



An empirical investigation of the influence of persona with personality traits on conceptual design



Farshid Anvari^{a,*}, Deborah Richards^a, Michael Hitchens^a, Muhammad Ali Babar^c,
Hien Minh Thi Tran^b, Peter Busch^a

^a Department of Computing, Macquarie University, Sydney, Australia

^b Office of Financial Services, Macquarie University, Sydney, Australia

^c CREST – The Centre for Research on Engineering Software Technologies, University of Adelaide, Australia and, IT University of Copenhagen, Denmark

ARTICLE INFO

Article history:

Received 4 November 2016

Revised 21 July 2017

Accepted 21 September 2017

Available online 22 September 2017

Keywords:

Design features

Conceptual design

Persona

Holistic Persona

Personality traits

User-centered design

Empirical study

ABSTRACT

Persona, an archetypical user, is increasingly becoming a popular tool for Software Engineers to design and communicate with stakeholders. A persona is a representative of a class of end users of a product or service. However, the majority of personas presented in the literature do not take into consideration that the personality of users affects the way they interact with a product or service. This study empirically explores variations in conceptual design based on the personality of a persona. We carried out two studies in Australia and one study in Denmark. We presented four personas with different personalities to 91 participants who collectively completed 218 design artifacts. The results from the studies indicate that the participants' views and prioritization of the needs and system requirements were influenced by the personality traits of the provided personas. For an introverted and emotionally unstable personality, inclusion of confidence building and socializer design features had a higher priority compared with the identified requirements for an extravert and emotionally stable personality. The findings support the proposition that personas with personality traits can aid software engineers to produce conceptual designs tailored to the needs of specific personalities.

© 2017 Elsevier Inc. All rights reserved.

1. Introduction

Products that cannot meet the needs of end users are not only unusable but they affect the economy (Goldberg et al., 2011). Based on three generations of software development at Intel Corporation, Terzakis (2013) reported that the quality of the software increased due to better requirements definition and management even though the second and third generations of software were more complex. Based on the experiences from several industrial projects, Kujala (2008) found that users' involvement during the early parts of projects improves the effectiveness and quality of software products. The close interactions between a system and its users require designers to be more involved in the thinking and emotional lives of a system's users (Miller et al., 2015). In some cases, such as e-health, end users may not be available to software engineers due to the sensitive nature of data about the patients' condition (Anvari and Tran, 2014; Jay et al., 2012) or in the case

of mass-user products there can be wide varieties of end users (Aoyama, 2007; Hjalmarsson et al., 2015).

Given these types of constraints, software development professionals may need to resort to alternative means of determining the needs of users and performing high-level conceptual design. One alternative is the use of personas. A persona, defined as an archetypical user of a product or service, is a tool within the User-Centered Design methodology. The use of personas is gaining significant adoption as a supplement or an alternative to end users' direct involvement in the Systems Development Lifecycle (SDLC), (Gould and Atkin, 2015).

Each persona incorporates a number of scenarios that describe interactions that the persona can have with an application to achieve a goal (Adlin and Pruitt, 2010; Goodwin, 2009). However, persona and scenario methods have known shortcomings (Gudjonsdottir, 2010). Matthews et al. (2012) found that designers do not use personas as they find personas to be abstract, impersonal, misleading and distracting. To make personas more closely resemble end users, Anvari and Tran (2013) proposed Holistic Personas; personas that have five dimensions: Factual, Personality, Intelligence, Knowledge and Cognitive Process. To evaluate the effectiveness of Holistic Personas for determining the needs of users

* Corresponding author.

E-mail addresses: farshid.anvari@acm.org (F. Anvari), deborah.richards@mq.edu.au (D. Richards), michael.hitchens@mq.edu.au (M. Hitchens), ali.babar@adelaide.edu.au (M.A. Babar), hien.tran@mq.edu.au (H.M.T. Tran), peter.busch@mq.edu.au (P. Busch).

and supporting conceptual design, we have designed and conducted a set of empirical studies aimed at determining and understanding whether or not the interactions between designers and personas with personality traits lead to variations in conceptual design due to the personality dimension of the Holistic Personas.

The rest of the paper is structured as follows, after a review of related work we present the research question and methodology, results, discussion and conclusions.

2. Related work

2.1. Creativity and conceptual design

Essential characteristics of creative products include novelty, value and surprising-ness (Nguyen and Shanks, 2009). Surprising-ness is an impact of the unusualness and unexpectedness of a product (Jackson and Messick, 1965). Plucker et al. (2004, p. 156), based on an analysis of articles examining creativity in a number of peer reviewed journals, defined creativity as ‘the interplay between ability and process by which an individual or group produces an outcome or product that is both novel and useful as defined within some social context’. Creativity is not a homogeneous concept and can, for example, be considered to have two types: Historical creativity, H type creativity, where the work is new historically, Personal type creativity, P type creativity, where the work is new for the creator but it has already been produced before (Boden, 2009; Howard et al., 2008).

Some studies of the design process have proposed dividing creative design into separate, synonymously named, phases or segments (Akin and Lin, 1995; Howard et al., 2008): problem understanding, design and retrospection. The design phase itself can be further divided into three sub-segments: conception, development and representation (Akin and Lin, 1995). Based on a literature review, Finger and Dixon (1989a) presented a summary of the canonical design process, which has segments similar to the above processes: recognition of need, specification of requirements, concept formulation, concept selection, embodiment of design details and production, sales, and maintenance. Finger and Dixon (1989a) also presented a prescriptive model of design where the process concentrates on attributes that the designed artifacts should have rather than the processes employed to generate the design. The design process need to have goals and requirements, identifying desired structural and behavioral properties of the design artifact (Ralph and Wand, 2009). Finger and Dixon (1989b) in defining feature-based design affirm that researchers do not agree on a definition of a feature but indicate that it is an abstraction of lower-level design information.

Many researchers agree that the most important and influential phase of design is the conceptual design phase in which the behavior of a system is formed (Christiaans and Almendra, 2010; Norman, 1986). Yu (1997) provided a framework for graphically modeling and analyzing the early phase of the design – ‘the “whys” that underlie system requirements’ (Yu, 1997, p. 226). Maiden et al. (2010) suggested that creative problem solving is part of requirements engineering and tools of creative problem solving (e.g., creative workshops) can be recruited to assist in framing the system requirements. Egbuomwan et al. (1996) defined design as transforming the requirements, which are based on human needs, into performance specifications and converting them into design solutions. Haan (2013) described an approach to teaching ‘Human Centred Creative Technology’ in which students are encouraged to think creatively, focus on users and be mindful that technology is changing rapidly. Haan (2015, p. 1) defined design as: ‘prototyping, feature-driven and an iterative/incremental activity, with a highly flexible and exploratory approach’. In a literature review of product development, Krishnan and Ulrich (2001) have noted that

product attributes, an abstraction of a product, are synonymous with customers’ needs such as customer attributes or customer requirements and product specifications such as engineering characteristics. Griffin and Hauser (1993) examined data from twenty-five US corporations who adopted Quality Function Deployment (QFD), a process that incorporates customers input into product or service development. They found that communication improves when customer needs, i.e., descriptions of the benefits of the product in customer’s words, are linked to engineering, management, and research and development decisions; hence, product design attributes and engineering measures of product performance are in accordance with customers’ needs. A function of QFD is to organize customers’ needs into a hierarchy and the strategic direction for the product or service are set based on the primary needs of customers (Griffin and Hauser, 1993). On the other hand, proposing novel requirements that customers have not previously considered, can lead to innovative products (Robertson, 2002) e.g., the mobile phone, Post it notes, and eBay. Mohanani et al. (2014) used the term desiderata to cover something “wanting, required or desired – mandatory or optional”, and then looked at the effect of presenting these alternatively as requirements or as user stories or case narratives to indicate what might be desirable. In an experiment Mohanani et al. (2014) demonstrated that presentation of system desiderata as ideas resulted in more creative design compared with its presentation as requirements.

In summary a design artifact has ‘attributes’ matching users’ needs. The attributes are synonymously referred to as attributes, needs, features, requirements, and goals. In this paper, we refer to the attributes of an application as design features. As this paper does not elaborate on stages of design, we use the term design synonymously with conceptual design, to refer to the conceptual (initial or high level) design stage.

2.2. Persona and its use in design of application

Software applications or products that are to be used by people have to be designed with the needs of the users in mind. To meet users’ goals, Norman and Draper (1986) proposed User-Centered Design (UCD) methodology. A persona, an archetypical user and fictional character that represents a typical user of a system (Cooper, 2004), is a tool within UCD methodologies. According to Cooper (2004), a persona consists of a name, a picture or illustration and a short narrative. Personas are used to design a software application or product and complement other quantitative and qualitative methods (Cooper, 2004; LeRouge et al., 2013; Pruitt and Grudin, 2003; Rosson and Carroll, 2009). Scenarios are the actions carried out by personas interacting with a system to achieve goals (Goodwin, 2009, p.11).

The use of personas in the design of applications is well established in the software industry (Miaskiewicz and Kozar, 2011). Miaskiewicz and Kozar (2011) surveyed experts and solicited their opinions about usefulness of persona during design activities. They identified and listed a range of benefits in employing personas during design activities. Hjalmarsson et al. (2015) used persona in the UCD of web-based e-services for a bus company. Their analysis of the data showed that the design confirmed the theoretical benefits as listed by Miaskiewicz and Kozar (2011).

Guo et al. (2011) outlined their experience with authoring personas to explore users’ needs and behavior and in using personas in the design and development of e-commerce applications. Nielsen et al. (2015) conducted a survey of the literature and analyzed recommendations from 11 templates for development of personas as well as investigating the development of 47 personas by Danish companies. Nielsen et al. (2015) found that in Danish industries the development and use of personas is increasing through community of practice rather than based

on literature. Madsen et al. (2014), for design of Targeted Professional Development Resources, developed and used personas to inform their design, create a task flow and identify the parts that were inconvenient, confusing or frustrating. Elkina and Pursian (2012) used personas to develop use cases and identify usability requirements for the development of a tool that provides detailed information on user behavior inside e-Learning environments. Goldberg et al. (2011) used personas to resolve challenges in health care requirements elicitation and provided a framework to design e-health information systems. In educational settings, Cleland-Huang et al. (2014) demonstrated the value of Architecturally Savvy Personas to analyze and prioritize architectural requirements in agile development process. Chen et al. (2011) found that designers who designed with a persona produced more empathetic designs compared with designs done without a persona. Acuña et al. (2012) documented the use of persona in Software Engineering research and practices.

