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Personality-targeted persuasive gamified systems: exploring the impact of application domain on the effectiveness of behaviour change strategies

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Abstract

Persuasive gamified systems for health are interventions that promote behaviour change using various persuasive strategies. While research has shown that these strategies are effective at motivating behaviour change, there is little knowledge on whether and how the effectiveness of these strategies vary across multiple domains for people of distinct personality traits. To bridge this gap, we conducted a quantitative study with 568 participants to investigate (a) whether the effectiveness of the persuasive strategies implemented vary within each domain (b) whether the effectiveness of various strategies vary across two distinct domains, (c) how people belonging to different personality traits respond to these strategies, and (d) if people high in a personality trait would be influenced by a persuasive strategy within one domain and not in the other. Our results show that there are significant differences in the effectiveness of various strategies across domains and that people's personality plays a significant role in the perceived persuasiveness of different strategies both within and across distinct

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domains. The *Reward* strategy (which involves incentivizing users for achieving specific milestones towards the desired behaviour) and the *Competition* strategy (which involves allowing users to compete with each other to perform the desired behaviour) were effective for promoting healthy eating but not for smoking cessation for people high in Conscientiousness. We provide design suggestions for developing persuasive gamified interventions for health targeting distinct domains and tailored to individuals depending on their personalities.

Keywords Persuasive system · Persuasive technology · Human–computer interaction · Persuasive strategies · Personality · Healthy eating · Smoking cessation

1 Introduction

Persuasive gamified systems or health are designed as systems with the primary purpose of promoting behaviour or attitude change (Bogost 2007; Fogg 2003; Oinas-Kukkonen and Harjumaa 2009; Orji et al. 2014). They employ various persuasive strategies to achieve their behaviour change objectives (Alqahtani et al. 2019; Oyebode 2020). Research has shown that persuasive gamified systems are effective at promoting behaviour changes across many domains (Aldenaini et al. 2020a; Hamari et al. 2014; Orji and Moffatt 2018). As a result, in recent years, we have witnessed a growing investment in the design and development of persuasive gamified systems targeted at solving problems in various domains including environmental sustainability (Bang et al. 2009; Gamberini et al. 2010; Gustafsson et al. 2010), promoting personal wellness, managing diseases (Almonani et al. 2014; Huss et al. 2003; Kato et al. 2008), engaging in preventive behaviours, physical activity (Chittaro and Sioni 2012; Fujiki et al. 2008), healthy eating (Orji et al. 2017b; Orji et al. 2013a; Orji 2014), avoiding risky behaviours, and substance abuse (Gamberini et al. 2007).

It has been shown that one-size-does-not-fit all when it comes to designing persuasive gamified systems to motivate behaviour change and that a persuasive strategy that works well for a user or user group may not work for others. Tailoring persuasive gamified systems can increase their effectiveness at motivating the desired behaviour change (Orji et al. 2013c). As a result, there is an increasing interest in investigating ways that persuasive gamified systems can be tailored. In line with this, research has investigated the possibility of tailoring persuasive gamified systems to various users characteristics' including age groups (Oyibo et al. 2017b; Velsen et al. 2019), gender groups (Oyibo et al. 2017b; Vries et al. 2017), gamer types (Orji et al. 2013c), gamification user type (Orji et al. 2018), and personality types (Anagnostopoulou et al. 2017; Orji et al. 2017d). Most of these existing research are focused on investigating how to tailor persuasive systems to various user characteristics. However, according to the Persuasive Systems Design (PSD) model (Oinas-Kukkonen and Harjumaa 2009), factors beyond user characteristics (such as usage contexts including the problem domain the application is targeted at) may affect the effectiveness of persuasive strategies. Nevertheless, there is little knowledge of whether and how the effectiveness of these strategies vary across multiple application domains for people of distinct personality traits. Personality has been found to have a significant impact in many areas of

Human–Computer Interaction (HCI) including persuasive systems (Sofia et al. 2016), games (Rau et al. 2017), gamified systems (Ghaban and Hendley 2019), and graphical user interfaces design(Sarsam and Al-Samarraie 2018). While there has been research on the impact of personality on the effectiveness of persuasive strategies (Halko and Kientz 2010; Hirsh et al. 2012; Orji et al. 2017d), none has investigated the combined effect of user-dependent factors (personality types) and usage context-dependent factors (different application domains) to establish the generalizability of the strategies or not and develop guidelines for tailoring persuasive gamified systems that takes both the target user personality and application domains into account.

To advance research in this area, we conducted a large-scale study of 568 participants to investigate how people of different personalities (based on the Five-Factor Model (John and Srivastava 1999; Rammstedt and John 2007)) responded to five persuasive strategies—*competition, cooperation, reward, personalization,* and *normative influence* that are commonly employed in persuasive gamified systems for health across multiple domains. We operationalized the strategies in persuasive gamified applications targeting two distinct domains as a case study: applications for promoting healthy eating and applications for smoking cessation. We followed closely how these strategies are operationalized in the literature.

Next, we developed models showing how people of distinct personalities respond to the individual strategies in each application domain using the Partial Least Square Structural Equation Modeling (PLS-SEM) (Ring et al. 2005) and pairwise comparison to assess for significant structural differences between the models across the two domains. Our results reveal that there are significant differences in the effectiveness of various persuasive strategies across domains and that people's personalities play a significant role in the perceived persuasiveness of different strategies both within and across distinct domains. For example, Conscientious people tend to be motivated by *competition, reward,* and *normative influence* in the healthy eating domain but not for smoking cessation; People high in Extraversion are motivated by *normative influence* in smoking cessation but not in the healthy eating domain; Emotionally stable people are more likely to be motivated by *cooperation* in the healthy eating domain, but *competition* in the smoking cessation domain. Agreeableness emerged as the personality type that shows the least variability with respect to their responsiveness to the persuasive strategies across distinct domains, while conscientiousness showed the most variability. Our findings highlight the need to consider the application domain alongside the people's personalities for tailoring persuasive gamified systems. Our findings can inform design decisions on which persuasive strategy to employ and which to avoid when designing persuasive gamified systems for people of different personalities targeting distinct domains.

Our work offers four main contributions to the field of persuasive gamified system design in HCI.

First, we validate and conduct within application domains comparisons of the perceived effectiveness of individual strategies and show that the strategies differ significantly in their effectiveness for promoting healthy eating and smoking cessation.

