Druga, S., Williams, R., Park, H.W., Breazeal, C., 2018. How smart are the smart toys? children and parents' agent interaction and intelligence attribution, in: *Proceedings of the 17th ACM Conference on Interaction Design and Children*. pp. 231–240.
- Dunbar, R., Dunbar, R.I.M., 1998. *Grooming, gossip, and the evolution of language*. Harvard University Press.
- Dunn, E.W., Aknin, L.B., Norton, M.I., 2008. Spending money on others promotes happiness. *Science* 319, 1687–1688.
- Dweck, C., 2016. What having a "growth mindset" actually means. *Harv. Bus. Rev.* 13, 213–226.
- Dweck, C., 2015. Carol Dweck revisits the growth mindset. *Educ. Week* 35, 20–24.
- Dweck, C.S., 2014. *Mindsets and math/science achievement*.
- Ebner, M., Holzinger, A., 2007. Successful implementation of user-centered game based learning in higher education: An example from civil engineering. *Comput. Educ.* 49, 873–890.
- Eggins, S., Slade, D., 2005. *Analysing casual conversation*. Equinox Publishing Ltd.
- Egloff, B., Schmukle, S.C., Burns, L.R., Kohlmann, C.-W., Hock, M., 2003. Facets of dynamic positive affect: Differentiating joy, interest, and activation in the positive and negative affect schedule (PANAS). *J. Pers. Soc. Psychol.* 85, 528–540.
- Eiband, M., Khamis, M., von Zezschwitz, E., Hussmann, H., Alt, F., 2017. Understanding shoulder surfing in the wild: Stories from users and observers, in: *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*. ACM, pp. 4254–4265.
- Eid, M., Diener, E., 2004. Global Judgments of Subjective Well-Being: Situational Variability and Long-Term Stability. *Soc. Indic. Res.* 65, 245–277.
- Fadhil, A., 2018. Beyond patient monitoring: Conversational agents role in telemedicine & healthcare support for home-living elderly individuals. *ArXiv Prepr. ArXiv180306000*.
- Fadhil, A., Gabrielli, S., 2017. Addressing challenges in promoting healthy lifestyles: the al-chatbot approach, in: *Proceedings of the 11th EAI International Conference on Pervasive Computing Technologies for Healthcare*. pp. 261–265.
- Fadhil, A., Schiavo, G., Wang, Y., Yilma, B.A., 2018. The effect of emojis when interacting with conversational interface assisted health coaching system, in: *Proceedings of the 12th*

- EAI International Conference on Pervasive Computing Technologies for Healthcare. pp. 378–383.
- Fast, E., Chen, B., Mendelsohn, J., Bassen, J., Bernstein, M.S., 2018. Iris: A Conversational Agent for Complex Tasks, in: *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*. ACM, p. 473.
- Findlater, L., McGrenere, J., 2004. A comparison of static, adaptive, and adaptable menus, in: *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. ACM, pp. 89–96.
- Fitzpatrick, K.K., Darcy, A., Vierhile, M., 2017. Delivering cognitive behavior therapy to young adults with symptoms of depression and anxiety using a fully automated conversational agent (Woebot): a randomized controlled trial. *JMIR Ment. Health* 4, e19.
- Flanagan, J.C., 1954. The critical incident technique. *Psychol. Bull.* 51, 327.
- Forlizzi, J., Battarbee, K., 2004. Understanding experience in interactive systems, in: *Proceedings of the 5th Conference on Designing Interactive Systems: Processes, Practices, Methods, and Techniques*. ACM, pp. 261–268.
- Frankl, V.E., 1963. Man's search for meaning: An introduction to logotherapy. *Am. J. Orthopsychiatry* 33, 390–390.
- Fredrickson, B.L., Cohn, M.A., Coffey, K.A., Pek, J., Finkel, S.M., 2008. Open hearts build lives: positive emotions, induced through loving-kindness meditation, build consequential personal resources. *J. Pers. Soc. Psychol.* 95, 1045.
- Friedman, B., 2010. Value sensitive design.
- Friedman, B., Kahn, P., Borning, A., 2002. Value sensitive design: Theory and methods. Univ. Wash. Tech. Rep.
- Friedman, B., Nissenbaum, H., 1996. User autonomy: who should control what and when?, in: *Conference Companion on Human Factors in Computing Systems*. ACM, p. 433.
- Fromm, E., 1981. On disobedience and other essays.
- Gable, S.L., Reis, H.T., Impett, E.A., Asher, E.R., 2004. What do you do when things go right? The intrapersonal and interpersonal benefits of sharing positive events. *J. Pers. Soc. Psychol.* 87, 228.
- Gajos, K.Z., Czerwinski, M., Czerwinski, M., Tan, D.S., Weld, D.S., 2006. Exploring the design space for adaptive graphical user interfaces, in: *Proceedings of the Working Conference on Advanced Visual Interfaces*. ACM, pp. 201–208.
- Gajos, K.Z., Everitt, K., Tan, D.S., Czerwinski, M., Weld, D.S., 2008. Predictability and accuracy in adaptive user interfaces, in: *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. ACM, pp. 1271–1274.