There are many techniques for identifying personas. Switzky (2012) developed personas based on use cases. Schneidewind et al. (2012) identified personas from project scope definitions. Elkina and Pursian (2012) authored personas and scenarios from interview and online survey data. Personas are often created based on a systematic and rigorous process of user analysis that leverages well-known marketing research approaches such as surveys, focus group discussions and interviews (Adlin and Pruitt, 2010; Goodwin, 2009). Each persona incorporates a number of scenarios that describe interactions that a persona can have with an application to achieve a goal; personas and scenarios are used within UCD methodologies for software application or product design and communication with stakeholders (Adlin and Pruitt, 2010; Goodwin, 2009). Software Engineers refine personas and scenarios to actors and use cases (Anvari and Tran, 2014; Rosson and Carroll, 2009). To encourage the use of personas for communication with stakeholders, different researchers and practitioners have developed various methods. For example, Guðjónsdóttir and Lindquist (2008) used posters and cardboard cut-outs to acquaint team members with personas. Long (2009) conducted a nine month study during which he tested the concept of persona with students doing industrial design. He found persona to be a useful tool for design and communication and reported that designers showed a higher level of empathy towards personas with photos of real people compared with illustrated personas.

2.3. Criticism of persona

Personas and scenario based approaches have known shortcomings (Anvari, 2016; Gudjonsdottir, 2010). Matthews et al. (2012) found that designers found personas abstract, impersonal, misleading and distracting. Gudjonsdottir (2010) found that personas are mainly used for communication with stakeholders. Chapman and Milham (2006) argued that personas may not be determined using real data but are more likely developed by teams that are in political conflict. Personas can be misinterpreted due to personal and cultural settings (Anvari and Tran, 2013). Nielsen (2012) noted that because personas “have fictitious elements, some find it difficult to see the relationship to real users” (p. 17). As personas are only summaries, some designers consider particular personas to have “missing or inaccurate components” (Nieters et al., 2007). Portigal (2008) criticized personas as being a means for designers to keep a “safe” distance from users and a means to create products for their desired customers rather than their actual users.

Personas should not be seen as a “one size fits all” approach. Instead it should be recognized that potential users of a software product or service will have individual differences (Lopez-Lorca et al., 2014). To address some of the limitations mentioned above and make personas more closely resemble end users,

Anvari and Tran (2013) have proposed Holistic Persona; i.e., where each persona has five dimensions: Factual, Personality, Intelligence, Knowledge and Cognitive Process.

2.4. Personality-based differences in application usage

Personality is one of the most commonly used differentiators of individuals and has been found to affect the way users interact with technology (Svendsen et al., 2013). Svendsen et al. (2013) in a study of the relationship between personality and technology acceptance in a sample of 1004 Norwegians found behavior intent, perceived usefulness and perceived ease of use varied depending on users' personalities. Extraverts and emotionally stable people demonstrate a positive relationship with behavior intent. Open to experience people show a positive relationship with perceived ease of use but do not show any relationship with behavior intent. Landers and Lounsbury (2006) found that those who were introverted and had a lower score on conscientiousness and agreeableness used the Internet more often. Nov et al. (2013) found that extraverted people tend to participate more in a website with a larger audience and emotionally stable people tend to be less influenced by a website's social anchoring. Lane and Manner (2011) in a study of a sample of 312 participants reported that extraverts were more likely to own a smart phone and used it more often for texting messages. In the same study, Lane and Manner (2011) found that agreeable personalities used the smart phone for voice communication. Devaraj et al. (2008) in a study of technology acceptance and personality traits reported that extraverts are more likely to use technology; extraverts are also more likely to act based on the opinions of those whom they consider as significant. A number of researchers have reported that extraverts prefer to use applications on their mobile phone (Butt and Phillips, 2008; Chittaranjan et al., 2011; Oliveira et al., 2013). Correa et al. (2010) conducted a study of personality, gender and social media use based on a sample of 959 adults in the United States (US) and concluded that extraverted personalities, especially young adults, and emotionally unstable and mature men were regular users of social media. Correa et al. (2010) speculated that emotionally unstable people have more time to think over their communication, hence, they prefer online communication. Halko and Kientz (2010) studied personality and persuasive technology among a sample of 240 participants (56% were 30 years old or younger) recruited mainly from the US (53.1%) and India (35.9%). They found that extraverts show negative correlation with persuasive strategies; openness to experience show positive correlation with authoritative strategies; conscientious people showed positive correlation with persuasive strategies. Moore and McElroy (2012) studied the relationship between personality and use of Facebook and regret about postings among a sample of 219 undergraduate students at a Midwestern university in US. They found that extraverts have a wider network of friends; emotionally unstable people spend more time on Facebook; emotionally stable and introverts use Facebook to keep in touch with their friends; emotionally stable, agreeable, conscious and introvert people expressed higher level of regret over inappropriate postings. Loiacono (2014) in sample of 359 participants found that extraverts are more likely and agreeable and neurotic personalities are less likely to disclose personal information on the social networking site.

2.5. Personality and design of an application

Given the potential effect of a user's personality on their use of software, there is a growing body of literature supporting the incorporation of personality into an applications' early (i.e., conceptual) design stages. McRorie et al. (2009) programmed a robot to use eye movements, gestures, and talking speed to

show personality. [Faily and Lyle \(2013\)](#) suggested software tools to author persona and its use during software development. [Svendsen et al. \(2013\)](#) investigated technology acceptance and personality of users. [Anvari and Tran \(2013\)](#) proposed Holistic Persona, with personality being one of the dimensions, to better assist in design work.

Multiple theoretical models of personality exist in the psychology literature. Arguably, the most common model used by researchers interested in computer-based applications is the Big-Five Factors (BFF) of personality. BFF has been used to incorporate personality into software as well as to measure end user personality ([Nov et al., 2013](#); [Oliveira et al., 2013](#)). The five factors of personality are: (1) Extraversion, (2) Agreeableness, (3) Conscientiousness, (4) Emotional Stability and (5) Imagination or Intellect ([Goldberg, 1993](#)). BFF is sometimes alternatively described by the acronym OCEAN defined as Openness, Conscientiousness, Extraversion, Agreeableness and Neuroticism ([Costa and McCrae, 1992](#)) where Openness and Neuroticism correspond to Imagination and Emotionally unstable personality factors, respectively. We have drawn inspiration from the BFF for our study.

3. The research methodology

To understand the role that personality can play in the use of personas, we carried out a set of empirical studies to answer the following main research question:

Does the use of personas, each with a different personality, result in a different conceptual design tailored to each personality?

Our data collection centered around participants being presented with personas with varying personality traits and asked to propose a design to address the personal issues the personas were identified as experiencing.

To analyze the data, we used a sequential mixed method approach. Mixed here refers to qualitative and quantitative approaches being utilized. In the first phase, a qualitative approach was taken to categorize the design concepts and in the second phase quantitative statistical methods were used to verify or falsify the hypothesis ([Cronholm and Hjalmarsson, 2011](#)). Qualitative research is typically used to understand a phenomena ([Walsham, 1993](#)), in this case the role of different personalities in a persona. At the same time qualitative research acknowledges non-replicability as a parameter ([Neuman, 2011](#)), meaning that interpretation of data, such as codes generated for this study using qualitative data analysis approaches inspired from grounded theory research will not necessarily lead to identical codes being produced by another researcher.

There are also a number of mixed method approaches such as Convergent Parallel, Explanatory Sequential and Exploratory Sequential methods ([Creswell, 2013](#)). In the first approach, a researcher more or less concurrently combines qualitative and quantitative data for a comprehensive study ([Creswell, 2013](#); [Teddle and Tashakkori, 2009](#)). The second approach adopts an initial quantitative analysis, then collects and analyses the qualitative data ([Creswell, 2013](#); [Teddle and Tashakkori, 2009](#)). The third method, used in this study, initially undertakes a qualitative analysis to understand the viewpoints of participants, the results of which then inform the following quantitative stage ([Creswell, 2013](#)). Specifically, using an iterative exploratory sequential approach to arrive at an outcome ([Teddle and Tashakkori, 2009](#)), we ‘explore’ the impact of personas, rather than seek to define them. While the legitimacy of mixed methods approaches have been slow to be acknowledged by many research communities, there is at least an understanding that combining qualitative and quantitative means of data interpretation aids in ecological validity, “the

overall strength should be more beneficial than using qualitative or quantitative research individually. One aim of using a mixed method is to increase the possibility to achieve findings that are more trustworthy and relevant than using the approaches separately” ([Cronholm and Hjalmarsson, 2011](#), p. 88).

Immersed within the qualitative and more specifically the interpretive paradigm rests Grounded Theory, a method being increasingly used by software engineers ([Stol et al., 2016](#)), which adopts deep immersion in the subject material, experiences of people, and textual analysis. That is to say the grounded theory is induced from the data rather than preceding data analysis ([Cutcliffe, 2000](#); [Partington, 2000](#)). The interpretive aspects of this research are the design artifacts for personas generated by the researchers which are of their own ‘interpretation’ and may not necessarily be replicated exactly by others ([Neuman, 2011](#)). The extrapolation of the design artifacts are ‘grounded’ within the data – and certainly not predetermined by the researcher(s) beforehand. This is the grounded theory aspect used in this research.

For analyzing and classifying the design artifacts created by the participants, we used thematic analysis. Thematic analysis consists of six phases: familiarization, generation of initial low level design codes, search, review and define high level design codes or design features (themes), and produce a report ([Braun and Clarke, 2006](#); [Crabtree and Miller, 1992](#)). Given that design artifacts are usually unstructured data, thematic analysis is considered a suitable method for analysis and classification of the design data. Thematic analysis requires repeated analysis, recoding and reclassifying the data – a process that is usually supported by an application such as a relational database to add or modify the codes for each data segments, reclassify the codes by changing the relations between the codes and the design features (themes) before producing a report.

3.1. The studies

We conducted three empirical studies involving four personas that were identical except for their personality. Except for a few full-time professionals, most of the participants were students. Out of the 190 participants in the three studies, 99 participants either did not give consent or did not complete the study. Study I was conducted at Macquarie University in the second half of 2013 with undergraduate students enrolled in a second-year Software Engineering unit with an enrolment of 165. Study II was conducted in the first half of 2014 at the same institution with second year undergraduate students enrolled in a Game Design unit with an enrolment of 79. Study III was conducted in the second half of 2014 with postgraduate students studying a Software Architecture unit with an enrolment of 40 offered at the IT University of Copenhagen. The first two studies were conducted at an Australian university. Study III was conducted at a Danish university. In these experiments, we were investigating whether the resultant conceptual design was tailored to the personality of a Holistic Persona; that means we were investigating the existence of a cause-effect relationship ([Easterbrook et al., 2008](#)).

In line with the ethics approval for this research given by the Macquarie University Human Research Ethics Committee, participation was voluntary in all three studies. The students did not receive any course credit for participating in the studies; nor did they receive any financial reward for participation, however, as an incentive they were provided with their spatial ability and personality scores after the study.

3.2. The materials: Holistic Personas with personality

For these studies, the first author authored Holistic Personas that differed in personality but were similar to each other in all

Table 1
Holistic Personas and their personality traits.