Second, we show the domain-dependency of the effectiveness of persuasive strategies by revealing that the strategies differ in their perceived effectiveness across the two

distinct domains: healthy eating and smoking cessation. Understanding this domain-dependency would help persuasive system designers select the appropriate persuasive strategies when developing behaviour change systems. Although prior research have highlighted the differences in the effectiveness of persuasive strategies in single domains, none has explored the effectiveness of specific implementations of persuasive strategies in persuasive gamified systems, across distinct domains. For example, Kaptien et al. (Kaptein et al. 2015) explored the effectiveness of three implementations of four different persuasive strategies for discourging snacking. Their study examined and compared the effectiveness of implicit and explicit personalization of persuasive strategies. This only gives insights into their effectiveness within the context of discouraging snacking.

Third, we emphasize the importance of considering different contexts in personalizing persuasive systems (by considering both the application domain and personality type simultaneously). Although research works such as Kaptien et al. (Kaptein and Eckles 2010) suggested that the effectiveness of persuasive strategies may be domain-independent, meaning the strategies may be equally effective across domains for the same type of person. However, our study shows that the effectiveness of the strategies varies both across individuals (personality factors) and across domains (eating and smoking), extending the existing knowledge. In fact, most studies including Kaptein's has focused on inter-individual differences in the effectiveness of the strategies but not the intra-individual differences in effectiveness due to differences in domain (Kaptein 2011; Kaptein et al. 2009, 2011; Kaptein and Eckles 2012). Hence, we reveal both within and between application domains differences in how people of different personalities respond to distinct persuasive strategies. Our research further emphasizes that personality traits are important factors that may determine the effectiveness of persuasive strategies either within or across domains of persuasion.

Finally, we provide insights to explain why some strategies may appeal to people of certain personalities. These insights were drawn from comments of participants exhibiting high levels of the different personality factors explored.

Our work is the first to investigate the combined impact of personality and persuasive technology usage context (application domain) on the effectiveness of persuasive strategies to find patterns in the motivation of people of distinct personalities that generalizes across application domains and those that vary to inform persuasive gamified systems design. Based on our findings, we offer design recommendations for persuasive gamified systems targeting distinct domains and tailored to individuals depending on their personalities.

2 Background

In this section, we provide the necessary background for the work conducted in this paper. We give a brief overview of existing persuasive system design frameworks, how persuasive strategies were implemented in some persuasive applications, personality theories and works showing the relationship of personality and the effectiveness of persuasive strategies.

Table 1 Five persuasive strategies and their descriptions

Persuasive strategies	Description
Personalization	Personalize app features, contents, and functionalities to each user to suit their needs
Rewards	Incentivizes users for achieving specific milestones using badges, points etc
Normative influence	Provide a means of gathering users with similar goals to facilitate behaviour change or reinforcement
Cooperation	Provide means for users to work together to achieve the intended behaviour
Competition	Allows users to compete with each other to perform the desired behaviour

2.1 Persuasive strategies

Persuasive strategies are techniques and principles employed in technological interventions to promote positive behaviour change (Oinas-Kukkonen and Harjumaa 2009). Over the years, a growing number of research has been targeted at developing persuasive strategies that can be employed in persuasive gamified systems design. For example, Cialdini (The Science of Persuasion - Scientific American 2004) proposed six principles for influencing human behaviour; Michie et al. (Michie et al. 2013) proposed Behaviour Change Technique Taxonomy; Fogg proposed seven persuasive tools (Fogg 2003); Oinas-Kukkonnen et al. (Oinas-Kukkonen and Harjumaa 2009) built on Fogg's work to develop 28 persuasive strategies for motivating behaviour change.

Among all these frameworks and models, the PSD model developed by Oinas-Kukkonen and Harjumaa (2009) has been widely employed in persuasive gamified systems design (Aldenaini et al. 2020a; Colineau and Paris 2011; Gamberini et al. 2007; Gerlach et al. 2018) due to its comprehensive nature. It combines strategies from other frameworks and offers some guidelines on how the strategies can be translated into software components in persuasive gamified systems design. Hence, we base our research on this framework. Table 1 shows a list of five commonly used persuasive strategies from the PSD framework selected for our study and their descriptions.

2.2 Persuasive technology research and interventions

Persuasive systems are technological systems developed through the intentional implementation of persuasive strategies to promote behaviour change (Oinas-Kukkonen and Harjumaa 2009). In recent years, we have witnessed an increasing number of research focused on designing and evaluating persuasive systems targeted at promoting behaviour change across many diverse domains including physical activity (Chen et al. 2014; Dickinson et al. 2015), smoking cessation (Karim et al. 2017; Khaled et al. 2008), healthy eating (Mazzotta et al. 2007; Orji et al. 2013a), sustainable management, disease management (Brown et al. 1997; Yoon and Godwin 2007), and online security (Ndulue et al. 2020). For example, in the domain of Physical Activity, Silver Cycling (Hosseini et al. 2018) is a persuasive system aimed at encouraging adults to be more physically active, with the use of an augmented bike that tracks user's activity.

This system employs several persuasive strategies, including *Rewards, Competition*, and *Cooperation*. The system provides a mirror that shows the user his current progress while cycling, with the use of a circular progress bar representing the daily goal of users. While they progress, users encounter motivational messages like "Good Job" or "Keep Cycling"; and also get incentivized for cycling a certain distance with points and achievements—*Rewards*. A ranked leaderboard is displayed showing the distance covered by each user—*Competition*. Their study revealed that users had more preference for social support strategies such as competition and cooperation than nonsocial ones.

In the domain of smoking cessation, '*Evitapp'* (Bascur et al. 2018) is a gameful persuasive app for promoting smoking cessation which employs various persuasive strategies including the *personalization, competition,* and *rewards* strategies. The app collected personal details about the users, including their current smoking behaviour—*Personalization*. This information is used to suggest various actions and tasks that users have to embark on towards smoking cessation. The number of cigarettes smoked by users is tracked by the app through self-reporting and users are rewarded with achievement badges for achieving specific smoking cessation goals—Reward. Users are also rewarded with points for these achievements which are presented on a global leaderboard where other users can see and compete with each other—*Competition*. Other persuasive systems for promoting smoking cessation include, '*Quitty'* (Paay et al. 2014), '*Heh'* (Graham et al. 2006) and a smoking cessation app prototype by Khaled et al. (Khaled et al. 2008).