- Ghandeharioun, A., McDuff, D., Czerwinski, M., Rowan, K., 2019. Towards understanding emotional intelligence for behavior change chatbots, in: 2019 8th International Conference on Affective Computing and Intelligent Interaction (ACII). IEEE, pp. 8–14.
- Ghandeharioun, A., McDuff, D., Czerwinski, M., Rowan, K., 2018. EMMA: An Emotionally Intelligent Personal Assistant for Improving Wellbeing. ArXiv Prepr. ArXiv181211423.
- Gil, D., Hobson, S., Mojsilović, A., Puri, R., Smith, J.R., 2020. AI for Management: An Overview, in: The Future of Management in an AI World. Springer, pp. 3–19.
- Glass, J., 1999. Challenges for spoken dialogue systems, in: Proceedings of the 1999 IEEE ASRU Workshop.
- Goddard, M., 2017. The EU General Data Protection Regulation (GDPR): European regulation that has a global impact. *Int. J. Mark. Res.* 59, 703–705.
- Google, 2020. Set up & manage Routines - Google Nest. URL <https://support.google.com/googlenest/answer/7029585?co=GENIE.Platform%3DAndroid&hl=en> (accessed 1.14.20).
- Google, 2019. Conversation design. Google Dev. URL <https://developers.google.com/assistant/actions/design> (accessed 12.4.19).
- Graesser, A.C., Dowell, N., Clewley, D., 2017. Assessing Collaborative Problem Solving Through Conversational Agents, in: Innovative Assessment of Collaboration. Springer, pp. 65–80.
- Graf, B., Krüger, M., Müller, F., Ruhland, A., Zech, A., 2015. Nombot: Simplify Food Tracking, in: Proceedings of the 14th International Conference on Mobile and Ubiquitous Multimedia, MUM '15. ACM, New York, NY, USA, pp. 360–363. <https://doi.org/10.1145/2836041.2841208>
- Guevarra, D.A., Howell, R.T., 2015. To have in order to do: Exploring the effects of consuming experiential products on well-being. *J. Consum. Psychol.* 25, 28–41.
- Hassenzahl, M., 2014. Let's design people happy.
- Hassenzahl, M., 2013. Experiences before things: A primer for the (yet) unconvinced, in: CHI'13 Extended Abstracts on Human Factors in Computing Systems. ACM, pp. 2059–2068.
- Hassenzahl, M., 2011. User experience and experience design. *Encycl. Hum.-Comput. Interact.*
- Hassenzahl, M., 2010. Experience Design: Technology for All the Right Reasons. Morgan & Claypool Publishers.
- Hassenzahl, M., 2008. User experience (UX): towards an experiential perspective on product quality, in: Proceedings of the 20th International Conference of the Association Francophone d'Interaction Homme-Machine. ACM, pp. 11–15.

- Hassenzahl, M., 2003. The thing and I: understanding the relationship between user and product, in: *Funology*. Springer, pp. 31–42.
- Hassenzahl, M., Beu, A., Burmester, M., 2001. Engineering joy. *Ieee Softw.* 18, 70.
- Hassenzahl, M., Diefenbach, S., Göritz, A., 2010. Needs, affect, and interactive products—Facets of user experience. *Interact. Comput.* 22, 353–362.
- Hassenzahl, M., Eckoldt, K., Diefenbach, S., Laschke, M., Len, E., Kim, J., 2013. Designing moments of meaning and pleasure. *Experience design and happiness. Int. J. Des.* 7.
- Hassenzahl, M., Monk, A., 2010. The inference of perceived usability from beauty. *Human–Computer Interact.* 25, 235–260.
- Hassenzahl, M., Platz, A., Burmester, M., Lehner, K., 2000. Hedonic and Ergonomic Quality Aspects Determine a Software’s Appeal, in: *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, CHI ’00*. ACM, New York, NY, USA, pp. 201–208. <https://doi.org/10.1145/332040.332432>
- Hassenzahl, M., Tractinsky, N., 2006. User experience - a research agenda. *Behav. Inf. Technol.* 25, 91–97. <https://doi.org/10.1080/01449290500330331>
- Hassenzahl, M., Wiklund-Engblom, A., Bengs, A., Hägglund, S., Diefenbach, S., 2015. Experience-Oriented and Product-Oriented Evaluation: Psychological Need Fulfillment, Positive Affect, and Product Perception. *Int. J. Hum.-Comput. Interact.* 31, 530–544. <https://doi.org/10.1080/10447318.2015.1064664>
- Hauswald, J., Laurenzano, M.A., Zhang, Y., Li, C., Rovinski, A., Khurana, A., Dreslinski, R.G., Mudge, T., Petrucci, V., Tang, L., 2015. Sirius: An open end-to-end voice and vision personal assistant and its implications for future warehouse scale computers, in: *Proceedings of the Twentieth International Conference on Architectural Support for Programming Languages and Operating Systems*. pp. 223–238.
- Hekkert, P., Schifferstein, H.N., 2008. Introducing product experience. *Prod. Exp.* 1–8.
- Hekler, E.B., Klasnja, P., Froehlich, J.E., Buman, M.P., 2013. Mind the theoretical gap: interpreting, using, and developing behavioral theory in HCI research, in: *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. pp. 3307–3316.
- Hektner, J.M., Csikszentmihalyi, M., 1996. A longitudinal exploration of flow and intrinsic motivation in adolescents.
- Helliwell, J.F., Layard, R., Sachs, J., 2019. *World Happiness Report 2019*. Sustainable Development Solutions Network New York.
- Helliwell, J.F., Layard, R., Sachs, J., De Neve, J.-E., 2020. *World Happiness Report 2020*. Sustainable Development Solutions Network New York.
- Horvitz, E., 1999. Principles of mixed-initiative user interfaces, in: *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. ACM, pp. 159–166.

- How conversation (with context) will usher in the AI future [WWW Document], 2015. . IBM Cogn. - Whats AI. URL <http://www.ibm.com/watson/advantage-reports/future-of-artificial-intelligence/ai-conversation.html> (accessed 2.24.20).
- Huang, T.-H., Chang, J.C., Bigham, J.P., 2018. Evorus: A Crowd-powered Conversational Assistant Built to Automate Itself Over Time. ArXiv Prepr. ArXiv180102668.
- Hunt, R.J., 1986. Percent agreement, Pearson's correlation, and kappa as measures of inter-examiner reliability. *J. Dent. Res.* 65, 128–130.
- Inglehart, R., 2015. The silent revolution: Changing values and political styles among Western publics. Princeton University Press.
- Inglehart, R., 1971. The silent revolution in Europe: Intergenerational change in post-industrial societies. *Am. Polit. Sci. Rev.* 65, 991–1017.
- Jansen, A., Van Mechelen, M., Slegers, K., 2017. Personas and Behavioral Theories: A Case Study Using Self-Determination Theory to Construct Overweight Personas, in: Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems. ACM, pp. 2127–2136.
- Jivani, F.D., Malvankar, M., Shankarmani, R., 2018. A Voice Controlled Smart Home Solution with a Centralized Management Framework Implemented Using AI and NLP, in: 2018 International Conference on Current Trends towards Converging Technologies (ICCTCT). IEEE, pp. 1–5.
- Johnstone, B., 2018. Discourse analysis. John Wiley & Sons.
- Jones, J., Ackerman, M.S., 2018. Co-constructing Family Memory: Understanding the Intergenerational Practices of Passing on Family Stories, in: Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems. pp. 1–13.
- Jordan, P.W., 2002. Designing Pleasurable Products: An Introduction to the New Human Factors. CRC Press.
- Jung, M.F., 2017. Affective Grounding in Human-Robot Interaction, in: Proceedings of the 2017 ACM/IEEE International Conference on Human-Robot Interaction. ACM, pp. 263–273.
- Kahneman, D., Deaton, A., 2010. High income improves evaluation of life but not emotional well-being. *Proc. Natl. Acad. Sci.* 107, 16489–16493.
- Kahneman, D., Diener, E., Schwarz, N., 1999. Well-being: Foundations of hedonic psychology. Russell Sage Foundation.
- Kampmann, I.L., Emmelkamp, P.M., Morina, N., 2016. Meta-analysis of technology-assisted interventions for social anxiety disorder. *J. Anxiety Disord.* 42, 71–84.
- Karapanos, E., Gouveia, R., Hassenzahl, M., Forlizzi, J., 2016. Wellbeing in the making: peoples' experiences with wearable activity trackers. *Psychol. Well-Being* 6, 4.