Australian Persona	Danish Persona	Extraversion	Emotional Stability	Examples of terms descriptive of personality traits
Doris	Helena	Extravert	Emotionally stable	Outgoing, long term member of clubs and charities, cheerful disposition, has long term goals
Katie	Katerina	Extravert	Emotionally unstable	Outgoing, joins social and volunteer groups for short time only, shows her annoyance when her opinion is opposed.
Minty	Meta	Introvert	Emotionally stable	Mostly spends time in solitude, dependable, has long term friends, does not refuse to assist when asked provided it is convenient
Eliza	Agneta	Introvert	Emotionally unstable	Mostly spends time alone, resents when asked for help but does not refuse even if she has difficulty assisting, has no long term goals, frets to voice her opinion

other dimensions: factual, intelligence, knowledge and cognitive process. Two of the BFF personality traits were varied as shown in Table 1. It was not feasible to conduct a study involving combinations of all five personality traits. We selected Emotional Stability and Extraversion for these studies as they are considered to relate more strongly and more consistently with subjective wellbeing at a personal level (Larsen and Ketelaar, 1989; Luhmann and Eid, 2009; Watson and Clark, 1992). Thus, we anticipated that the participants would be able to distinguish the personality traits of the personas and they would find the combinations plausible and be able to design a software product that could address the persona's wellbeing. See the appendix for an example of an extravert and emotionally unstable Holistic Persona, named Katerina, as used in the Danish study. The same persona was used in the Australian studies, with the name Katie.

All the Holistic Personas used in the three studies had one common significant health issue (overweight) and three common minor issues (i.e., 1: forgetting to take her glasses with her; 2: forgetting to apply sun-screen lotion when she goes out in the sun; and 3: forgetting to mention her allergy to peanuts while ordering her meals).

3.3. The procedure

The procedure in each of the studies was identical, except that in Study I participants only performed a design activity for one of the four personas randomly assigned to them whereas in the second and third studies, students were asked to generate conceptual designs for all four personas, presented in random orders. The personas in the three studies were identical except the familiar Australian names of the personas and places used in Studies I and II, were modified in Study III to provide familiar Danish names and places.

To ensure that all participants had a basic understanding of persona, scenario, UCD and conceptual design, we provided a brief online text-based introduction to UCD methodologies, an example of a persona, a conceptual design and a scenario for educational purposes, with quizzes to test their understanding. After answering the quizzes, the participants were provided with the correct answers. This introduction took approximately 10 min.

The data collected was part of a larger study that consisted of six parts:

- 1) demographics questionnaire,
- 2) self-assessment of the participant's personality traits,
- 3) assessment of the personality of the four Holistic Personas,

- 4) identification of Holistic Persona's requirements and a design activity (for one persona in Study I and four personas in Studies II and III),
- 5) post design questionnaires, and
- 6) spatial ability test.

Study I took on average 50 min, Studies II and III took on average 70 min. Data gathered from parts 1, 2, 3, 5 and 6 have already been published (Anvari and Richards, 2015; Anvari et al., 2015). This paper considers only the data gathered from Parts 1 and 4 to focus on the participants' performance on conceptual designs.

3.4. The design activity

Due to the importance of creativity during conceptual design, in general, and the importance of novelty, value and surprise in creative products, in particular, (Nguyen and Shanks, 2009), we did not stipulate the type of application to be designed. This avoided stifling participants' creativity (Mohanani et al., 2014). The rating and design activity per persona was expected to take approximately 15 min. The studies were conducted on-line using Qualtrics (2015), a web-based tool for building surveys.

Before the design task, the participants were introduced to conceptual design and scenario writing. As part of their design activity, the participants were free to suggest any aspect of design. The participants were asked to write a scenario to demonstrate how the Holistic Persona would use the application. The participants could type their thoughts in a provided text box. As the design time was short, we made no provision for participants to draw a diagram or make other entries such as uploading images.

In the first study, the participants were first presented with all four Holistic Personas in random order and asked to rate the personality of each Holistic Persona. The personality assessment questions were adopted from the Ten-Item Personality Inventory (TIPI) (Gosling et al., 2003). Then they performed one design activity with a randomly assigned Holistic Persona.

To increase the number of designs and allow within-subject comparison of designs, in the two subsequent studies, the participants created a design for each of the four personas, following rating of the persona's personality, presented in random order. In each study, each participant was expected to provide a conceptual design or recommend an application that would help the given persona to overcome her issues and a scenario to demonstrate how the persona would use the designed or recommended application (see Appendix for the task description).

3.5. The process of analyzing and classifying the design ideas

As previously mentioned, we used the thematic analysis approach for analyzing and classifying design ideas (as mentioned in Table 4). Without any pre-conceptions, the first author repeatedly read and analyzed each conceptual design artifact and listed all the phrases that contained design features (Tables 5a and 5b). A design feature comprised both a recommended software application or a product, and the intention for its recommendation. For example, a forum recommended for socialization would have a code different from that of a forum that was recommended for confidence building. Each of the design features was coded and entered into a database (Microsoft Access) along with the intention for its recommendation, producing a list of design features. The list was reviewed by an independent and experienced designer, the fifth author, and randomly crosschecked by the second author. Each design artifact could have numerous design feature codes.

The features that were similar to each other were condensed into higher level features (i.e., categories of features). For example, two design features that are categorized as group applications (an application that connects one participant with other participants) are: (1) a forum as it connects the participant to other participants who use forums (2) a sporting application that allows the participant taking part in a sporting event to check who in the group has completed the sporting activity. The categories were confirmed through discussions between the first, the second and the fifth author, boundary cases were reviewed by the third author.

Following the qualitative part of the sequential mixed method, we hypothesized that differences in conceptual designs would be found according to the different personalities represented in the persona. In the subsequent quantitative part of the sequential mixed method, we used categorical statistics to analyze the classified design ideas and verify or falsify our hypothesis.

4. Results

The results of the participants' ratings of the four Holistic Personas and the personalities of the participants have been reported at two conference "Educational" tracks (Anvari and Richards, 2015; Anvari et al., 2015). Key findings from those papers, that provide background to this paper, are: (1) The evaluation of the personalities of the Holistic Personas was similar to the intended personality of the authored personas (Table 1); (2) The participants rated the Holistic Personas as representative of a real person (Anvari et al., 2015).

Section 4.1 provides the demographics for the participants who gave their consent. Section 4.2 presents the design evaluation, which consists of feature identification and categorization of the conceptual designs. Section 4.3 presents our statistical analysis of the design features, Section 4.4 presents categories of conceptual design, and Section 4.5 discusses threats.

4.1. Demographics

Table 2 presents the demographic data of the participants including the roles of those working in industry. There were ninety one (91) designers, aged between 18 and 67 who completed the assigned design tasks. These include 77 males (85%) and 12 females (13%); 2 participants preferred not to reveal their gender (2%). There were 51 participants (56%) who were native English speakers, while 35 participants (38%) had spoken and written English for more than three years and 5 participants (6%) wrote and spoke English for 1–3 years. The data for those who had spoken and written English for three years or less was examined carefully as it was important that the participants could demonstrate a reasonable level of competence in understanding the required con-

Table 2
Number of participants and demographics.

Participants	Country		
	Australia	Denmark	
Study	I	II	III
Professional ^a	7	0	9
Postgraduate	4	1	16
Undergraduate	30	24	0
Male	32	23	22
Female	7	2	3
Preferred not to answer the gender question	2	0	0
English is first language	30	20	1
Spoken and written in English > 3 years	8	3	24
Spoken and written in English for 1–3 years	3	2	0
Sub total	41	25	25
Total	91		
Discarded ^b	86	11	6

^a Those who classified themselves as professional in Australia were: Financial Analyst, Artist, Hydrolic Engineer, Human Resources Manager, Chef and unknown (two). Those who classified themselves as professional in Denmark were postgraduate students; their professions were: Skilled IT, Senior Developer, Developer (three), Front-end Developer, System Developer, Programmer and IT Architect.

^b These participants did not give consent or discontinued the study or used inappropriate language. Their data was discarded.

cepts. We did not detect any significant problems caused by the language used for the study.

4.2. Design evaluation – feature identification and categorization

A total of 91 participants in the three studies produced 218 conceptual designs, which were distributed nearly evenly for all four Holistic Personas with Minty having 58 design artifacts, the highest number, and Katie having 50 design artifacts, the lowest number. Table 4 lists a sample of the conceptual design artifacts. A participant's design for each of the Holistic Personas was considered as a single design; in 5.5% of the design artifacts participants recommended more than one application in one design artifact. In these cases each design artifact was considered as a single design meeting different requirements.

Overall 15 high level design features were identified. Fig. 1 presents a summary of the top-level design features captured in the design artifacts across each study for each of the Holistic Personas. Tables 5a and 5b show examples of analyzing the design artifacts 2118 and 3147 respectively:

- (1) Participant Id 2118 design artifact (Table 4) recommended both fitness and scheduler. Hence, it is included in Tables 7 and 8, Item 1 (Fitness), Item 2 (Scheduler) and Item 3 (Combined Fitness and Scheduler).
- (2) Participant Id 3147 recommended a weight loss feature in his design not only for Eliza to manage her weight (Tables 7 and 8, Item 1 – fitness) but also to build her confidence (Tables 7 and 8, Item 9 – confidence builder).

Table 6 presents a sample of the list of design features.

4.3. Statistical analysis

In this section, we present the results of the statistical analysis of the differences between the categories of design features that the participants selected for each Holistic Persona. This is based on (1) participants from different cohorts with different backgrounds, and (2) personalities of Holistic Personas. In the null hypothesis (H0), for each case, we assume that there is no association among groups, the data are homogeneous, and hence any differences observed are due to chance. We use the significance testing approach

Table 3
Design statistics^a.

	Study	Doris	Katie	Minty	Eliza	Totals
No of design activity	All	60	60	61	60	241
Completed / attempted design activities	I	7	7	10	9	33
	II	23	22	23	23	91
	III	24	21	25	24	94
Total Completed / attempted the design activities	All	54 ^c	50 ^c	58 ^c	56 ^c	218
Did not attempt a design activity ^b	All	6	10	3	4	23

^a Numbers of designs for each Holistic Persona. A participant's design for each of the Holistic Personas was considered as a single design.

^b Did not attempt a design activity: The participants assessed Holistic Persona's personality, answered post design questionnaire and continued with the study but did not make a meaningful entry in the design field for only that Holistic Persona.

^c Statistics used for percentage evaluations for each of the Holistic Personas.