In the domain of healthy eating, '*LunchTime*' (Orji et al. 2013b), which employs the *Reward*, *Competition*, and *Comparison* strategies, is a slow-casual game for motivating healthy eating. Players play as restaurant customers, to choose the healthiest option from a list of food choices. Players are awarded points for healthy choices—*Reward*, and each player can view and compare their performance with that of other players—*Competition* and *Comparison*. Other healthy eating persuasive systems include *Playful Bottle*' (Chiu et al. 2009) (a persuasive system for promoting healthy nutrition in children, which also employs the *Reward, Competition, Comparison* strategies), and '*MACO*' (Almonani et al. 2014) (a persuasive system for promoting healthy eating hence reduce obesity which employs the *Rewards* and *Personalization* strategies).

While systematic reviews of persuasive technology by Hamari et al. (2014), Oyebode et al. (2020) and Alqahtani et al. (2019) have shown that over the years, persuasive strategies have been employed in various persuasive gamified systems to promote positive changes in user behaviours and attitudes, other research, such as Orji et al. (Hirsh et al. 2012), showed that the effectiveness and user perception of these persuasive strategies may vary due to varying user characteristics. In line with this, various user characteristics have been shown to affect the effectiveness of persuasive gamified systems including gamer types (Ciocarlan et al. 2019; Orji et al. 2013c), gamification user type (Orji et al. 2018), and personality types (Anagnostopoulou et al. 2017; Okpo et al. 2017; Orji et al. 2017d; Thomas et al. 2017).

The next section briefly highlights the personality models used in persuasive technology research and research around personality traits and their impact on the effectiveness of persuasive strategies.

2.3 Personality theory, persuasion, and HCI

Several attempts have been made towards developing models for classifying individuals into different personalities. Some of these attempts include the Value In Action (VIA) classification of Character Traits (Seligman et al. 2004), Four personality types proposed by Gerlach et al. (2018), the Jungian Theory of personality (Blutner and Hochnadel 2010), and the Five-Factor Model (FFM) of personality (Goldberg 1993). The FFM proposes five personality factors: Extraversion, Openness, Neuroticism, Conscientiousness, Agreeableness. Table 2 shows the different personality factors and their descriptions.

Of all these models, the FFM is the most popular and widely accepted personality model and has been predominantly used in HCI and persuasive technology research. It has been shown that personality factors affect many aspects of HCI including the area of persuasive technology (Alkiş and Taşkaya Temizel 2015; Orji et al. 2017d), games (Rau et al. 2017), gamified systems (Ghaban and Hendley 2019), and how people interact with Graphical User Interfaces (Sarsam and Al-Samarraie 2018). For example, Orji et al. (2017d) investigated how different personality types respond to various persuasive systems used in a persuasive game for alcohol cessation using the FFM. Their findings uncovered that strategies like *goal-setting, simulation, self-monitoring,* and *feedback* are more effective for Conscientious people, while extraverted people would be easily demotivated by persuasive strategies such as *rewards, competition, comparison,* and *cooperation*. In another work, Hirsh et al. (2012) investigated the impacts of users' personality traits on the effectiveness of persuasive messages. They found that persuasive messages are more effective in promoting behaviour change when they are personalized to various personality traits according to FFM. Similarly, Oyibo et al. (2017a) investigated the influence of user personality traits on the effectiveness of Cialdini's persuasive strategies (The Science of Persuasion - Scientific American 2004) using the FFM. Also, Jia et al. (2016) investigated the relationships between users' personality traits and their preferences for various persuasive strategies, as it related to gamified systems using the FFM. Their findings revealed that extroverted people tend to be motivated by strategies like *rewards* (points) and *competition* (leaderboards), while imaginative people are less likely to be motivated by strategies involving the use of Avatars in the area of physical activity. Halko et al. (2010) explored the relationships between personality and persuasive technology in mobile health applications. They

Table 2 Description of the Five-Factor personality traits

Personality trait	They have a tendency to…
Agreeableness	… be considerate, cooperative, tolerant, friendly, caring, and helpful
Extraversion	… be outgoing, expressive and seek need opportunities
Conscientiousness	.. to be self-disciplined, plan actively, organized and dependable
Neuroticism	… be nervous fearful, sensitive, distrustful and emotionally unstable
Openness to experiences	… be curious, imaginative, hold unconventional values and be creative

found that people with the Neuroticism trait had a positive correlation towards the *negative reinforcement* strategy while extraversion and agreeableness correlated positively with the *competition* strategy. People with the conscientiousness trait showed the greatest tendency to successfully achieve their health goals with mobile health apps since they exhibited the highest amount of positive correlations with the persuasive strategies.

In summary, this literature review shows that a lot of effort has been focused on designing persuasive applications to promote different healthy behaviours, including healthy eating and smoking cessation, employing persuasive strategies such as *Personalization, Rewards, Normative influence, Cooperation,* and *Competition*. It also highlighted the various ways these strategies have been implemented in these applications. The literature uncovered that users' responsiveness to persuasive strategies may vary depending on many user characteristics, including users' personalities. However, none of the existing research has investigated possible variations in the effectiveness of persuasive strategies across distinct domains and if the impact of an individual's personality on the effectiveness of persuasive strategies is domain-dependent. Although prior research have shown the impact of personality traits on the effectiveness of persuasive strategies and applications in a single domain, we do not know if these findings generalize across other domains beyond the domain the research was carried out or whether there are domain-dependent variabilities on the effectiveness of the strategies for different personalities as suggested by the PSD model. For example, Orji's et al. (2017d) research on the response of different personality traits to persuasive strategies was based on the domain of alcohol cessation, Jia's et al. (2016) study was based on physical activity, and Hirsh's et al. (2012) research was in the E-Commerce domain. Whether or not these findings could generalize to other domains such as healthy eating (Encouraging Desirable Behaviours) or smoking cessation (Discouraging Undesirable Behaviours) is an open research question which we aim to investigate in this work.

2.4 Perceived effectiveness of persuasive technologies

Many theories have highlighted that attitude is a predictor of behaviour including the theory of planned behaviour and the theory of reasoned action. In this work, we measure the effectiveness of persuasive strategies in the persuasive systems by participants' perception of their persuasiveness. Although there is a difference between perceived persuasion and actual persuasion, it is common for researchers to assess attitude or perception as a precursor of actual behaviour or effectiveness. Specifically, research shows that perception can be used to inform design decisions (in line with user-centred design) and predict actual behaviours. For example, a TOCHI paper (Orji et al. 2017c) shows the relation between perception and actual behaviour by showing that a persuasive technology (PT) informed by models developed based on users perception (Orji et al. 2014) was more effective than a generic one. The effectiveness of self-report-driven personalization of PT in actual behaviour has also been shown in multiple other areas including eCommerce, physical activity and snacking (Kaptein et al. 2012a, 2015). In line with this, it is widely acknowledged in the area of PT that both explicit measures (users' tendencies (perception/self-assessment) to comply to

distinct persuasive strategies) and implicit measures (actual responses) are effective approaches to PT design and both have been shown to be effective—Kaptein et al. (2015). "Such an explicit approach could be used to tailor persuasive applications: if we have a questionnaire that elicits the tendencies of individual users to comply to distinct influence principles we would be able to measure these tendencies a priori and adapt the interaction with the user according to the obtained estimates"—Kaptein et al. (2015). Hence, our findings hold promise for designing PTs to promote actual behaviour outcomes.