- Kim, J., Park, S., Robert, L., 2019. Conversational Agents for Health and Wellbeing: Review and Future Agendas.
- Kimani, E., Rowan, K., McDuff, D., Czerwinski, M., Mark, G., 2019. A Conversational Agent in Support of Productivity and Wellbeing at Work, in: 2019 8th International Conference on Affective Computing and Intelligent Interaction (ACII). IEEE, pp. 1–7.
- King, L.A., Napa, C.K., 1998. What makes a life good? *J. Pers. Soc. Psychol.* 75, 156.
- Kiseleva, J., Williams, K., Jiang, J., Hassan Awadallah, A., Crook, A.C., Zitouni, I., Anastasakos, T., 2016. Understanding user satisfaction with intelligent assistants, in: Proceedings of the 2016 ACM on Conference on Human Information Interaction and Retrieval. ACM, pp. 121–130.
- Klopfenstein, L.C., Delpriori, S., Malatini, S., Bogliolo, A., 2017. The Rise of Bots: A Survey of Conversational Interfaces, Patterns, and Paradigms, in: Proceedings of the 2017 Conference on Designing Interactive Systems, DIS '17. ACM, New York, NY, USA, pp. 555–565. <https://doi.org/10.1145/3064663.3064672>
- Kocielnik, R., Xiao, L., Avrahami, D., Hsieh, G., 2018. Reflection companion: a conversational system for engaging users in reflection on physical activity. *Proc. ACM Interact. Mob. Wearable Ubiquitous Technol.* 2, 1–26.
- Koehler, J., 2018. Business Process Innovation with Artificial Intelligence: Levering Benefits and Controlling Operational Risks. *Eur. Bus. Manag.* 4, 55–66.
- Kokku, R., Sundararajan, S., Dey, P., Sindhgatta, R., Nitta, S., Sengupta, B., 2018. Augmenting Classrooms with AI for Personalized Education, in: 2018 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP). IEEE, pp. 6976–6980.
- Korhonen, H., Arrasvuori, J., Väänänen-Vainio-Mattila, K., 2010. Analysing user experience of personal mobile products through contextual factors, in: Proceedings of the 9th International Conference on Mobile and Ubiquitous Multimedia. ACM, p. 11.
- Krippendorff, K., 2007. Computing Krippendorff's alpha reliability. *Dep. Pap. ASC* 43.
- Krumm, J., 2016. Ubiquitous computing fundamentals. Chapman and Hall/CRC.
- Kubey, R.W., Csikszentmihalyi, M., 1990. Television as escape: Subjective experience before an evening of heavy viewing. *Commun. Rep.* 3, 92–100.
- Kulesza, T., Burnett, M., Wong, W.-K., Stumpf, S., 2015. Principles of explanatory debugging to personalize interactive machine learning, in: Proceedings of the 20th International Conference on Intelligent User Interfaces. ACM, pp. 126–137.
- Larson, R.W., Richards, M.H., Perry-Jenkins, M., 1994. Divergent worlds: the daily emotional experience of mothers and fathers in the domestic and public spheres. *J. Pers. Soc. Psychol.* 67, 1034.

- Laurel, B., 1997. Interface agents: Metaphors with character. *Hum. Values Des. Comput. Technol.* 207–219.
- Layous, K., Lyubomirsky, S., 2013. The how, why, what, when, and who of happiness.
- Lee, K., 2009. Homo faber: the unity of the history and philosophy of technology, in: *New Waves in Philosophy of Technology*. Springer, pp. 13–39.
- Lee, Y.-K., Chang, C.-T., Lin, Y., Cheng, Z.-H., 2014. The dark side of smartphone usage: Psychological traits, compulsive behavior and technostress. *Comput. Hum. Behav.* 31, 373–383.
- Lehman, J.F., Leite, I., 2016. Turn-taking, children, and the unpredictability of fun. *AI Mag.* 37, 55–62.
- Li, I., Dey, A., Forlizzi, J., Höök, K., Medynskiy, Y., 2011. Personal informatics and HCI: design, theory, and social implications, in: *CHI'11 Extended Abstracts on Human Factors in Computing Systems*. pp. 2417–2420.
- Li, I., Medynskiy, Y., Froehlich, J., Larsen, J., 2012. Personal informatics in practice: improving quality of life through data, in: *CHI'12 Extended Abstracts on Human Factors in Computing Systems*. pp. 2799–2802.
- Liu, S., 2019. Number of Google Assistant actions/apps U.S. 2019 [WWW Document]. Statista. URL <https://www.statista.com/statistics/972935/united-states-google-assistant-actions-total/> (accessed 4.7.20).
- Lomas, J.D., Koedinger, K., Patel, N., Shodhan, S., Poonwala, N., Forlizzi, J.L., 2017. Is difficulty overrated?: The effects of choice, novelty and suspense on intrinsic motivation in educational games, in: *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*. ACM, pp. 1028–1039.
- Lopatovska, I., Williams, H., 2018. Personification of the Amazon Alexa: BFF or a mindless companion, in: *Proceedings of the 2018 Conference on Human Information Interaction & Retrieval*. pp. 265–268.
- Lovato, S., Piper, A.M., 2015. Siri, is this you?: Understanding young children's interactions with voice input systems, in: *Proceedings of the 14th International Conference on Interaction Design and Children*. ACM, pp. 335–338.
- Lucas, G.M., Gratch, J., King, A., Morency, L.-P., 2014. It's only a computer: Virtual humans increase willingness to disclose. *Comput. Hum. Behav.* 37, 94–100.
- Lucas, G.M., Krämer, N., Peters, C., Taesch, L.-S., Mell, J., Gratch, J., 2018. Effects of Perceived Agency and Message Tone in Responding to a Virtual Personal Trainer, in: *Proceedings of the 18th International Conference on Intelligent Virtual Agents*. pp. 247–254.
- Luger, E., Sellen, A., 2016. Like having a really bad PA: the gulf between user expectation and experience of conversational agents, in: *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*. ACM, pp. 5286–5297.