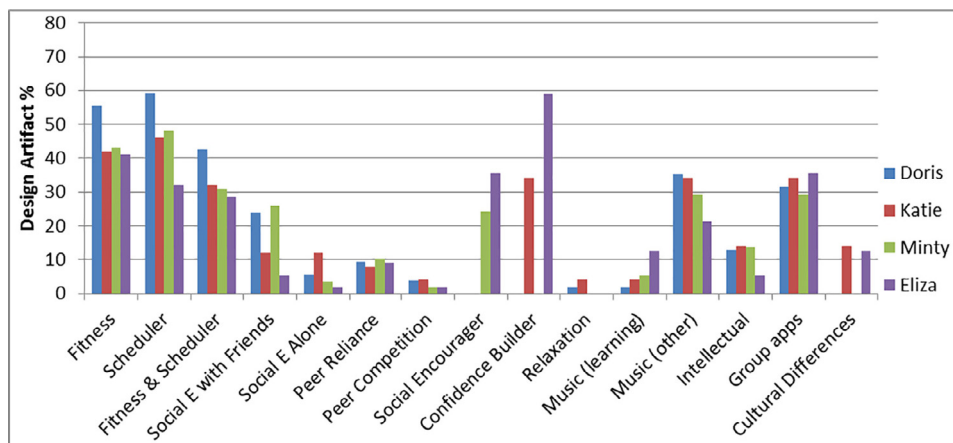


Fig. 1. Design Features.

of Ronald Fisher (Field et al., 2012) to check the homogeneity of data, and reject the null hypothesis only if the data obtained from design artifacts are significantly unlikely. As the numerical values of a number of cells are small, Fisher's exact test is used. For these conditions Pearson's Chi Squared test would not produce valid results. For the categories of design features where Fisher's exact test returns a probability of less than .05 (or 5%), it can be inferred that the differences in the number of categories of design feature selected are not due to chance. Fisher's exact test has been calculated for all categories of design features for studies I, II and III (Table 7 – different cohorts of participants) and for the four Holistic Personas (Table 8).

Fisher's exact tests for each category of the conceptual design for the four Holistic Personas (Table 8) are indicative of the differences identified due to the personality of the personas. The Holistic Personas had personality traits (Table 1). Hence, any significant differences in the design features are caused by the participants' differentiation of Holistic Personas' personalities. The result of the participants recommended design features are presented in the section below identifying the design categories that are influenced by personalities of the Holistic Personas. In the section on discussion of the results, these statistical findings are discussed in depth.

4.4. Categories of conceptual design

From Fisher's exact test, presented in Table 7, the statistical analysis for each category of design features shows that the data are homogeneous except for Categories 2 (Scheduler) and 14 (Group apps) which will be discussed in Section 5. Hence, the data source triangulation and the analysis of combining data from the

studies I, II and III indicated that the data from the three studies can be analyzed in combination for all the categories with the exception of the above two categories. In the next section, we present the combined analysis of the designs from all three studies.

The following subsections provide descriptions and examples of the design categories from Tables 7 and 8. In order to avoid uneven distributions of design features, the percentages have been calculated based on the total number of design artifacts for each of the Holistic Personas (Table 3).

4.4.1. Fitness and scheduler

Fitness and *Scheduler* were the main design features that were highlighted for the Holistic Personas and a majority of the participants included these in their designs (Tables 7 and 8 and Fig. 1). The Holistic Personas had two main issues: (1) to reduce weight and (2) be reminded about applying sun cream lotion, take reading glasses and tell a waiter about her allergy. These features were separated into two categories: (1) *Fitness* – food and exercise; and (2) *Scheduler* – scheduler and reminder (memory management). All design artifacts that met the first feature, *fitness*, centered on either food or exercise or both food and exercise. In most designs, the participants addressed one of the issues related to *fitness* or *scheduler*. However, some of the participants addressed both issues in their design artifacts (Tables 7 and 8, Items 1, 2 & 3). Fisher's exact test for Table 8, Items 1 and 3 do not show that Holistic Persona's personality were influential in variations in the selection of the two categories of the design features. The result for the *Scheduler* design feature is significant both for different cohorts, Table 7 Item 2 ($p < .05$) and different Holistic Personas, Table 8, Item 2, ($p < .05$). Fisher's exact test for study II and study III, 185 design

Table 4
Participants' design artifacts^a.

Id	persona	Affected personality	Participants' Artifacts
1023	Eliza	Introvert/Emotionally unstable	"An anonymous, public forum of message board where discussion is encouraged. -This would allow Eliza to find groups of people with similar interests, issues, and ideas to discuss and socialize with reduced pressure from her introverted personality (since the application is online and anonymous). -When she would otherwise be under too much social anxiety or has been previously rejected in face-to-face conversations, an online forum would allow group discussion and input from other users who are much more likely to empathize. This can also boost self-esteem from the support other users are likely to provide."
1036	Minty	Introvert/Emotionally stable	"Minty could possibly benefit from an app that recommended local social events. Social events could possible include new or recently recommended restaurants in a close proximity to Minty's location. Social events could also include concerts, festivals or movies. This would encourage Minty to socialize more with the people she is already comfortable around and continue to engage her social skills in new, yet familiar environments. The main design of the application could possible be a calendar with events on the relevant dates. Perhaps the weekend events or special/promoted events are larger or more noticeable compared with more regular events. The user would also be able to tailor recommended events that are more suited to their preferences or history of attended events. Minty might use the software app if she is thinking of meeting up with some of her friends on her day off from University next week and she wants to do something different than just going to the cafe. Therefore, Minty can browse events in the application and read reviews/details about events/activities that appeal to her situation."
2118	Doris	Extravert/Emotionally stable	"A regular reminder software that, instead of reacting to timing alone, reacts to external stimuli as well as timing to remind Doris of her need for her skin cream and glasses, and to warn restaurateurs of her special diet. / / The software would use a smartphones on-Obaord [sic] GPS and movement sensitivity to tell when it has been moved after long periods of inactivity (indicating going outside) and when it is moving into an area that the maps software knows to be a restauraunt. / / Doris would use the software by entering the details of when she will need special reminders, and again when she triggers the set activation procedures"
3147	Eliza	Introvert/Emotionally unstable	"I would recommend her a programme for weight loss, especially by doing exercise. I believe that such a programme would mae her more of an extrovert. Design based on the messaging pattern. Scenario: Agneta is a person that is influenced by her weight problem. She would like to try an application that could manage her weight problems that might also cause her to be more anxios about herself, therefore becoming an introvert. The diatery and weight-loss application would help her manage both her diet but also include exercise in her daily routine, which in time would motivate her self esteem."
3149	Katie	Extravert/Emotionally unstable	"Software: / Calories calc / / Design idea: / Software that based on image recognition can recognize food based on images to declarations / / Possible to setup alerts when thresholds are passed / / Possible to log intake historical / / Scenarios: / Katarina uses calories calc to watch her intake / / Katarina uses calories calc to plan her meals during the day and know if she can take the little extra something that day or not / / Katarina uses calories calc to track historical how much she eats and compare to training plans to see if she's eating more or less than planned."
1035	Doris	Extravert/Emotionally stable	"A software product that can help a user lose weight. By entering all the food they eat in a day, users will be able to keep track of how much they have eaten to ensure that they do not overeat. They can see graphical information about what they eat, and hints for how to improve their diet, such as reducing the foods with high fat, or having more protein etc. The product will provide information on how much the user should eat per day to ensure that they keep losing weight until they are within a good weight range. Doris is out for lunch at a cafe with some of her friends. She orders a coffee with a slice of cake, and records this information down in the application so that it can track her food consumption. The application tells her that she is only allowed a very healthy dinner due to her eating cake for lunch."

^a Participants typed the texts in a hurry. No correction is made to the text in this table.

artifacts, (Table 9 Item 2, $p=.07$) does not show the data is significantly different. Hence, the study I has the higher number of design artifacts with the *Scheduler* design feature. This is explored further in Section 5.

4.4.2. Conceptual design categories influenced by the personalities of the Holistic Personas

The conceptual design categories that were influenced by the personalities of the Holistic Personas were: social event with

friends, social encouragers and confidence builders (Table 8, Items 4, 8 and 9). These categories were homogeneous for different cohorts (Table 7, Items 4, 8 and 9).

Social Event with Friends: The designs that provided for search and purchase of tickets for social activities such as concerts with friends were of two types: the Holistic Persona would attend the function either (1) in the company of her friends or (2) invite her friends to take part (Table 8, Items 4). Fisher's exact tests show that the results are not homogeneous for various Holistic Personas

Table 5a
Design features analysis and coding.

Participant Id	Holistic Persona	Design feature (Quote from participants)	Brief	Low Level Design Code
2118	Doris	A regular reminder software that,	Reminder	sf ^a
2118	Doris	instead of reacting to timing alone, reacts to external stimuli as well as timing	Reminder with feature	sf ^b
2118	Doris	to remind Doris of her need for her skin cream and glasses, and to warn restaraunters [sic] of her special diet.	Reminder	sf ^b
2118	Doris	The software would use a smartphones on-Obaord GPS and movement	Technical Detail	–
2118	Doris	sensitivity to tell when it has been moved after long periods of inactivity (indicating going outside) and	Exercise / Fitness	we ^a
2118	Doris	when it is moving into an area that the maps software knows to be a restaurant [sic]	Food/Diet/ Reminder	sf ^b / wf ^a
2118	Doris	Doris would use the software by entering the details of	Technical Detail	–
2118	Doris	when she will need special reminders,	Reminder	sf ^b
2118	Doris	and again when she triggers the set activation procedures	Technical Detail	–

Note: The low level code is counted only once in the design artifact.

^a These items are counted in the number of design features.

^b These items are repeated and hence not counted in the number of design features.

Table 5b
Design features analysis.

Participant Id	Holistic Persona	Design feature (Quote from participants)	Brief	Low Level Design Code
3147	Eliza	I would recommend her a programme [sic] for weight loss,	Fitness	ef ^a
3147	Eliza	especially by doing exercise	Fitness	
3147	Eliza	I believe that such a programme [sic] would mae [sic] her more of an extrovert.	Social Encourager	
3147	Eliza	Design based on the messaging pattern.	Group app	ca ^a
3147	Eliza	Scenario: Agneta is a person that is influenced by her weight problem.	Fitness	cf ^a
3147	Eliza	She would like to try an application that could manage her weight problems	Fitness	
3147	Eliza	that might also cause her to be more anxios [sic] about herself,	Confidence builder	
3147	Eliza	therefore becoming an introvert	Social Encourager	ef ^b
3147	Eliza	The diatery [sic] and weight-loss application would help her manage both her diet	Fitness	cf ^b
3147	Eliza	but also include exercise in her daily rutine [sic],	Fitness	
3147	Eliza	which in time would motivate her self esteem.	Confidence builder	

Notes: For meaning of symbols please see notes of Table 5a.

Table 6
Low level Design features (sample).

Low level code	Description	High level code
cc	Lack of Confidence recommended coach	9
cf	Confidence builder through Fitness app with incentive	1,9
ec	Social encourager through couch	8
ed	Social encourager dating arrangement	8
ef	Social encourager through fitness	1,8
em	Social encourager through music learning	8,11
sf	Reminder using special features (e.g. weather, map)	2
we	Exercise calorie burnt	1
wf	Fitness both food and exercise	3
ca	Group app - connected to other participants' applications	15

Note: For High level code please see Tables 7 and 8.

($p < .01$), but they are homogeneous for different cohorts of participants ($p > .05$). Table 8 Item 4 shows that for Doris and Minty, 13 (24%) and 15 (26%) of designs artifacts respectively contains this feature. But for Katie and Eliza, 6 (12%) and 3 (5%) of design artifacts respectively contain this feature.