3 Research questions

With this explorative study, we try to broaden existing knowledge about the effectiveness of persuasive strategies employed in persuasive gamified systems by trying to uncovering the impact of users' personality factors on the effectiveness of persuasive strategies implemented across two domains. To explore this research area, we address the following research questions:

RQ1: How persuasive are the strategies with respect to discouraging smoking?
RQ2: How persuasive are the strategies with respect to promoting healthy eating behaviour?
RQ3: Are there any domain-dependent variations in the effectiveness of the strategies?
RQ4: Are there any effects of the personality on the effectiveness of the strategies within a domain of persuasive technology?
RQ5: Are there any effects of the personality on the effectiveness of the strategies across domains—healthy eating and smoking cessation?

4 Method

In this study, our main aim is to investigate whether the effectiveness of persuasive strategies varies across two distinct domains for people of distinct personality traits. To do this, we investigated the relationship between the five personalities traits from the FFM (*Extraversion, Openness, Neuroticism, Conscientiousness, Agreeableness*) and the persuasiveness of the five persuasive strategies (*Personalization, Rewards, Normative influence, Cooperation, Competition*) implemented in two distinct application domains of persuasive technology: one, applications for promoting healthy behaviours (Healthy Eating) and two, applications for discouraging risky behaviours (Smoking Cessation). The domains were chosen to represent two reasons: (1) They represent two distinct application domains, allowing us to investigate the generalizability of finding across unrelated domains; healthy eating deals with promoting a good/healthy behaviour while smoking cessation deals with discouraging unhealthy behaviour. (2) Eating is a compulsory behaviour because every human eats food while smoking is an optional behaviour. Table 3 shows a description of each of these persuasive strategies and their selected implementations.

Table 3 Description of the five persuasive strategies and their implementations

Persuasive strategies	Description	Selected implementation	Paper
Personalization	Personalize the app to a specific individual	Users are required to enter personal details and their goals, then a personalized plan is prescribed for them based on their information	Kaipainen et al. (2012), Orji et al. (2017) and Peng 2009)
Rewards	Incentivizes users for achieving specific milestones	Users are rewarded with various badges for completing different milestones towards the target behaviour change	Fritz et al. (2014), Ganesh et al. (2014) and Katule et al. (2016)
Normative influence	Provide a means of gathering users with similar goals to facilitate behaviour performance	Users have access to in-app forums or blogs, where other users with similar behaviour change goals talk about their experiences, post about their progress, and get reactions from their community	Graham et al. (2009), Karppinen et al. (2014) and Pollak et al. 2010)
Cooperation	Provide means for users to work together to achieve the intended behaviour	Users can begin a group behaviour change challenge and work together with other selected users to complete the challenge	Orji et al. (2019) and Staiano et al. (2018)
Competition	Allows users to compete with each other to perform the desired behaviour	Users can view a leaderboard that ranks all users of the app according to their progress towards the target behaviour change	Edney et al. (2017), and Foster et al. (2010)

4.1 Measurement instrument

To collect data for our research, we adapted an already established approach that has been used by many HCI research (Orji et al. 2014; Orji et al. 2017d). First, we selected five popular persuasive strategies from the literature and carried out a literature review of the various ways the strategies were implemented. After this search, we discovered up to three unique implementations of each strategy in persuasive gamified systems. After a group brainstorming session, we selected the popular implementation for each strategy. Table 3 shows a description of the selected implementation of each strategy.

To understand the perceived effectiveness of each persuasive strategy in each domain, we represented each implementation first as a feature in a low-fidelity prototype of persuasive applications targeted at promoting Healthy Eating and Smoking

Cessation. Before the main study, the prototypes were evaluated three times by 15 experts in Human–Computer Interaction and persuasive technology to identify any existing issues and correct them. The evaluation included ensuring that the prototype for the two domains does not differ (are identical). Their feedbacks were taken and translated to the High-Fidelity prototype of the systems which was again evaluated by the same group of people. Each strategy was implemented twice, (1) in an application for promoting healthy eating and (2) in an application for smoking cessation. Therefore, we had a total of 10 prototypes for the five strategies investigated in this paper. For each strategy, we ensured that the implementations look the same with only a minor tweak such as domain-related information which may unlikely affect the perceived effectiveness of the strategies. The main evaluation resumed when all evaluators agreed that the prototypes representing the two domains were identical. Figure 1 shows the prototype of the competition strategy for both domains.

To get feedback from participants on the effectiveness of these strategies, we developed a survey to collect users' perceived effectiveness of strategies. In this survey, to eliminate possible bias due to the ordering of the prototypes, we used the page randomization functionality provided by *Opinio* survey (https://surveys.dal.ca/opinio/admin/folder.do), which rotates the position of the prototypes and varies their ordering for each participant. Each prototype was preceded by a brief description of the functionalities and followed by validated scales for assessing perceived persuasiveness. The