- Lupton, D., 2016. *The quantified self*. John Wiley & Sons.
- Lyubomirsky, S., 2014. Subjective Happiness Scale (SHS). *Posit. Psychol. Quest.*
- Lyubomirsky, S., 2011. Hedonic adaptation to positive and negative experiences. *Oxf. Handb. Stress Health Coping* 200–224.
- Lyubomirsky, S., 2007. *The How of Happiness: A New Approach to Getting the Life You Want*. Penguin Books, New York, NY, USA.
- Lyubomirsky, S., King, L., Diener, E., 2005a. The benefits of frequent positive affect: does happiness lead to success? *Psychol. Bull.* 131, 803.
- Lyubomirsky, S., Layous, K., 2013. How do simple positive activities increase well-being? *Curr. Dir. Psychol. Sci.* 22, 57–62.
- Lyubomirsky, S., Sheldon, K.M., Schkade, D., 2005b. Pursuing happiness: the architecture of sustainable change. *Rev. Gen. Psychol.* 9, 111.
- Mahlke, S., Thüring, M., 2007. Studying antecedents of emotional experiences in interactive contexts, in: *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. ACM, pp. 915–918.
- Malinowski, B., 1994. The problem of meaning in primitive languages. *Lang. Lit. Soc. Pract. Read.* 1–10.
- Malone, T.W., Lai, K.-Y., Fry, C., 1995. Experiments with Oval: a radically tailorable tool for cooperative work. *ACM Trans. Inf. Syst. TOIS* 13, 177–205.
- Martela, F., Sheldon, K.M., 2019. Clarifying the Concept of Well-Being: Psychological Need Satisfaction as the Common Core Connecting Eudaimonic and Subjective Well-Being. *Rev. Gen. Psychol.* 23, 458–474.
- Mashhadi, A., Mathur, A., Kawsar, F., 2014. The myth of subtle notifications, in: *Proceedings of the 2014 ACM International Joint Conference on Pervasive and Ubiquitous Computing*: Adjunct Publication. pp. 111–114.
- Maslow, A.H., 1971. *Self-actualization*. Big Sur Recordings.
- McCarthy, J., Wright, P., 2004. Technology as experience. *interactions* 11, 42–43.
- McCullough, M.E., 2000. Forgiveness as human strength: Theory, measurement, and links to well-being. *J. Soc. Clin. Psychol.* 19, 43–55.
- McGregor, I., Little, B.R., 1998. Personal projects, happiness, and meaning: on doing well and being yourself. *J. Pers. Soc. Psychol.* 74, 494.
- McReynolds, E., Hubbard, S., Lau, T., Saraf, A., Cakmak, M., Roesner, F., 2017. Toys that listen: A study of parents, children, and internet-connected toys, in: *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*. pp. 5197–5207.

- Mekler, E.D., Hornbæk, K., 2016. Momentary Pleasure or Lasting Meaning?: Distinguishing Eudaimonic and Hedonic User Experiences, in: Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems, CHI '16. ACM, New York, NY, USA, pp. 4509–4520. <https://doi.org/10.1145/2858036.2858225>
- Microsoft, 2019. Principles of bot design. URL <https://docs.microsoft.com/en-us/azure/bot-service/bot-service-design-principles> (accessed 12.4.19).
- Mirsch, T., Lehrer, C., Jung, R., 2018. Making digital nudging applicable: the digital nudge design method, in: Proceedings of the 39th International Conference on Information Systems (ICIS). Association for Information Systems. AIS Electronic Library (AISeL).
- Moar, J., 2019. The Digital Assistants of Tomorrow [WWW Document]. URL <https://www.juniperresearch.com/document-library/white-papers/the-digital-assistants-of-tomorrow> (accessed 2.25.20).
- Moore, R.J., Arar, R., Ren, G.-J., Szymanski, M.H., 2017. Conversational UX Design, in: Proceedings of the 2016 CHI Conference Extended Abstracts on Human Factors in Computing Systems, CHI EA '17. ACM, New York, NY, USA, pp. 492–497. <https://doi.org/10.1145/3027063.3027077>
- Müller, H., Sedley, A., 2014. HaTS: large-scale in-product measurement of user attitudes & experiences with happiness tracking surveys, in: Proceedings of the 26th Australian Computer-Human Interaction Conference on Designing Futures: The Future of Design. ACM, pp. 308–315.
- Müller, L.J., Mekler, E.D., Opwis, K., 2015. Facets In HCI: Towards Understanding Eudaimonic UX–Preliminary Findings, in: Proceedings of the 33rd Annual ACM Conference Extended Abstracts on Human Factors in Computing Systems. ACM, pp. 2283–2288.
- Myers, C., Furqan, A., Nebolsky, J., Caro, K., Zhu, J., 2018. Patterns for how users overcome obstacles in voice user interfaces, in: Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems. ACM, p. 6.
- Nafus, D., Sherman, J., 2014. Big data, big questions| this one does not go up to 11: the quantified self movement as an alternative big data practice. *Int. J. Commun.* 8, 11.
- Nakamura, J., Csikszentmihalyi, M., 2014. The concept of flow, in: *Flow and the Foundations of Positive Psychology*. Springer, pp. 239–263.
- Nathan, T.M., Csillag, M.P., Rubin, R., Lin, K., Turchi, M.A., Madsen, S., Shuster, K.L., Meeks, B., 2018. Distraction prevention system for mobile devices.
- Nguyen, Q.N., Sidorova, A., 2017. AI capabilities and user experiences: a comparative study of user reviews for assistant and non-assistant mobile apps.
- Niedderer, K., Ludden, G., Clune, S., Lockton, D., Mackrill, J., Morris, A., Cain, R., Gardiner, E., Evans, M., Gutteridge, R., others, 2016. Design for behaviour change as a driver for

sustainable innovation: Challenges and opportunities for implementation in the private and public sectors. *Int. J. Des.* 10, 67–85.