Social Encourager and Confidence Builder: Socialization was a feature in 14 and 21 designs (24% and 36% of designs) for Minty and Eliza only (Table 8, Item 8). Similarly 17 and 33 designs (34% and 59% of designs) for Katie and Eliza only were related to lack of confidence (Table 8, Item 9). The participants conceived the fol-

lowing design features with the apparent intention of encouraging socialization: forum for networking, application for chatting with friends and strangers, introduction and meeting organizer with people having similar personality traits, fitness applications that provide incentive e.g., free music download, and the suggestion of using a coach for social training. The participants conceived the following design features with the apparent intention of confidence building: scheduler or reminder applications, forums and socially connected applications (group apps), music applications, competitive fitness applications, and use of a coach. In describ-

Table 7Summary of design features per study^a.

No	Design Features	Study I	Study II	Study III	Fisher's Exact Test ^b
1	Fitness (design may include Scheduler feature)	17	37	45	0.460
2	Scheduler (design may include fitness feature)	24	44	33	0.001 ^e
3	Combined Fitness & Scheduler (design includes both fitness and scheduler) ^c	14	32	27	0.337
4	Social Event With Friends	6	15	16	0.970
5	Social Event Alone	1	6	5	0.853
6	Peer Reliance	7	6	7	0.052
7	Peer Competition	0	1	5	0.170
8	Social Encourager	7	13	15	0.636
9	Confidence Builder	7	19	24	0.744
10	Relaxation	0	3	0	0.132
11	Music (learning app)	0	4	9	0.119
12	Music (other than learning app)	5	26	34	0.069
13	Intellectual, Investigator	3	7	16	0.131
14	Group apps - connected with others app	5	25	42	0.003 ^e
15	Cultural Differences (Issue with Holistic Persona's personality) ^d	4	3	7	0.156
	Total number of designs ^f	33	91	94	

^a A design often meets multiple requirements.^b Fisher's exact test calculations are based on the total number of designs for each of the Holistic Personas.^c Combined Fitness & Scheduler: This item represents the percentage of participants who considered both fitness and scheduler in their design. The data is repeated in both Items 1 and 2.^d Cultural Differences: Australian and Danish participants found different personality combinations difficult to design for. Australian participants found Eliza's personality (Introvert, Emotionally unstable) a hindrance to their design work whereas participants from Denmark found Katie's personality (Extravert, Emotionally unstable) a hindrance to their design work.^e Reject the null hypothesis that the data are homogenous at probability of ($p < .05$).^f Reproduced from Table 3.**Table 8**Summary of design features per persona^a.

No	Design Features	Doris	Katie	Minty	Eliza	Fisher's exact test ^b
1	Fitness (design may include Scheduler feature)	30	21	25	23	0.396
2	Scheduler (design may include fitness feature)	32	23	28	18	0.041 ^e
3	Combined Fitness & Scheduler (design includes both fitness and scheduler) ^c	23	16	18	16	0.435
4	Social Event With Friends	13	6	15	3	0.007 ^f
5	Social Event Alone	3	6	2	1	0.156
6	Peer Reliance	5	4	6	5	0.988
7	Peer Competition	2	2	1	1	0.771
8	Social Encourager	0	0	14	21	0.000 ^f
9	Confidence Builder	0	17	0	33	0.000 ^f
10	Relaxation	1	2	0	0	0.099
11	Music (learning app)	1	2	3	7	0.136
12	Music (other than learning app)	19	17	17	12	0.380
13	Intellectual, Investigator	8	7	8	3	0.326
14	Group apps - connected with others app	17	18	17	20	0.849
15	Cultural Differences (Issue with Holistic Persona's personality) ^d	0	7	0	7	0.000 ^f
	Total number of designs ^g	54	50	58	56	

^a A design often meets multiple requirements.^b Fisher's exact test calculations are based on the total number of designs for each of the Holistic Personas.^c Combined Fitness & Scheduler: This item represents the percentage of participants who considered both fitness and scheduler in their design.^d Cultural Differences: See Table 7 note.^e Reject the null hypothesis that the data are homogenous at probability of ($p < .05$).^f Reject the null hypothesis that the data are homogenous at probability of ($p < .01$).^g Reproduced from Table 3.**Table 9**

Design feature scheduler for studies II & III.

Item No	Design Features	Study II	Study III	Fisher's exact test for each study ^a
2	Scheduler	44	33	0.075
14	Group apps	25	42	0.021 ^b
	Total number of designs ^c	91	94	

^a Fisher's exact test calculations are based on the total number of designs for each of the Studies.^b Reject the null hypothesis that the data are homogenous at probability of ($p < .05$).^c Reproduced from Table 3.

ing these designs, the participants mentioned that the applications were a confidence building or socialization measure.

4.4.3. Conceptual designs not influenced by the personalities of the Holistic Personas

The statistics for the design features listed below (from Table 8) did not show that the Holistic Personas' personalities influenced

the design feature selection. Further Fisher's exact test did not show that for these design features there were any observable differences between the participants' data from different cohorts.

Peer Reliance and Competition: Peer reliance (Table 8, Item 6) refers to reliance on peers for reminders, e.g., the participant Id 2115 wrote: 'Potentially add a concept of having friends on this platform, and when you set reminders you can ping your friends to

remind you at certain times'. Item 7 (Table 8) refers to peer competition to motivate the Holistic Persona to undertake or accomplish an activity, e.g., the participant Id 2113 wrote: 'If she completes the challenge she indicates so, and she can see who else in her group on the software has not yet completed the challenge'.

Table 8 shows that Fishers' exact test for peer reliance, Item 6, is $p = .988$ ($p > .05$) and for peer competition, Item 7, is $p = .771$ ($p > .05$). Table 7 shows that Fishers' exact test for peer reliance, Item 6, is $p = .052$ ($p > .05$). The results for these items are further explored in Section 5 of this paper.

Music: All Holistic Personas had similar information regarding their musical abilities (see Appendix). However, some of the participants whilst designing or recommending an application for one or more of the Holistic Persona viewed music or music-related features as a priority. The participants provided designs that were either to improve musical ability or organize music collections or they were instrumental in achieving other objectives (e.g., encourage socialization). Two main categories were identified: (1) a need to learn music such as playing the guitar (Item 11, Tables 7 and 8), and (2) other, (Item 12, Tables 7 and 8). Some participants conceived design solutions which were music related with the purpose of addressing the Holistic Persona's personality related issues, such as to improve confidence or gain social skills. For example, the participant Id 3160 stated '... would help Katerina gain self confidence and get a better control with temper ... and music would be the obvious choice...'. For Minty/Meta, participant Id 3139 stated: 'I would recommend a product that would help fuel her music passion and teach her how to better master the guitar. Meta is mostly a loner and at most occasions she is not socialising (sic) giving her more time to indulge in her new found hobby.' Participant Id 2137 stated: 'Eliza could use GT to help build her guitar skills and her confidence. Removing the social interaction element of learning guitar would benefit Eliza's personal development.'

4.4.4. Application categories

The design works referred to two broad categories of applications: (1) Single user applications, applications that are used and operated by a single participant where the participant does not communicate with other participants through the application and (2) Group applications, applications that have connections with other participants and hence are part of a group or social network such as forums. The single user applications came in various forms: network connected as client server, self-contained applications with a local database, applications that connect to web sites and portals, to collect information such as weather or ticket prices. The types of group applications designed were: Private communication with friends, specialized forum (which require registration) and Public Forum (users can be anonymous).

Table 8 shows that Fishers' exact test for group applications, Item 14, is $p = .849$ ($p > .05$) however Table 7 shows that Fishers' exact test for peer reliance, Item 14, is $p = .003$ ($p < .01$). Though the Holistic Personas personality did not make difference in the data, the cohorts of participants did make a difference. In study I, 15% and in study II, 27% of the design artifacts contain group connected application whereas in study III, 45% of the design artifacts contain group connected application. Table 9 shows that Fishers' exact test for group applications for study II and study III, Item 14, is $p = .021$ ($p < .05$). The results for this item are further explored in Section 5 of this paper.

4.4.5. Cultural differences

Due to the cohorts coming from two different cultural backgrounds (i.e., Australian and Danish), some possible cultural differences were identified in the way that Australian and Danish participants expressed their responses to and (dis)like of the personality traits of Eliza/Agnetta and Katie/Katerina. Some Australian partici-

pants found it difficult to design a product for, Eliza; for example an Australian participant (Id 2131) stated: 'I don't [sic] recommend any product or apps for eliza as she is an unrealistic persona. All her traits are not likable and has no positive traits'. But some of the Danish participants found Katie/Katerina a difficult personality to design for; one Danish participant stated (Id 3140) 'I don't have any recommendations for Katerina. I think she needs a personal coach'. Another Danish participant mentioned 'I do not have any design to offer to Katerina.' Another Danish participant (participant Id 3156) suggested 'an e-book to teach Katerina better behaviour'.

Table 8 shows that Fishers' exact test for cultural Differences, Item 15, is $p = .000$ ($p < .01$) however Table 7 shows that Fishers' exact test for peer reliance, Item 15, is $p = .156$ ($p > .05$). The Holistic Personas' personality made differences in the data but the cohorts of participants did not make a difference. The results for this item will be further explored in Section 5 of this paper.

4.5. Threats to validity of the study

Two types of threats, internal and external, were identified during the design of the study and measures were taken to minimize their potential effects.

4.5.1. Internal threats

The internal threats included partial completion of the study, maturation effect, boredom, fatigue, and learning effects, where a participant may learn a certain response from the examples given during the introduction to UCD. For each known threat, we took appropriate measures to mitigate its potential effects. To mitigate the learning effect, we did not make any mention of the personalities of personas or users during the introduction to UCD. For the design section of our studies, which relate to this paper, the participants' answers to the design scenario were checked for correctness. One participant's answers were excluded as he did not use appropriate language.

Different cohorts and data triangulation: To increase the precision of the empirical research we used data source triangulation (Runeson and Höst 2009). However, this raises a potential threat to be mitigated concerning the combination of the data from Study I, where four Holistic Personas were presented and rated and only one design was performed with a randomly assigned Holistic Persona, with studies II and III, where each of the four Holistic Personas was presented, rated and designed for in random order. Statistical evaluations of the design categories for the three studies are also presented in Table 7. As shown in Table 7, the data obtained from Study I, Study II and Study III are homogeneous for all categories with the exception of Item 2 (scheduler) and Item 14 (group applications), both items are explored further in the Section 5 of this paper.

Different cultural and educational backgrounds: Another potential threat to be mitigated concerns the combining of data from different participants with different educational and cultural backgrounds. In our studies, we found that Australian and Danish participants perceive personality of personas similarly (Anvari et al., 2015). Fisher's exact test in Table 7 shows that the data from the studies are homogeneous and hence can be combined for further statistical evaluation with some caution taken about Item 2 and Item 14.

The differences in the educational background were not analyzed because there was insufficient data available. However the test results and visual inspection of the design artifacts did not reveal notable differences.