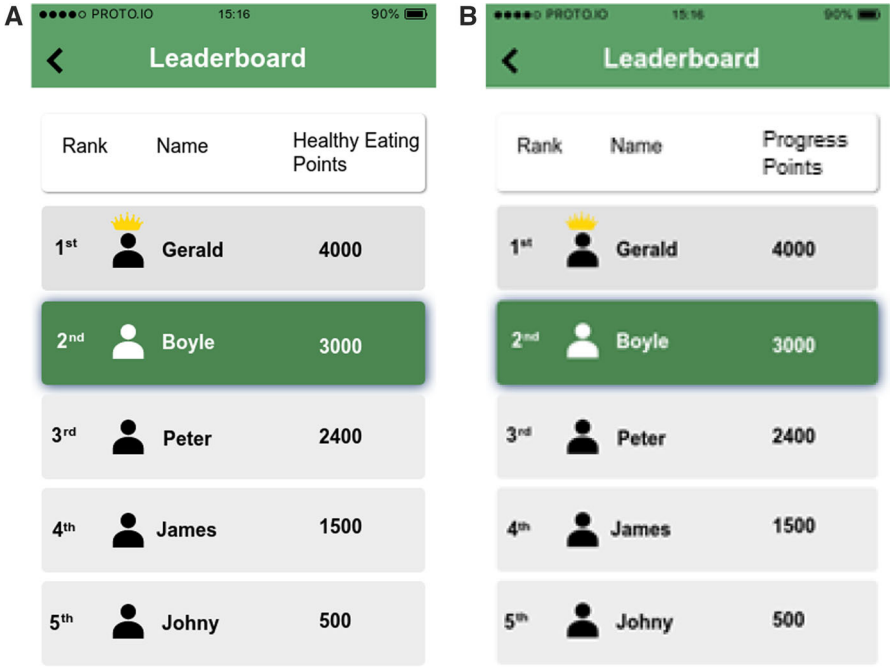

Fig. 1 High Fidelity prototype illustrating the Competition strategy in the healthy eating (**A**) and smoking cessation (**B**) domains

scale, which we adapted from Thomas et al. (Thomas et al. 2019) and Drodz et al. (Drozd et al. 2012), is an established scale for assessing the perceived persuasiveness of system features and has been used in other HCI and related research (Busch et al. 2016; Drozd et al. 2012; Orji et al. 2014, 2017c). The adapted scale consists of five questions for each domain:

For smoking cessation:

(i) "*This app would influence me to stop smoking.*"
(ii) "*This app would convince me to quit smoking.*"
(iii) "*This app would be personally relevant to me.*"
(iv) "*This app would make me reconsider my smoking habits.*"
(v) "*The strategy would make or motivate me to use the app.*"

For healthy eating:

(i) "*This app would influence me to eat healthily.*"
(ii) "*This app would convince me to improve my eating habits.*"
(iii) "*This app would be personally relevant to me.*"
(iv) "*This app would make me reconsider my eating habits.*"
(v) "*The strategy would make or motivate me to use the app.*"

We measure participants' agreement with these questions on a 7-point Likert scale ranging from "1 = Strongly agree" to "7 = Strongly Disagree" for each strategy's prototype. Each prototype was also followed by an open-ended question to collect qualitative comments from participants to justify their rating of each strategy and highlight any other opinions in line with what they like or dislike about the features in the prototypes.

We also included demographic questions, attention check questions and the 10-item personality inventory to assess user personality traits based on the FFM (Goldberg 1993; Rammstedt and John 2007).

4.2 Data collection and participant demography

Our survey was developed on our university's official survey tool, *Opinio* (https://surveys.dal.ca/opinio/admin/folder.do), in accordance with the ethics approval provided by the University's Research Ethics Office. Participants for the survey were recruited using Amazon's Mechanical Turk (Mturk). We used MTurk because it is a general research-proven medium for efficiently gathering large and diverse users' responses across the world, within a short period, at low costs (Hirsh et al. 2012; Mason and Suri 2012). Also, due to the COVID-19 pandemic, an online survey was the safest option for the study as in-lab studies were against the safety guidelines for the pandemic. The prototypes were presented to participants in a random order to guard against order effects.

A total of 568 participants was included in this analysis, after filtering out incomplete responses and incorrect responses to comprehension and attention-determining questions. Our inclusion criteria were: (1) *Participants must have smoked at some*

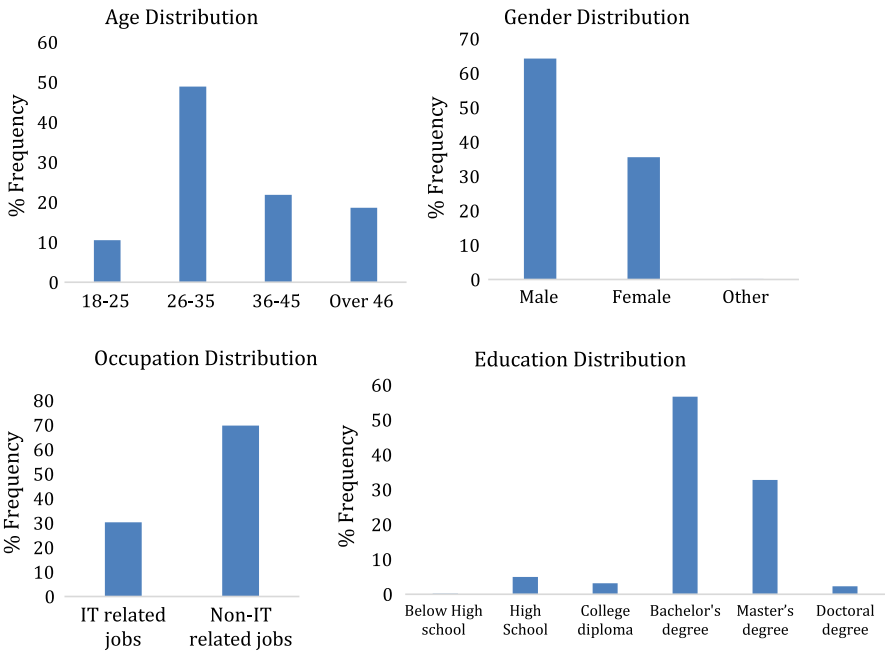

Fig. 2 Participants' demographic information

time, and read and understand English well. (2) *Participants must answer the attention check questions correctly*. (3) *Participants must complete the entire survey*. (4) *Participants must be at least 18 years of age and read at the time of data collection and understand English well*. The participants received a small monetary compensation in compliance with the study ethics approval. Figure 2 shows our participant demographic information. Generally, we had a diverse sample of participants based on occupation, gender, age, and level of education. 64.26% of our participants were male, 35.56% were female, and 0.18% were of 'other' gender (or did not disclose). The highest age group were people between the ages of 26 to 35 years, with 48.94%, while the lowest age group was between the ages of 18 to 25 (10.56%). 30.28% of the participants have IT-related occupations, while 69.72% have non-IT related occupations. Also, most of our participants were educated, with 56.69% having a Bachelor's degree, 32.75% having a Master's degree, and only 0.18% having less than a high school degree.

4.3 Data analysis

A major focus of our research is to investigate whether the effectiveness of persuasive strategies varies across two distinct domains for people of different personality factors. This entails exploring and comparing the relationship between the effectiveness of five persuasive strategies and users' personality traits across multiple domains. To achieve

this, we used several well-known analytical tools and procedures. Below we summarize the steps we took while analysing the data collected from the survey.