- Nielsen, J., 1995. 10 usability heuristics for user interface design. Nielsen Norman Group 1.
- Nielsen, J., 1994a. 10 Heuristics for User Interface Design: Article by Jakob Nielsen [WWW Document]. Nielsen Norman Group. URL <https://www.nngroup.com/articles/ten-usability-heuristics/> (accessed 10.24.19).
- Nielsen, J., 1994b. Usability engineering. Elsevier.
- Nikitina, S., Callaioli, S., Baez, M., 2018. Smart conversational agents for reminiscence, in: 2018 IEEE/ACM 1st International Workshop on Software Engineering for Cognitive Services (SE4COG). IEEE, pp. 52–57.
- Nix, G.A., Ryan, R.M., Manly, J.B., Deci, E.L., 1999. Revitalization through self-regulation: The effects of autonomous and controlled motivation on happiness and vitality. *J. Exp. Soc. Psychol.* 35, 266–284.
- Norman, D.A., 2005. Emotional design: Why we love (or hate) everyday things. Basic books.
- Norman, D.A., 1994. How might people interact with agents. *Commun. ACM* 37, 68–71.
- Oosterlaken, E.T., 2013. Taking a capability approach to technology and its design: A philosophical exploration. TU Delft, Delft University of Technology.
- Organization, W.H., 1946. Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity, in: International Health Conference, New York. pp. 19–22.
- Ortiz Nicolas, J.C., 2013. Understanding and designing pleasant experiences with products. Imperial College London.
- Ortíz Nicolás, J.C., Aurisicchio, M., 2011. The scenario of user experience, in: DS 68-7: Proceedings of the 18th International Conference on Engineering Design (ICED 11), Impacting Society through Engineering Design, Vol. 7: Human Behaviour in Design, Lyngby/Copenhagen, Denmark, 15.-19.08. 2011.
- Ortiz Nicolas, J.C., Aurisicchio, M., Desmet, P.M.A., 2013. Differentiating positive emotions by products: An exploration of perceived differences between 25 positive emotions by designers and product users. The Design Society.
- Park, Sanguk, Lee, S., Park, Sangmin, Park, Sehyun, 2019. AI-based physical and virtual platform with 5-layered architecture for sustainable smart energy city development. *Sustainability* 11, 4479.
- Parks, A.C., Biswas-Diener, R., 2013. Positive interventions: Past, present and future. *Mindfulness Accept. Posit. Psychol. Seven Found. Well-Being* 140–165.

- Parks, A.C., Schueller, S.M., Tasimi, A., 2013. Increasing happiness in the general population: empirically supported self-help. *Appaer Oxf. Handb. Happiness*.
- Partala, T., Kallinen, A., 2012. Understanding the most satisfying and unsatisfying user experiences: Emotions, psychological needs, and context. *Interact. Comput.* 24, 25–34.
- Pavot, W., Diener, E.D., Colvin, C.R., Sandvik, E., 1991. Further validation of the satisfaction with life scale: Evidence for the cross-method convergence of well-being measures. *J. Pers. Assess.* 57, 149–161.
- Payr, S., 2013. *Virtual Butlers and Real People: Styles and Practices in Long-Term Use of a Companion*. Springer.
- Peng, W., Lin, J.-H., Pfeiffer, K.A., Winn, B., 2012. Need Satisfaction Supportive Game Features as Motivational Determinants: An Experimental Study of a Self-Determination Theory Guided Exergame. *Media Psychol.* 15, 175–196. <https://doi.org/10.1080/15213269.2012.673850>
- Pennebaker, J.W., Seagal, J.D., 1999. Forming a story: The health benefits of narrative. *J. Clin. Psychol.* 55, 1243–1254.
- Peters, D., Calvo, R.A., Ryan, R.M., 2018. Designing for Motivation, Engagement and Wellbeing in Digital Experience. *Front. Psychol.* 9. <https://doi.org/10.3389/fpsyg.2018.00797>
- Peterson, C., 2000. The future of optimism. *Am. Psychol.* 55, 44.
- Peterson, C., Seligman, M.E., 2004. *Character strengths and virtues: A handbook and classification*. Oxford University Press.
- Picard, R.W., 2003. Affective computing: challenges. *Int. J. Hum.-Comput. Stud.* 59, 55–64.
- Pina, L.R., Sien, S.-W., Ward, T., Yip, J.C., Munson, S.A., Fogarty, J., Kientz, J.A., 2017. From Personal Informatics to Family Informatics: Understanding Family Practices Around Health Monitoring, in: *Proceedings of the 2017 ACM Conference on Computer Supported Cooperative Work and Social Computing, CSCW '17*. ACM, New York, NY, USA, pp. 2300–2315. <https://doi.org/10.1145/2998181.2998362>
- Pinelle, D., Wong, N., Stach, T., 2008. Heuristic Evaluation for Games: Usability Principles for Video Game Design, in: *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, CHI '08*. ACM, New York, NY, USA, pp. 1453–1462. <https://doi.org/10.1145/1357054.1357282>
- Pohlmeier, A.E., 2014. Enjoying joy: a process-based approach to design for prolonged pleasure, in: *Proceedings of the 8th Nordic Conference on Human-Computer Interaction: Fun, Fast, Foundational*. ACM, pp. 871–876.
- Pohlmeier, A.E., 2013. Positive Design: New Challenges, Opportunities, and Responsibilities for Design, in: *Design, User Experience, and Usability. User Experience in Novel Technological Environments*. Springer, pp. 540–547.