Evaluation of the design artifacts: The third threat to be mitigated surrounds the evaluation of the design artifacts. In this paper, we present the results as a list of design features. For the design activity, the participants were required to read the descrip-

tion of the Holistic Persona, understand her requirements and prepare a design work within fifteen minutes. The range of design artifacts, including the levels of detail and quality, were varied. A quantitative analysis of the results was considered to answer the research question, as it would not be prone to subjectivity and variability. The creativity of the design artifacts and their evaluation using a design rubric were considered in another publication (Anvari and Richards, 2015). To ensure the quality of data, the results were cross-checked independently as outlined in Section 4.2. The statistics are based on what the participants stated in their design artifacts. We did not make any assumptions about the intention that the participants had in their design artifacts. Some participants identified all the factors that they considered in their design, while other participants made minimal comments about their design. Each design was evaluated accordingly. For example, the designs that had similar features (e.g., a forum for music discussion), the feature was allocated to a category based on the reason given for selecting the feature (e.g., confidence building or socialization); if the participant did not mention her reasoning for selecting the feature then it was not added to either of the two categories. The differences in design artifacts demonstrate the quality of thinking and expression, which are reflected in the statistics.

4.5.2. External threats

The external threats to generalize the findings from the study were identified and suggested measures to overcome these in the future studies are outlined below.

Small sample size: The results presented and the statistical tests carried out are limited by the small sample size. A fully rigorous treatment would require a larger data set. The results cannot be generalized due to the limited sample size from the selected population. The empirical studies have been carried out in two countries: Australia and Denmark. A future plan is to conduct this study in an Asian country and to identify the cultural differences in identifying a system's requirements for the same set of Holistic Personas.

Student participation: The results cannot be generalized to professional populations because the majority of the participants were students. The Australian participants were mostly undergraduate students and the Danish participants were postgraduate students; some participants had professional experience. We plan to mitigate this threat by conducting a similar study with participants invited from professional groups. However, we believe that personality traits and design abilities which rely on intuition and spatial ability (Field, 2007) are not easily changed and hence our results which rely on personality traits can be extended to professionals (Anvari and Richards, 2015).

5. Discussion

Our empirical studies report on the potential of using Holistic Personas (personas with personality traits) for identification of design features during conceptual design. The results demonstrate variations in system designs due to designers' perceptions of the needs of the Holistic Personas who represent end users of the system. The participants' design artifacts tended to fall into one of three categories: (1) one generic design was offered for all four Holistic Personas; (2) one design was considered but its details were varied to suit each of the Holistic Personas; (3) different designs were presented for each of the Holistic Personas to meet the higher priority needs that the Holistic Personas had. The majority of the participants offered at least one design, which was centered on fitness or scheduler for Doris/Helena (Tables 7 and 8, Items 1, 2 and 3). Thus, the participants were aware of the needs of the Holistic Persona for weight reduction and memory issues. However, the participants identified 15 high level features including fitness and

memory. In the following section we will discuss the results for each of the design features and where the data shows the influence of the Holistic Personas' personality on the design features conceived. In the following section we discuss the relevance of our work for Software Engineers and we end the paper by drawing conclusions from our results.

5.1. Answering the research question

The research question addresses the issue of whether the use of personas result in different designs tailored to specific personas. To answer that question, we review the various design features offered and their applicability to the target persona.

Fitness and Scheduler: We can draw following observations from data in Table 8 Items 1–3. The majority of participants did not see the issues of fitness and scheduler to be of equal importance for all Holistic Personas; for Doris 56% participants designed for reducing weight and 59% designed a scheduler or a reminder feature but for Eliza only 41% and 32% produced the same features respectively (Table 8 Items 1 and 2). However, for Minty 48% of the designs (Table 8 Item 2) provided for a scheduler, which indicates that Minty needs a scheduler rather than a weight reduction feature (43% – Table 8 Item 1). A participant stated that Minty feels good about herself so she does not want to lose weight as much as Katie.

Hence the participants recognized the needs of the Holistic Personas and provided designs for the needs they thought more relevant.

Socializer and confidence builder: Socialization is a feature that the participants identified for Eliza and Minty (Table 8 Item 8) and confidence building (Table 8 Item 9) was identified for Eliza and Katie. Lack of socialization for Eliza was often dealt with in combination with confidence building measures. Some participants saw lack of confidence as an important issue that needed to be addressed initially to assist Eliza and Katie. A participant commented that issues related to lack of confidence must be addressed otherwise the Holistic Persona would not use the application that he would design for her. Hence participants either suggested a forum, personal coach or enhancement of their musical abilities. Table 8 Item 9 shows that the personality traits of Eliza and Katie led a number of participants to include in their design features for building their confidence. None of the participants made any suggestion for a confidence building design feature for Doris or Minty. For Minty only socialization features were provided in the proposed designs such as forums and match making applications. A comparison of Items 8 and 9 of Tables 7 and 8 reveals that confidence building features were suggested more than social building features.

Other observations from our data are: (1) some participants identified competitive traits for Doris and Katerina (extravert) and provided conceptual designs that were based on this trait; (2) the participants perceived that Doris and Minty, who are emotionally stable, are more likely to go to social events with their friends.

Group applications: Group and single user application architectures were considered by participants in their designs to meet the requirements of the Holistic Personas. Group applications were often proposed to satisfy the need for group improvement whereas single user applications were mainly to meet personal needs of the Holistic Personas (e.g., a reminder or calorie counter). Section 4.4.4 – Application categories, lists various types of group application and Table 8 shows that the proposed frequencies are in similar proportions for all Holistic Personas, however, the underlying reasons for designing group applications are different. For Doris, the group connected applications are mainly used for peer connection as she has a number of friends and relies on her friends for support or remains in contact with her friends. For

Eliza, the majority of the connected applications are socially interactive forums which she can join anonymously to build confidence and socialize but Minty can use the forums anonymously only for socialization; anonymous forums are suitable for introverts. Hence, introducing personality to persona can help to better represent the target users of the application or service. For example, the requirement for Doris is in line with the finding of Moore and McElroy (2012) that extraverts have a wider network of friends. The requirement for Eliza is in line with Landers and Lounsbury (2006)'s findings: emotionally unstable women seek information online anonymously and Lagoe and Atkin's (2015) report: neurotic people with health anxiety are more incline to seek online health information. Other factors that led the participants to design group applications are explored below.

Cultural differences: Our study highlights how people in different cultures may view and respond to different personalities. The results present the differences in how Australian and Danish people view Eliza/Agneta and Katie/ Katerina (Section 4.4.5). Table 7 Item 15 indicates that Fisher's exact test for cohorts of participants did not reveal a difference, but Table 8 Item 15 shows that equal numbers (7 exactly) of Australian and Danish participants found it difficult to design for a particular but different personality; Eliza the emotionally unstable introvert and Katie the emotionally unstable extrovert, for the Australian and Danish cohorts, respectively. This shows that cultural differences may affect the ability to design for a particular persona. In an exploratory study of the use of personas representing farmers in Australia and Vietnam, it has been found that users and designers in different countries have different expectations (Anvari and Tran, 2013). This study contributes further to identifying possible cultural differences and limitations regarding the appropriateness or utility of certain personas.

Another cultural difference identifiable from Table 7 Item 14 is group applications (Fisher's exact test < 0.05). The higher percentage of participants in whose design artifacts this feature were identified, were in study III (42 designs out of a total of 94 designs or 44%) compared to studies I (5 designs out of a total of 33 designs or 15%) and II (25 designs out of a total of 91 designs or 27%). This suggests that Danish participants place more emphasis on social connectedness. From the World Happiness Report, Denmark has a 'very high level of social trust not matched almost anywhere else in the world' (Helliwell et al., 2015, p. 160). Earlier it was pointed out that in Danish industries the development and use of personas is increasing through a community of practice (Nielsen et al., 2015).

Another way to interpret our study would be that besides addressing the main issues faced by the users, different features need to be designed to match their personality. Thus for Doris (extravert and emotionally stable) a major part of an application can concentrate on the given issues (in our case it was fitness and scheduler) with some features for socialization; whereas for Eliza (introvert and emotionally unstable) the bulk of the application should concentrate on confidence building and socialization (Table 8).

In our study, the issues the Holistic Personas faced were fitness and scheduler (memory management). We envision that our findings will also benefit other personal improvement, behavior modification and cognitively demanding situations such as obesity, unhealthy eating habits, smoking. This study can also apply to educational issues such as migrants or refugees learning new languages and new skills in a new country, or international students adapt to new environments, or self-improvement skills such as gaining confidence in public speaking. As increasing number of users demand personalized applications and devices (e.g., personalized wearable device in medical field (Rubel et al., 2004)) our study assists in providing a method for designing customized solutions to meet the needs of users.

In summary, our studies provide empirical evidence that the use of personas with different personalities result in different conceptual designs that are tailored to personality of the personas.

5.2. Complementing other studies and contributions to Software Engineering

Our studies complement and enhance other researchers' studies in uses of persona (e.g. (Cleland-Huang et al., 2014; Gudjonsdottir, 2010; Hjalmarsson et al., 2015; Miaskiewicz and Kozar, 2011)) by incorporating personality within the persona framework during investigation and authoring processes. Participants in our studies performed design activities based on persona with personality. In our study, the level of engagement with Holistic Personas is high and is in contrast with Matthews et al.'s (2012) study where designers found personas to be abstract, impersonal, misleading and distracting and hence did not use personas. Cleland-Huang et al. (2014) considered 30 architecturally savvy personas in a course teaching architectural design. It seems that none of the personas were designed with personality. According to students' comments in that study, use of personas in design were limited. Our study in this paper indicates that the level of engagement with the personas is increased when personality is incorporated in the persona. Hjalmarsson et al. (2015) included 'six customer profiles divided by age, e-service maturity and travel pattern' (Hjalmarsson et al., 2015, p. 5) without including personality. Miaskiewicz and Kozar (2011) investigated the benefits of using personas in UCD but did not include personality. Based on our studies, we argue that inclusion of personality in the authoring of personas would have increased the list of benefits the personas brings to the applications designed based on UCD principles.

This study's contributions to Software Engineering include support for the following:

- Introducing personality to personas can help to better represent the target users of the application or service.
- More consideration must be paid when designing applications for people who are introvert and emotionally unstable than when designing applications for people who are extravert and emotionally stable. Participants' contributions (Table 7 and Table 8) demonstrate that if an application is targeted at a population with different personalities, varying portions of the application should be devoted to satisfy personality needs of the users rather than just addressing the main issues.
- While designing an application, it is important to consider cultural attitudes of the designers and of the targeted end users. The participants from Denmark and Australia saw the extreme personalities differently.
- If users are involved in a project for design of applications, awareness that an end user's personality may influence the design and development of an application assists the selection of appropriate participants for inclusion in the project.

Regarding the last point, our deduction is based on findings from the three studies that (1) participants in both countries report that the Holistic Personas represent real persons (identified via their response to the question: "I think [Holistic Persona] is a real person"; participants' answers were analyzed and presented in another publication (Anvari et al., 2015)) and (2) our observation that some participants' engagement with Holistic Personas were intense to the extent that they resonated with the Holistic Persona and produced a substantial design or they were disengaged and could not produce any design. Nevertheless, this conjecture needs further research.