(i) To determine the suitability of our data for analysis, we carried out a Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy and the Bartlett Test of Sphericity (Kaiser 1970). Specifically, we measured the sampling adequacy of the variables in our data. Kaiser–Meyer–Olkin (KMO) and Bartlett's Test of Sphericity essentially check to see if the variables are related and can be summarized with fewer factors. That is if there are redundancies between the variables that we can summarize with fewer factors. While the recommended KMO value should not be less than 0.6, for excellent factor data analytic, the KMO value should be at least 0.8 (Kaiser 1970). Conducting these tests is an essential step before detailed analysis and modelling, especially in multi-variable models like the one used in this paper.

(ii) To examine and compare the effectiveness of the strategies overall across the two domains, we calculated the average score for each strategy used and conducted a Repeated Measure ANOVA (RM-ANOVA) followed by pairwise comparison, after validating for the ANOVA assumptions.

(iii) To investigate the relationships between personality traits and the persuasive strategies, we employed the Partial Least Square Structural Equation Modeling (PLS-SEM) (Halko and Kientz 2010) to develop models showing the relations between the personality traits and the persuasiveness of the strategies in each domain, (see Fig. 2) with the personality traits being the exogenous constructs. PLS-SEM is a popular method for estimating path models to uncover complex inter-relationships between observed and latent variables (Sarstedt and Cheah 2019). We chose PLS-SEM over other approaches (e.g., covariant-based) because it is highly appropriate for complex predictive models (Kupek 2006) and has been successfully used in estimating relationships between variables by many HCI researchers (Anagnostopoulou et al. 2017; Drozd et al. 2012; Orji et al. 2018, 2017d). The latent variables are the five personality traits constructs and the five strategies, while the observed variables are the items or indicators (i.e., participants' responses) used in assessing the constructs and are linked to the latent variables. We used the SmartPLS 3 tool (Product|SmartPLS) to develop the models.

(iv) Finally, we investigate for significant differences in the persuasiveness scores (path coefficient) of the strategies between the model for healthy eating and that of smoking cessation using a well-established method that has been employed in other CHI research (Clogg et al. 1995; Orji et al. 2013c; Sánchez 2009), after establishing measurement invariance in the models—a statistical property that indicates that the same underlying construct is being measured across the domains (Adolf et al. 2014; Bialosiewicz et al. 2013). More details on each of these analysis processes and their results are provided below.

4.3.1 Determining the suitability of our data

Using the KMO sampling adequacies and the Bartlett Test of Sphericity, we determined the suitability of our data before proceeding with the analysis. Our results show that the KMO was 0.894, well above the recommended value of 0.6. The Bartlett Test of Sphericity was statistically significant ($\chi^2(190) = 6713.278$, $p < 0.0001$). These results show that our data were suitable for further analysis (Kupek 2006).

4.3.2 Measurement model

After determining the suitability of our data, we used PLS-SEM to develop models showing the relationship between the personality types and the persuasiveness of the strategies in each domain separately. Figure 3 shows an overview of the general model. PLS-SEM is a recommended technique for modelling relationships between variables (Kupek 2006). According to Hair et al. (2019), the PLS-SEM is preferred "when the structural model is complex and includes many constructs, indicators and/or

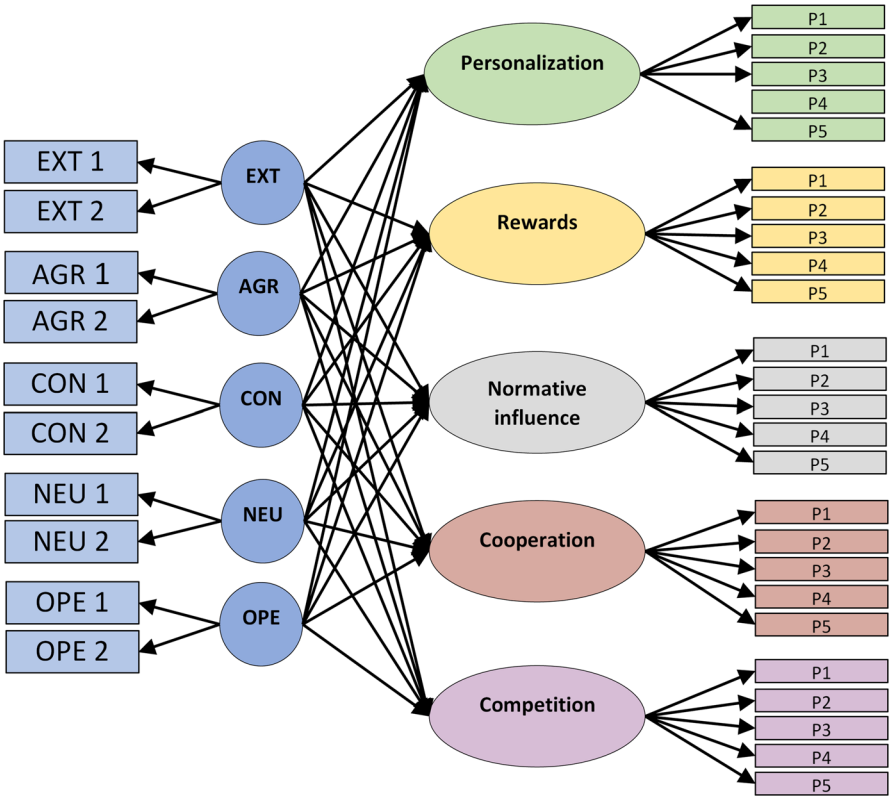

Fig. 3 PLS-SEM model structure for each domain. (P1–P5 = Rating responses of the five persuasiveness scale questions; EXT 1, EXT2 … OPE 1, OPE 2 = Rating responses to the two personality scale questions for each personality trait)

model relationships". As recommended, we validated the measurement model before estimating the structural paths to test for the relationship between the variables using the criteria suggested for assessing PLS-SEM model validity and reliability (Hair et al. 2017). Specifically, we performed PLS-SEM model validity and reliability checks using a set of common criteria as shown below and in the "Appendix".

(i) *Indicator reliability* Internal reliability assesses the consistency of results across items within a test. Our examination of the indicator loadings of the models showed that they were all above the recommended value which is 0.7 (Chin 1998).

(ii) *Internal consistency* We assessed the internal consistency and reliability using composite reliability (CR) and Cronbach's alpha and all were higher than their threshold value of 0.7 (Chin 1998). The composite reliability and Cronbach's alpha is used to analyse the strength of each indicator's correlation with their variables.