- Pohlmeyer, A.E., 2012. Design for happiness. *Interfaces* 92, 8–11.
- Porcheron, M., Fischer, J.E., McGregor, M., Brown, B., Luger, E., Candello, H., O'Hara, K., 2017. Talking with Conversational Agents in Collaborative Action, in: *Companion of the 2017 ACM Conference on Computer Supported Cooperative Work and Social Computing, CSCW '17 Companion*. ACM, New York, NY, USA, pp. 431–436. <https://doi.org/10.1145/3022198.3022666>
- Porcheron, M., Fischer, J.E., Reeves, S., Sharples, S., 2018. Voice Interfaces in Everyday Life, in: *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*. ACM, p. 640.
- Poslad, S., 2011. *Ubiquitous computing: smart devices, environments and interactions*. John Wiley & Sons.
- Pradhan, A., Mehta, K., Findlater, L., 2018. Accessibility Came by Accident: Use of Voice-Controlled Intelligent Personal Assistants by People with Disabilities, in: *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*. ACM, p. 459.
- Provoost, S., Lau, H.M., Ruwaard, J., Riper, H., 2017. Embodied conversational agents in clinical psychology: A scoping review. *J. Med. Internet Res.* 19.
- Przybylski, A.K., Rigby, C.S., Ryan, R.M., 2010. A motivational model of video game engagement. *Rev. Gen. Psychol.* 14, 154–166. <https://doi.org/10.1037/a0019440>
- Purington, A., Taft, J.G., Sannon, S., Bazarova, N.N., Taylor, S.H., 2017. Alexa is my new BFF: Social Roles, User Satisfaction, and Personification of the Amazon Echo, in: *Proceedings of the 2017 CHI Conference Extended Abstracts on Human Factors in Computing Systems*. ACM, pp. 2853–2859.
- Rader, E., Cotter, K., Cho, J., 2018. Explanations as mechanisms for supporting algorithmic transparency, in: *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*. ACM, p. 103.
- Ragu-Nathan, T.S., Tarafdar, M., Ragu-Nathan, B.S., Tu, Q., 2008. The consequences of technostress for end users in organizations: Conceptual development and empirical validation. *Inf. Syst. Res.* 19, 417–433.
- Ram, A., Prasad, R., Khatri, C., Venkatesh, A., Gabriel, R., Liu, Q., Nunn, J., Hedayatnia, B., Cheng, M., Nagar, A., 2018. Conversational ai: The science behind the alexa prize. *ArXiv Prepr. ArXiv180103604*.
- Rammohan, R., Dhanabalsamy, N., Dimov, V., Eidelman, F.J., 2017. Smartphone Conversational Agents (Apple Siri, Google, Windows Cortana) and Questions about Allergy and Asthma Emergencies. *J. Allergy Clin. Immunol.* 139, AB250.
- Ransbotham, S., Gerbert, P., Reeves, M., Kiron, D., Spira, M., 2018. Artificial intelligence in business gets real. *MIT Sloan Manag. Rev.* 60280.

- Reddy, S., 2018a. Conversational Artificial Intelligence -- The Final Phase Of The Information Revolution [WWW Document]. Hidden Insights. URL <https://blogs.sas.com/content/hiddeninsights/2019/05/03/hidden-insights-samuel-blanquet/> (accessed 1.13.20).
- Reddy, S., 2018b. Council Post: Conversational Artificial Intelligence -- The Final Phase Of The Information Revolution [WWW Document]. URL <https://www.forbes.com/sites/forbestechcouncil/2018/08/17/conversational-artificial-intelligence-the-final-phase-of-the-information-revolution/#2a98cbd37de8> (accessed 1.13.20).
- Reeves, S., Porcheron, M., Fischer, J.E., Candello, H., McMillan, D., McGregor, M., Moore, R.J., Sikveland, R., Taylor, A.S., Velkovska, J., 2018. Voice-based Conversational UX Studies and Design, in: Extended Abstracts of the 2018 CHI Conference on Human Factors in Computing Systems. ACM, p. W38.
- Reis, A., Paulino, D., Paredes, H., Barroso, J., 2017. Using intelligent personal assistants to strengthen the elderlies' social bonds, in: International Conference on Universal Access in Human-Computer Interaction. Springer, pp. 593–602.
- Responsible AI principles from Microsoft [WWW Document], 2020. . Microsoft. URL <https://www.microsoft.com/en-us/ai/responsible-ai> (accessed 3.12.20).
- Ribeiro, M.T., Singh, S., Guestrin, C., 2016. “ Why should i trust you?” Explaining the predictions of any classifier, in: Proceedings of the 22nd ACM SIGKDD International Conference on Knowledge Discovery and Data Mining. pp. 1135–1144.
- Rigby, S., Ryan, R.M., 2011. Glued to games: How video games draw us in and hold us spellbound: How video games draw us in and hold us spellbound. AbC-CLIo.
- Ritchie, H., Roser, M., 2018. Mental Health. Our World Data.
- Rogers, Y., 2009. The changing face of human-computer interaction in the age of ubiquitous computing, in: Symposium of the Austrian HCI and Usability Engineering Group. Springer, pp. 1–19.
- Roozenburg, N.F., Eekels, J., 1995. Product design: fundamentals and methods. John Wiley & Sons Inc.
- Ruitenbergh, H.P., 2010. Design for subjective well-being. TU Delft, Delft University of Technology.
- Ryan, R.M., Deci, E.L., 2017. Self-determination theory: Basic psychological needs in motivation, development, and wellness. Guilford Publications.
- Ryan, R.M., Deci, E.L., 2001. On happiness and human potentials: a review of research on hedonic and eudaimonic well-being. *Annu. Rev. Psychol.* 52, 141–166. <https://doi.org/10.1146/annurev.psych.52.1.141>