Finally, our studies provide empirical evidence that selection of personality traits when building personas can direct the focus of design features. This is a critical finding that requires additional

studies to determine which personality traits to include or omit. Selection of certain traits or omission of them can lead to application not used by critical demographics. This is likely important for certain domains, e.g., in health, certain personal characteristics may need additional support or product features to ensure users with those characteristics become engaged with the application – Dennis et al. (2015) reported that patients who are low in conscientiousness would require different types of reminders for an Achieving Self-directed Integrated Cancer Aftercare Skin-Checker application and Consolvo et al. (2006) described a mobile social application that peers encouraged each other to increase their daily walking.

6. Conclusion

The results from our empirical studies show that a software engineer's design can be affected by the personality traits of the personas he or she uses. For example, for an introverted and emotionally unstable personality, a software engineer would identify the need for a confidence builder and socializer a higher priority compared with an extravert and emotionally stable personality. Thus, we can conclude that the use of personas with different personalities does result in conceptual designs tailored to that personality. As an interesting outcome of conducting these studies in two different countries, some cultural differences were found in terms of what features were identified and the participants' preferences to design for certain types of personalities.

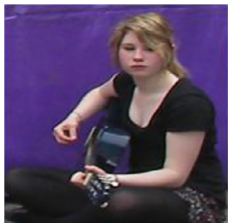
Whilst further studies and more data are needed to provide conclusive evidence, our findings suggest that Personas with personality traits could be a viable approach to identify design features suitable for different groups of users without needing to involve actual human subjects during the design process.

Acknowledgments

We thank COMP255 Software Engineering Semester two 2013 and COMP260 Game Design Semester one 2014 students and tutors at Macquarie University and postgraduate Software Engineering Semester two 2014 students from IT University of Copenhagen for their participation in the study. We appreciate the helpful comments provided by the editor and the anonymous reviewers.

Appendix: an example of a persona with personality traits and design activity instructions

The following persona, Katerina, represents an archetypical user of the product or software application which you are designing or recommending to her.



Katerina's grand-parents have lived in Odense since 1945. Her parents are busy in their professional careers. Katerina is studying at the University of Southern Denmark and is midway through her Bachelor of Arts. Since childhood, she has had interest in music and recently learnt to play guitar.

Katerina is an outgoing person and likes to meet people. She likes musical concert and attends all musical events in Odense. After the concerts, she goes out with her friends to local restaurants.

She has a large collection of records and enjoys sharing albums with her friends.

Katerina meets new people by engaging in activities around the university campus. Occasionally, she takes part in community activities. Recently she joined the 'Assisting Socially Disadvantaged Group', a volunteer group that helps socially disadvantaged people in Odense. She is not sure whether she will continue working with the group.

Katerina is short sighted and has sensitive skin but she often forgets to take her glasses with her or apply sun-screen lotion when she goes out.

Katerina is vocal. She rarely listens to other people's point of view. She frets when her views are challenged. Katerina's friends feel that Katerina is high-strung and anxious. She talks about her plans but she rarely follows them through. She often rejects any requests for help from her friends as she lacks confidence in her abilities, but internally she feels guilty.

Katerina is allergic to peanut but she often forgets to mention this fact while ordering her meals. Katerina has read about relationships between height, weight and energy content of various foods.

Katerina has realized that she is overweight and wishes to reduce her weight.

Please spend about 10 min on the following tasks:

- Recommend a software application or product.
- Briefly describe your design ideas or recommendation.
- Write a scenario in which Katerina uses your software application or product.

References

- Acuña, S.T., Castro, J.W., Juristo, N., 2012. A HCI technique for improving requirements elicitation. *Inf. Software Technol.* 54 (12), 1357–1375.
- Adlin, T., Pruitt, J., 2010. *The Essential Persona Lifecycle: Your Guide to Building and Using Personas*. Morgan Kaufmann.
- Akin, Ö., Lin, C., 1995. Design protocol data and novel design decisions. *Des. Stud.* 16 (2), 211–236.
- Anvari, F., 2016. *Effectiveness of Persona with Personality on Conceptual Design and Requirements*. Master of Philosophy, Empirical studies, Macquarie University, Sydney Unpublished.
- Anvari, F., Richards, D., 2015. Using personality traits and a spatial ability test to identify talented aspiring designers in user-centred design methodologies. In: *Proceedings of the ENASE 10th International Conference on Evaluation of Novel Approaches to Software Engineering*, pp. 90–101.
- Anvari, F., Richards, D., Hitchens, M., Babar, M.A., 2015. Effectiveness of persona with personality traits on conceptual design. In: *Software Engineering (ICSE), 2015 IEEE/ACM 37th IEEE International Conference on*, pp. 263–272.
- Anvari, F., Tran, H.M.T., 2013. Persona ontology for user centred design professionals. In: *Proceedings of the ICIME 4th International Conference on Information Management and Evaluation*, Vietnam. Ho Chi Minh City, pp. 35–44.
- Anvari, F., Tran, H.M.T., 2014. Holistic personas and reflective concepts for software engineers. In: *8th European Conference on IS Management and Evaluation: EC-IME2014*. Ghent, Belgium, pp. 20–28.
- Aoyama, M., 2007. Persona-scenario-goal methodology for user-centered requirements engineering. In: *Requirements Engineering Conference, 2007. RE'07. 15th IEEE International: IEEE*, pp. 185–194.
- Boden, M.A., 2009. Computer models of creativity. *AI Mag.* 30 (3), 23.
- Braun, V., Clarke, V., 2006. Using thematic analysis in psychology. *Qual. Res. Psychol.* 3 (2), 77–101.
- Butt, S., Phillips, J.G., 2008. Personality and self reported mobile phone use. *Comput. Hum. Behav.* 24 (2), 346–360.
- Chapman, C.N., Milham, R.P., 2006. The personas' new clothes: methodological and practical arguments against a popular method. In: *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*. SAGE Publications, pp. 634–636.
- Chen, R.C., Nivala, W.C., Chen, C., 2011. Modeling the role of empathic design engaged personas: an emotional design approach. In: *Universal Access in Human-Computer Interaction. Users Diversity: Springer*, pp. 22–31.
- Chittaranjan, G., Blom, J., Gatica-Perez, D., 2011. Mining large-scale smartphone data for personality studies. *Pers. Ubiquitous Comput.* 17 (3), 433–450.
- Christiaans, H., Almendra, R.A., 2010. Accessing decision-making in software design. *Des. Stud.* 31 (6), 641–662.
- Cleland-Huang, J., Babar, M.A., Mirakhorli, M., 2014. An inverted classroom experience: engaging students in architectural thinking for agile projects. In: *Companion Proceedings of the 36th International Conference on Software Engineering: ACM*, pp. 364–371.