(iii) *Convergent reliability* Convergent reliability refers to how closely each variable is related to other variables and other measures of the same construct. We also checked the data for convergent reliability by assessing average variance extracted (AVE) by the variables from its indicator items and all constructs have an AVE above the recommended threshold of 0.5 (Chin 1998).

(iv) *Discriminant validity* The Discriminant validity test is used to show that two measures that are not supposed to be related are in fact, unrelated. We assessed discriminant validity using the Heterotrait-Monotrait (HTMT) ratio of correlations and found that HTMT was all below the recommended limit of 0.9 (Chin 1998).

The measurement models yielded an acceptable value of all indices for PLS model validity and reliability. The tables in "Appendix" show the Cronbach's alpha, Composite Reliability, AVE, and HTMT values of the model for the two domains.

Finally, before we investigate for significant differences in the persuasiveness scores (path coefficient) of the strategies between the model for healthy eating and that of smoking cessation, there is a need to establish that we are not comparing dissimilar groups. We established measurement invariance following the three-step procedure established for PLS-SEM (Henseler et al. 2016). Measurement invariance in the models is a statistical property that indicates that the same underlying construct is being measured across the domains (Adolf et al. 2014; Bialosiewicz et al. 2013). We established (1) configural invariance which ensures that the same basic factor structure exists in all the groups, (2) compositional invariance (i.e., equal indicator weights), and (3) the equality of composite mean values and variances across groups.

To examine, for significant differences in path coefficient (Beta) across the two domains, we followed the method in Clogg et al. (1995); Sánchez 2009), which have been used in other works including (Orji et al. 2013c). After establishing invariance, we ran the PLS Algorithm and Bootstrap and recorded the Standard Error (SE) and Beta for each construct, which we used to calculate the pairwise t-statistics and corresponding p value to test for significant differences in beta (Clogg et al. 1995; Sánchez 2009), using pairwise comparison approach (Clogg et al. 1995; Sánchez 2009). A significant p value indicates a significant Beta difference across the two domains.

5 Results

In this section, we present results that answer our five research questions. We answer RQ1 by presenting the results of the effectiveness of the five persuasive strategies in the smoking cessation domain. We answer RQ2 by presenting the results of the effectiveness of the five persuasive strategies in the healthy eating domain. We answer RQ3 by presenting a comparison of the overall effectiveness of these strategies across the domains of healthy eating and smoking cessation. We answer RQ4 by showing the relationships between the five FFM personality factors and the persuasive strategies within each domain. We answer RQ5 by comparing the relationships between the five FFM personality factors and the persuasive strategies across the two domains. We also provide insights on why some strategies may appeal to people of certain personalities factors from participants' comments.

5.1 Effectiveness of the persuasive strategies

First, we examine the effectiveness of the persuasive strategies overall in each of the two domains. To do this, we computed the means of the persuasiveness for each of the five strategies in their respective domains. Our results showed that all the persuasive strategies were effective, as all the means were above the midpoint of 4.0. Comparing the effectiveness of the strategies between the two domains, our results reveal that all the strategies were more effective in the healthy eating domain than in the smoking domain. Below, we present detailed results.

5.1.1 The persuasiveness of the strategies in smoking cessation overall (RQ1)

To answer RQ1, the results of a one-sample t-test show that all the strategies were perceived as effective for promoting smoking cessation overall, $t(567) = 31.81$, $p = 0.0001$. As shown in Table 4 and Fig. 4, the means of the strategies are significantly above the midpoint of 4.0. Comparing the means of the persuasiveness scores for each of the strategies, cooperation followed by *personalization* emerged as the most preferred persuasive strategy for smoking cessation apps, while *normative influence* emerged as the least preferred.

Table 4 The averaged means of the effectiveness of the persuasive strategies in the smoking cessation domain

Smoking cessation	Mean	SD	Sig.
Personalization	5.436	1.1090	0.0001
Cooperation	5.477	1.1396	0.0001
Reward	5.414	1.2558	0.0001
Normative influence	5.374	1.3131	0.0001
Competition	5.402	1.3528	0.0001
Overall mean	5.421	1.0642	0.0001

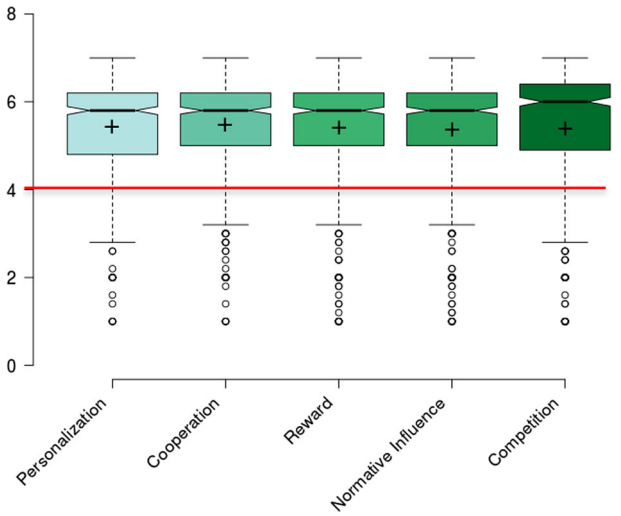

Fig. 4 The boxplot shows the overall persuasiveness (*y*-axis) of the 5 persuasive strategies (*x*-axis) for the smoking cessation domain on a scale of 1 to 7. A higher number indicates a higher persuasiveness. The horizontal line indicates a neutral value of 4

5.1.2 Comparing the persuasiveness of the strategies in healthy eating overall (RQ2)

To answer RQ2, the results of a one-sample t test show that all the strategies were perceived as effective for promoting healthy eating overall, $t(567) = 40.762$, $p = 0.0001$. As shown in Table 5 and Fig. 5, the means of the strategies are significantly above the midpoint of 4.0. Comparing the means of the persuasiveness scores for each of the strategies, *cooperation* followed by *personalization* emerged as the most preferred persuasive strategy for promoting healthy eating, while normative influence emerged as the least preferred.