- Ryan, R.M., Deci, E.L., 2000. Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *Am. Psychol.* 55, 68.
- Ryan, R.M., Rigby, C.S., Przybylski, A., 2006. The Motivational Pull of Video Games: A Self-Determination Theory Approach. *Motiv. Emot.* 30, 344–360. <https://doi.org/10.1007/s11031-006-9051-8>
- Ryff, C.D., Keyes, C.L.M., 1995. The structure of psychological well-being revisited. *J. Pers. Soc. Psychol.* 69, 719.
- Ryff, C.D., Singer, B., 1998. The contours of positive human health. *Psychol. Inq.* 9, 1–28.
- Sabelli, A.M., Kanda, T., Hagita, N., 2011. A conversational robot in an elderly care center: an ethnographic study, in: 2011 6th ACM/IEEE International Conference on Human-Robot Interaction (HRI). IEEE, pp. 37–44.
- Sahami Shirazi, A., Henze, N., Dingler, T., Pielot, M., Weber, D., Schmidt, A., 2014. Large-scale assessment of mobile notifications, in: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems. pp. 3055–3064.
- Salber, D., Dey, A.K., Abowd, G.D., 1998. Ubiquitous computing: Defining an hci research agenda for an emerging interaction paradigm. Georgia Institute of Technology.
- Salovey, P., Rothman, A.J., Detweiler, J.B., Steward, W.T., 2000. Emotional states and physical health. *Am. Psychol.* 55, 110.
- Sarwar, M., Soomro, T.R., 2013. Impact of smartphone's on society. *Eur. J. Sci. Res.* 98, 216–226.
- Schneider, K.P., 1988. Small talk: Analyzing phatic discourse. Hitzeroth.
- Sciuto, A., Saini, A., Forlizzi, J., Hong, J.I., 2018. “Hey Alexa, What’s Up?” A Mixed-Methods Studies of In-Home Conversational Agent Usage, in: Proceedings of the 2018 Designing Interactive Systems Conference. pp. 857–868.
- Scott, B., Neil, T., 2009. Designing web interfaces: Principles and patterns for rich interactions. O'Reilly Media, Inc.
- Scott Jr, W.E., 1966. Activation theory and task design. *Organ. Behav. Hum. Perform.* 1, 3–30.
- Sebastian, J., Richards, D., 2017. Changing stigmatizing attitudes to mental health via education and contact with embodied conversational agents. *Comput. Hum. Behav.* 73, 479–488.
- Seligman, M., 2018. PERMA and the building blocks of well-being. *J. Posit. Psychol.* 13, 333–335.
- Seligman, M., 2011. Flourish: A visionary new understanding of happiness and well-being.
- Seligman, M.E., 2006. Learned optimism: How to change your mind and your life. Vintage.

- Seligman, M.E., Csikszentmihalyi, M., 2000. Positive psychology. An introduction. *Am. Psychol.* 55, 5–14.
- Seligman, M.E., Rashid, T., Parks, A.C., 2006. Positive psychotherapy. *Am. Psychol.* 61, 774.
- Seligman, M.E., Steen, T.A., Park, N., Peterson, C., 2005. Positive psychology progress: empirical validation of interventions. *Am. Psychol.* 60, 410.
- Shamekhi, A., Bickmore, T., 2015. Breathe with me: a virtual meditation coach, in: *International Conference on Intelligent Virtual Agents*. Springer, pp. 279–282.
- Sheldon, K.M., 2018. Understanding the good life: Eudaimonic living involves well-doing, not well-being, in: *The Social Psychology of Living Well*. Routledge, pp. 116–136.
- Sheldon, K.M., Abad, N., Ferguson, Y., Gunz, A., Houser-Marko, L., Nichols, C.P., Lyubomirsky, S., 2010. Persistent pursuit of need-satisfying goals leads to increased happiness: A 6-month experimental longitudinal study. *Motiv. Emot.* 34, 39–48.
- Sheldon, K.M., Abad, N., Hinsch, C., 2011. A two-process view of Facebook use and relatedness need-satisfaction: Disconnection drives use, and connection rewards it. *J. Pers. Soc. Psychol.* 100, 766.
- Sheldon, K.M., Boehm, J.K., Lyubomirsky, S., 2012. Variety is the spice of happiness: The hedonic adaptation prevention (HAP) model. *Oxf. Handb. Happiness* 901–914.
- Sheldon, K.M., Elliot, A.J., Kim, Y., Kasser, T., 2001. What is satisfying about satisfying events? Testing 10 candidate psychological needs. *J. Pers. Soc. Psychol.* 80, 325.
- Sheldon, K.M., Lyubomirsky, S., 2019. Revisiting the Sustainable Happiness Model and Pie Chart: Can Happiness Be Successfully Pursued? *J. Posit. Psychol.* 1–10.
- Sheldon, K.M., Lyubomirsky, S., 2012. The challenge of staying happier testing the hedonic adaptation prevention model. *Pers. Soc. Psychol. Bull.* 38, 670–680.
- Sheldon, K.M., Lyubomirsky, S., 2006. How to increase and sustain positive emotion: The effects of expressing gratitude and visualizing best possible selves. *J. Posit. Psychol.* 1, 73–82.
- Sheldon, K.M., Lyubomirsky, S., 2004. Achieving sustainable new happiness: Prospects, practices, and prescriptions. *Posit. Psychol. Pract.* 127–145.
- Sheth, A., Jaimini, U., Thirunarayan, K., Banerjee, T., 2017. Augmented personalized health: how smart data with IoTs and AI is about to change healthcare, in: *2017 IEEE 3rd International Forum on Research and Technologies for Society and Industry (RTSI)*. IEEE, pp. 1–6.
- Tao, J., Tan, T., 2005. Affective computing: A review, in: *International Conference on Affective Computing and Intelligent Interaction*. Springer, pp. 981–995.