- Consolvo, S., Everitt, K., Smith, I., Landay, J.A., 2006. Design requirements for technologies that encourage physical activity. In: *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, Montréal, Québec, Canada: ACM, pp. 457–466.
- Cooper, A., 2004. *The Inmates are Running the Asylum: Why High-Tech Products Drive Us Crazy and How to Restore the Sanity*, New ed. Sams Publishing.
- Correa, T., Hinsley, A.W., de Zúñiga, H.G., 2010. Who interacts on the web?: The intersection of users' personality and social media use. *Comput. Hum. Behav.* 26 (2), 247–253.
- Costa, P., McCrae, R., 1992. personality inventory (NEO-PI-R) and NEO five-factor inventory (NEO-FFI) professional manual, 1992. Psychological Assessment Resources, Odessa, FL.
- Crabtree, B.F., Miller, W.F., 1992. A template approach to text analysis: developing and using codebooks. In: Miller, B.F.C.W.L. (Ed.), *Doing Qualitative Research*. US: Sage Publications, Inc., Thousand Oaks, CA, pp. 93–109.
- Creswell, J.W., 2013. *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*. Sage publications.
- Cronholm, S., Hjalmarsson, A., 2011. Experiences from sequential use of mixed methods. *Electr. J. Bus. Res. Methods* 9 (2), 87–95.
- Cutcliffe, J.R., 2000. Methodological issues in grounded theory. *J. Adv. Nurs.* 31 (6), 1476–1484.
- Dennis, M., Smith, K.A., Masthoff, J., Tintarev, N., 2015. How can skin check reminders be personalised to patient conscientiousness? In: *Proceedings of the 1st International Workshop on Personalisation and Adaptation in Technology for Health (PATH 2015)*. 23rd Conference on User Modeling, Adaptation and Personalization, CEURWS.
- Devaraj, S., Easley, R.F., Crant, J.M., 2008. Research note-how does personality matter? Relating the five-factor model to technology acceptance and use. *Inf. Syst. Res.* 19 (1), 93–105.
- Easterbrook, S., Singer, J., Storey, M.-A., Damian, D., 2008. Selecting empirical methods for software engineering research. In: *Guide to Advanced Empirical Software Engineering*. Springer, pp. 285–311.
- Elkina, M. and Pursian, A. (2012) Utilizing the Personas Concept as a Basis for Modeling Use Cases of a Learning Analytic Application.
- Evbuomwan, N.F.O., Sivaloganathan, S., Jebb, A., 1996. A survey of design philosophies, models, methods and systems. In: *Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture*, 210, pp. 301–320.
- Faily, S., Lyle, J., 2013. Guidelines for integrating personas into software engineering tools. In: *Proceedings of the 5th ACM SIGCHI Symposium on Engineering Interactive Computing Systems*. ACM, pp. 69–74.
- Field, A., Miles, J., Field, Z., 2012. *Discovering Statistics Using R*. SAGE Publications Ltd, London, UK.
- Field, B.W., 2007. Visualization, intuition, and mathematics metrics as predictors of undergraduate engineering design performance. *J. Mech. Des.* 129 (7), 735–743.
- Finger, S., Dixon, J., 1989a. A review of research in mechanical engineering design. Part I: descriptive, prescriptive, and computer-based models of design processes. *Res. Eng. Des.* 1 (1), 51–67.
- Finger, S., Dixon, J., 1989b. A review of research in mechanical engineering design. Part II: representations, analysis, and design for the life cycle. *Res. Eng. Des.* 1 (2), 121–137.
- Goldberg, L., Lide, B., Lowry, S., Massett, H.A., O'Connell, T., Preece, J., Quesenberry, W., Shneiderman, B., 2011. Usability and accessibility in consumer health informatics current trends and future challenges. *Am. J. Prev. Med.* 40 (5 Suppl 2) S187–S197.
- Goldberg, L.R., 1993. The structure of phenotypic personality traits. *Am. Psychol.* 48 (1), 26–34.
- Goodwin, K., 2009. *Designing for the Digital Age*. Wiley.
- Gosling, S.D., Rentfrow, P.J., Swann Jr, W.B., 2003. A very brief measure of the Big-Five personality domains. *J. Res. Pers.* 37 (6), 504–528.
- Gould, N., Atkin, D., 2015. Towards a semantic layer to support road and public transport user decision-making. In: *Computer and Information Technology; Ubiquitous Computing and Communications; Dependable, Autonomic and Secure Computing; Pervasive Intelligence and Computing (CIT/IUCC/DASC/PICOM)*, 2015 IEEE International Conference on, pp. 1498–1503.
- Griffin, A., Hauser, J.R., 1993. The voice of the customer. *Market. Sci.* 12 (1), 1–27.
- Gudjonsdottir, R., 2010. *Personas and Scenarios in Use* Unpublished 08 Doctoral thesis, monograph. KTH, Stockholm.
- Guðjónsdóttir, R., Lindquist, S., 2008. Personas and scenarios: design tool or a communication device? In: *8th International Conference on the Design of Cooperative Systems*, Carry Le Rouet, France, pp. 165–176.
- Guo, F.Y., Shamdassani, S., Randall, B., 2011. Creating effective personas for product design: insights from a case study. In: *Internationalization, Design and Global Development*. Springer, pp. 37–46.
- Haan, G.D., 2013. A Vision of the Future of Media Technology Design Education - design and education from HCI to UbiComp. In: *Paper Presented to the Proceedings of the 3rd Computer Science Education Research Conference on Computer Science Education Research*. Arnhem, Netherlands.
- Haan, G.D., 2015. HCI Design Methods: where next? from user-centred to creative design and beyond. In: *Paper Presented to the Proceedings of the European Conference on Cognitive Ergonomics 2015*. Warsaw, Poland.
- Halko, S., Kientz, J.A., 2010. Personality and persuasive technology: An exploratory study on health-promoting mobile applications. In: *Persuasive Technology*. Springer, pp. 150–161.
- Helliwell, J., Layard, R., Sachs, J., 2015. *World Happiness Report*. The Earth Institute, Columbia University.
- Hjalmarsson, A., Gustafsson, E., Cronholm, S., 2015. Exploring the use of personas in user-centered design of web-based e-services. In: *iConference 2015 Proceedings*.
- Howard, T.J., Culley, S.J., Dekoninck, E., 2008. Describing the creative design process by the integration of engineering design and cognitive psychology literature. *Des. Stud.* 29 (2), 160–180.
- Jackson, P.W., Messick, S., 1965. The person, the product, and the response: conceptual problems in the assessment of creativity. *J. Pers.* 33 (3), 309–329.
- Jay, C., Harper, S., Calman, L., 2012. Personas for lung cancer patients, carers and healthcare professionals, developed through the ethnographic coding of empirical data. http://files.figshare.com/1027598/OSS_personas_scenarios.pdf.
- Krishnan, V., Ulrich, K.T., 2001. Product development decisions: a review of the literature. *Manage. Sci.* 47 (1), 1–21.
- Kujala, S., 2008. Effective user involvement in product development by improving the analysis of user needs. *Behav. Inf. Technol.* 27 (6), 457–473.
- Landers, R.N., Lounsbury, J.W., 2006. An investigation of Big Five and narrow personality traits in relation to Internet usage. *Comput. Hum. Behav.* 22 (2), 283–293.
- Lane, W., Manner, C., 2011. The impact of personality traits on smartphone ownership and use. *Int. J. Bus. Social Sci.* 2 (17), 22–28.
- Larsen, R.J., Ketelaar, T., 1989. Extraversion, neuroticism and susceptibility to positive and negative mood induction procedures. *Pers. Individ. Differ.* 10 (12), 1221–1228.
- LeRouge, C., Ma, J., Sneha, S., Tolle, K., 2013. User profiles and personas in the design and development of consumer health technologies. *Int. J. Med. Inform.* 82 (11), e251–e268.
- Loiacono, E.T., 2014. Self-disclosure behavior on social networking web sites. *Int. J. Electr. Commer.* 19 (2), 66–94.
- Long, F., 2009. Real or imaginary: the effectiveness of using personas in product design. In: *Proceedings of the Irish Ergonomics Society Annual Conference*, pp. 1–10.
- Lopez-Lorca, A.A., Miller, T., Pedell, S., Mendoza, A., Keirnan, A., Sterling, L., 2014. One size doesn't fit all: diversifying "the user" using personas and emotional scenarios. In: *Paper Presented to the Proceedings of the 6th International Workshop on Social Software Engineering*. Hong Kong, China.
- Luhmann, M., Eid, M., 2009. Does it really feel the same? Changes in life satisfaction following repeated life events. *J. Pers. Soc. Psychol.* 97 (2), 363–381.
- Madsen, A., McKagan, S.B., Sayre, E.C., Martinuk, M. and Bell, A. (2014) Personas as a powerful methodology to design targeted professional development resources. *arXiv preprint arXiv:1408.1125*.
- Maiden, N., Jones, S., Karlsen, K., Neill, R., Zachos, K., Milne, A., 2010. Requirements engineering as creative problem solving: a research agenda for idea finding. In: *Requirements Engineering Conference (RE)*, 2010 18th IEEE International, pp. 57–66.
- Matthews, T., Judge, T., Whittaker, S., 2012. How do designers and user experience professionals actually perceive and use personas? In: *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. ACM, pp. 1219–1228.
- McRorie, M., Sneddon, I., de Sevin, E., Bevacqua, E., Pelachaud, C., 2009. A model of personality and emotional traits. In: *Intelligent Virtual Agents*. Springer, pp. 27–33.
- Miaskiewicz, T., Kozar, K.A., 2011. Personas and user-centered design: how can personas benefit product design processes. *Des. Stud.* 32 (5), 417–430.
- Miller, T., Pedell, S., Lopez-Lorca, A.A., Mendoza, A., Sterling, L., Keirnan, A., 2015. Emotion-led modelling for people-oriented requirements engineering: the case study of emergency systems. *J. Syst. Software* 105 (0), 54–71.
- Mohanani, R., Ralph, P., Shreeve, B., 2014. Requirements fixation. In: *Paper Presented to the Proceedings of the 36th International Conference on Software Engineering*. Hyderabad, India.
- Moore, K., McElroy, J.C., 2012. The influence of personality on Facebook usage, wall postings, and regret. *Comput. Hum. Behav.* 28 (1), 267–274.
- Neuman, W.L., 2011. *Social Research Methods: Qualitative and Quantitative Approaches*, 7th ed. Allyn & Bacon.
- Nguyen, L., Shanks, G., 2009. A framework for understanding creativity in requirements engineering. *Inf. Software Technol.* 51 (3), 655–662.
- Nielsen, L., 2012. *Personas – User Focused Design*. Springer Publishing Company, Incorporated.
- Nielsen, L., Hansen, K.S., Stage, J., Billestrup, J., 2015. A template for design personas: analysis of 47 persona descriptions from danish industries and organizations. *Int. J. Sociotechnol. Knowl. Dev. (IJSKD)* 7 (1), 45–61.
- Nieters, J.E., Ivaturi, S., Ahmed, I., 2007. Making personas memorable. *Paper Presented to the CHI '07 Extended Abstracts on Human Factors in Computing Systems*.
- Norman, D.A., 1986. Cognitive engineering. In: *User Centered System Design*, pp. 31–61.
- Norman, D.A., Draper, S.W., 1986. *User Centered System Design; New Perspectives On Human-Computer Interaction*. L. Erlbaum Associates Inc.
- Nov, O., Arazy, O., López, C., Brusilovsky, P., 2013. Exploring personality-targeted UI design in online social participation systems. In: *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. ACM, pp. 361–370.
- Oliveira, R.D., Cherubini, M., Oliver, N., 2013. Influence of personality on satisfaction with mobile phone services. *ACM Trans. Comput.-Hum. Interact.* 20 (2), 1–23.
- Partington, D., 2000. Building grounded theories of management action. *Br. J. Manage.* 11 (2), 91–102.
- Plucker, J.A., Beghetto, R.A., Dow, G.T., 2004. Why isn't creativity more important to educational psychologists? Potentials, pitfalls, and future directions in creativity research. *Educ. Psychol.* 39 (2), 83–96.
- Portugal, S., 2008. TRUE TALES: persona non grata. *Interactions* 15 (1), 72–73.

- Pruitt, J., Grudin, J., 2003. Personas: practice and theory. In: *Proceedings of the 2003 Conference on Designing for User Experiences*. ACM, pp. 1–15.
- Qualtrics (2015) qualtrics.com (viewed 6 Nov., 2015).
- Ralph, P., Wand, Y., 2009. A proposal for a formal definition of the design concept. In: Lyytinen, K., Loucopoulos, P., Mylopoulos, J., Robinson, B. (Eds.), *Design Requirements Engineering: A Ten-Year Perspective*. Springer, Berlin Heidelberg, pp. 103–136.
- Robertson, J., 2002. Eureka! Why analysts should invent requirements. *Software, IEEE* 19 (4), 20–22.
- Rosson, M.B., Carroll, J.M., 2009. Scenario based design. In: Sears, A., Jacko, J.A. (Eds.), *Human-Computer Interaction: Development Process*. CRC Press, Taylor & Francis Group, pp. 145–162.
- Rubel, P., Fayn, J., Simon-Chautemps, L., Atoui, H., Ohlsson, M., Telisson, D., Adami, S., Arod, S., Forlini, M.C., Malossi, C., 2004. New paradigms in telemedicine: ambient intelligence, wearable, pervasive and personalized. *Stud. Health Technol. Inform.* 108, 123–132.
- Runeson, P., Höst, M., 2009. Guidelines for conducting and reporting case study research in software engineering. *Empir. Software Eng.* 14 (2), 131–164.
- Schneidewind, L., Horold, S., Mayas, C., Kromker, H., Falke, S., Pucklitsch, T., 2012. How personas support requirements engineering. In: *Usability and Accessibility Focused Requirements Engineering (UsARE), 2012 First International Workshop on*. IEEE, pp. 1–5.
- Stol, K.J., Ralph, P., Fitzgerald, B., 2016. Grounded Theory in software engineering research: a critical review and guidelines. In: *2016 IEEE/ACM 38th International Conference on Software Engineering (ICSE)*, pp. 120–131.
- Svendsen, G.B., Johnsen, J.-A.K., Almås-Sørensen, L., Vittersø, J., 2013. Personality and technology acceptance: the influence of personality factors on the core constructs of the Technology Acceptance Model. *Behav. Inf. Technol.* 32 (4), 323–334.
- Switzky, A., 2012. Incorporating UCD into the software development lifecycle: a case study. In: *CHI'12 Extended Abstracts on Human Factors in Computing Systems*. ACM, pp. 469–484.
- Teddlie, C., Tashakkori, A., 2009. *Foundations of Mixed Methods Research: Integrating Quantitative and Qualitative Approaches in the Social and Behavioral Sciences*. Sage.
- Terzakis, J., 2013. The impact of requirements on software quality across three product generations. In: *Requirements Engineering Conference (RE), 2013 21st IEEE International*. IEEE, pp. 284–289.
- Walsham, G., 1993. *Interpreting Information Systems in Organizations*. John Wiley & Sons, Inc.
- Watson, D., Clark, L.A., 1992. On traits and temperament: general and specific factors of emotional experience and their relation to the five-factor model. *J. Pers.* 60 (2), 441–476.
- Yu, E.S.K., 1997. Towards modelling and reasoning support for early-phase requirements engineering. In: *Requirements Engineering, 1997., Proceedings of the Third IEEE International Symposium on*, pp. 226–235.