- Tarafdar, M., Beath, C.M., Ross, J.W., 2019. Using AI to Enhance Business Operations. *MIT Sloan Manag. Rev.* 60, 37–44.
- Thaler, R.H., Sunstein, C.R., 2009. *Nudge: Improving decisions about health, wealth, and happiness*. Penguin.
- Thangaraj, C., 2019. Utilizing Transportation Infrastructure, Big Data and AI for Localized EV Energy Neutrality, in: 2019 International Energy and Sustainability Conference (IESC). IEEE, pp. 1–4.
- Tuch, A.N., Trusell, R., Hornbæk, K., 2013. Analyzing users' narratives to understand experience with interactive products, in: *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. ACM, pp. 2079–2088.
- Upton, N., Yates, I., 2001. Putting design research to work. *WDK Publ.* 51–58.
- Van Boven, L., Gilovich, T., 2003. To Do or to Have? That Is the Question. *J. Pers. Soc. Psychol.* 85, 1193–1202. <https://doi.org/10.1037/0022-3514.85.6.1193>
- Vandenbergh, B., 2017. Bot Personas as Off-The-Shelf Users, in: *Proceedings of the 2017 CHI Conference Extended Abstracts on Human Factors in Computing Systems*. ACM, pp. 782–789.
- Veenhoven, R., 2011. Greater Happiness for a Greater Number: Is that possible? If so, how?, in: Sheldon, K.M., Kashdan, T.B., Steger, M.F. (Eds.), *Designing Positive Psychology*. Oxford Press, Oxford, UK, pp. 392–409.
- Verbeek, P.-P., 2005. *What things do: Philosophical reflections on technology, agency, and design*. Penn State Press.
- Vertegaal, R., Slagter, R., Van der Veer, G., Nijholt, A., 2001. Eye gaze patterns in conversations: there is more to conversational agents than meets the eyes, in: *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. ACM, pp. 301–308.
- Vtyurina, A., Savenkov, D., Agichtein, E., Clarke, C.L., 2017. Exploring Conversational Search With Humans, Assistants, and Wizards, in: *Proceedings of the 2017 CHI Conference Extended Abstracts on Human Factors in Computing Systems*. ACM, pp. 2187–2193.
- Wagner, H.S., Ahlstrom, B., Redden, J.P., Vickers, Z., Mann, T., 2014. The myth of comfort food. *Health Psychol.* 33, 1552.
- Waterman, A.S., 1993. Two conceptions of happiness: Contrasts of personal expressiveness (eudaimonia) and hedonic enjoyment. *J. Pers. Soc. Psychol.* 64, 678.
- Waterman, A.S., Schwartz, S.J., Conti, R., 2008. The implications of two conceptions of happiness (hedonic enjoyment and eudaimonia) for the understanding of intrinsic motivation. *J. Happiness Stud.* 9, 41–79.
- Watson, D., Clark, L.A., Tellegen, A., 1988. Development and validation of brief measures of positive and negative affect: the PANAS scales. *J. Pers. Soc. Psychol.* 54, 1063.

- Weld, D.S., Bansal, G., 2018. Intelligible artificial intelligence. ArXiv E-Prints March 2018.
- Westermann, T., Möller, S., Wechsung, I., 2015. Assessing the relationship between technical affinity, stress and notifications on smartphones, in: Proceedings of the 17th International Conference on Human-Computer Interaction with Mobile Devices and Services Adjunct. pp. 652–659.
- White, R.W., 1959. Motivation reconsidered: The concept of competence. *Psychol. Rev.* 66, 297.
- Wijayaratna, K.P., Cunningham, M.L., Regan, M.A., Jian, S., Chand, S., Dixit, V.V., 2019. Mobile phone conversation distraction: Understanding differences in impact between simulator and naturalistic driving studies. *Accid. Anal. Prev.* 129, 108–118.
- Winkler, R., Söllner, M., Neuweiler, M.L., Conti Rossini, F., Leimeister, J.M., 2019. Alexa, Can You Help Us Solve This Problem?: How Conversations With Smart Personal Assistant Tutors Increase Task Group Outcomes, in: Extended Abstracts of the 2019 CHI Conference on Human Factors in Computing Systems - CHI '19. Presented at the Extended Abstracts of the 2019 CHI Conference, ACM Press, Glasgow, Scotland Uk, pp. 1–6. <https://doi.org/10.1145/3290607.3313090>
- Winner, E., 2000. The origins and ends of giftedness. *Am. Psychol.* 55, 159.
- Wolters, M.K., Kelly, F., Kilgour, J., 2016. Designing a spoken dialogue interface to an intelligent cognitive assistant for people with dementia. *Health Informatics J.* 22, 854–866.
- Woolsey, L.K., 1986. The critical incident technique: An innovative qualitative method of research. *Can. J. Couns.*
- World Health Organisation, W.H., 2017. Depression and other common mental disorders: global health estimates. World Health Organization.
- Worthington, E.L., Witvliet, C.V.O., Pietrini, P., Miller, A.J., 2007. Forgiveness, health, and well-being: A review of evidence for emotional versus decisional forgiveness, dispositional forgivingness, and reduced unforgiveness. *J. Behav. Med.* 30, 291–302.
- Xiao, Z., Zhou, M.X., Fu, W.-T., 2019. Who should be my teammates: Using a conversational agent to understand individuals and help teaming, in: Proceedings of the 24th International Conference on Intelligent User Interfaces. pp. 437–447.
- Yanco, H.A., Drury, J.L., Scholtz, J., 2004. Beyond Usability Evaluation: Analysis of Human-robot Interaction at a Major Robotics Competition. *Hum-Comput Interact* 19, 117–149. https://doi.org/10.1207/s15327051hci1901&2_6
- Yang, X., Aurisicchio, M., Baxter, W., 2019. Understanding Affective Experiences with Conversational Agents, in: Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems - CHI '19. Presented at the the 2019 CHI Conference, ACM Press, Glasgow, Scotland Uk, pp. 1–12. <https://doi.org/10.1145/3290605.3300772>

- Yang, X., Aurisicchio, M., Mackrill, J., Baxter, W., 2017. On the products and experiences that make us happy, in: DS 87-8 Proceedings of the 21st International Conference on Engineering Design (ICED 17) Vol 8: Human Behaviour in Design, Vancouver, Canada, 21-25.08. 2017. pp. 499–508.
- Yaqoob, I., Khan, L.U., Kazmi, S.A., Imran, M., Guizani, N., Hong, C.S., 2019. Autonomous Driving Cars in Smart Cities: Recent Advances, Requirements, and Challenges. *IEEE Netw.*
- Yoon, J., Desmet, P.M., van der Helm, A., 2012. Design for interest: Exploratory study on a distinct positive emotion in human-product interaction. *Int. J. Des.* 6.
- Yu, K.-H., Beam, A.L., Kohane, I.S., 2018. Artificial intelligence in healthcare. *Nat. Biomed. Eng.* 2, 719–731.
- Zaidan, A.A., Zaidan, B.B., 2020. A review on intelligent process for smart home applications based on IoT: coherent taxonomy, motivation, open challenges, and recommendations. *Artif. Intell. Rev.* 53, 141–165.
- Zamora, J., 2017. Rise of the Chatbots: Finding A Place for Artificial Intelligence in India and US, in: Proceedings of the 22Nd International Conference on Intelligent User Interfaces Companion, IUI '17 Companion. ACM, New York, NY, USA, pp. 109–112. <https://doi.org/10.1145/3030024.3040201>