Table 5 The averaged means of the effectiveness of the persuasive strategies in the healthy eating domain

Healthy eating	Mean	SD	Sig
Personalization	5.568	0.8955	0.0001
Cooperation	5.650	0.9759	0.0001
Reward	5.558	1.1288	0.0001
Normative influence	5.468	1.2354	0.0001
Competition	5.547	1.2316	0.0001
Overall mean	5.558	0.91104	0.0001

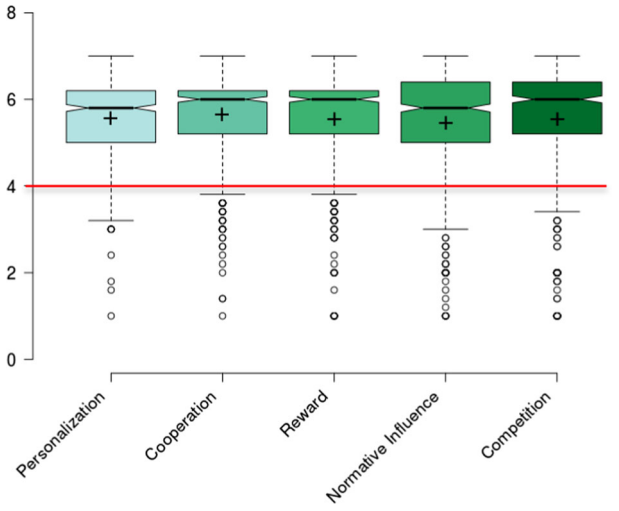

Fig. 5 The boxplot shows the overall persuasiveness (y-axis) of the 5 persuasive strategies (x-axis) for healthy eating domain on a scale of 1 to 7. A higher number indicates a higher persuasiveness. The horizontal line indicates a neutral value of 4

5.2 Comparing the persuasiveness of all the strategies (RQ3)

To answer RQ3, we conducted an RM-ANOVA with the strategies and domains as within-subject factors. The results of the RM-ANOVA show significant main effects of strategy type ($F_{3.373,\ 1912.533} = 3.902, p < 0.006$). This means that there are significant differences between the strategies with respect to their persuasiveness overall, without considering domains. The results also show significant main effects of domain type ($F_{1,\ 567} = 37.351, p < 0.0001$). This also means that there are significant differences between domains. There was also a significant interaction between the domain and strategy ($F_{3.889,\ 2205.121} = 1.145, p < 0.042$). This implies that the perceived effectiveness of a persuasive strategy may vary across domains. A Bonferonni-corrected pairwise comparison shows that cooperation emerged as the most preferred strategy in general, significantly different from *normative influence,* which emerged as the least preferred overall. The rest of the strategies—*personalization, reward*, and *competition*—were in the middle, with personalization leading the list. To understand if there are significant differences in the effectiveness of the strategies across the two domains overall, we performed a pairwise comparison of each of the strategies across the two domains. The results of the pairwise comparison show that all the strategies are significantly more persuasive in the healthy eating domains compared to the smoking cessation—*personalization* ($p < 0.0001$), *cooperation* ($p < 0.0001$), *reward* ($p < 0.0001$), *normative influence* ($p < 0.0003$), and *competition* ($p < 0.0001$) as shown in Figs. 6 and 7.

This implies that the strategies were perceived to be more effective with respect to their potential to promote healthy behaviours (healthy eating) in general, compared to discouraging risky or unhealthy behaviours (smoking cessation).

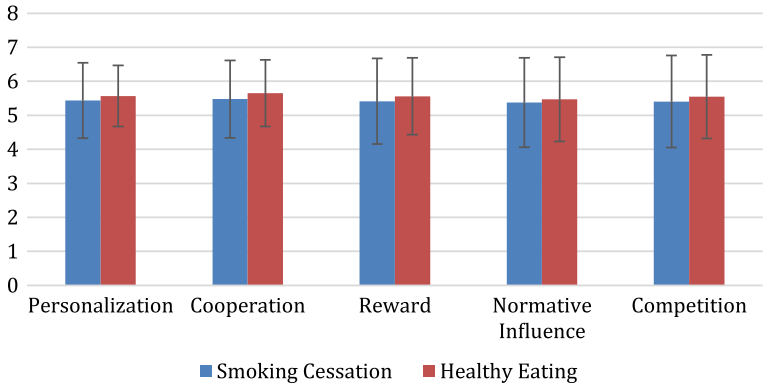

Fig. 6 Mean scores of the effectiveness of the strategies for healthy eating and smoking cessation

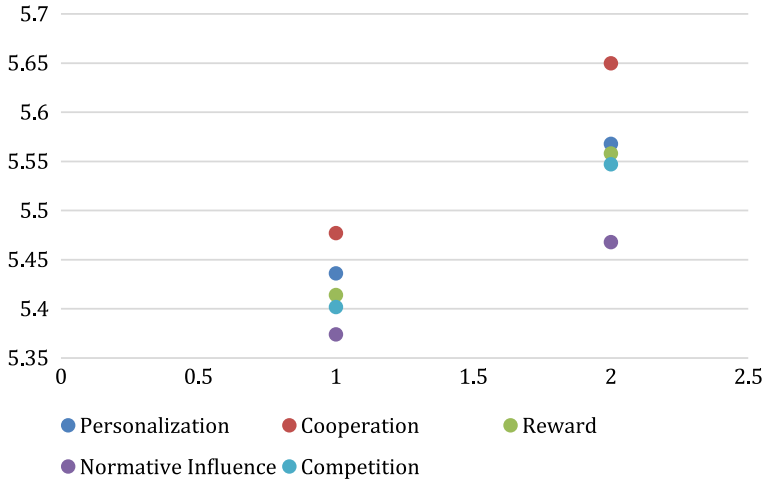

Fig. 7 Mean scores of the effectiveness of the strategies for healthy eating and smoking cessation

5.3 The structural model

The structural models determine the relations between the five personality traits from the FFM and the persuasiveness of the strategies (see Fig. 3). An important criterion to measure the strength of relationships between variables in structural models is to calculate the level of the path coefficient β (which measures the influence of one variable on another), and the significance of the path coefficient, p (Hair et al. 2011). The individual path coefficients (β) and their corresponding level of significance (p) obtained from our models are summarized in Tables 6 and 7.

Table 6 Standardized path coefficients and significance of the models for smoking cessation

Results for smoking cessation only					
Factors	AGR	CON	EXT	NEU	OPE
Competition	**0.26**	–	–	− 0.10	**− 0.26**
Cooperation	**0.27**	0.10	0.12	–	**− 0.21**
Normative influence	**0.24**	–	0.10	–	**− 0.39**
Personalization	**0.18**	0.10	**0.17**	− 0.10	**− 0.21**
Reward	**0.19**	–	0.11	− 0.11	**− 0.27**

Bolded coefficients are $p < 0.001$, non-bolded are $p < 0.05$ and '–' represents non-significant coefficients, where negative values represent demotivation and positive values represent motivation
AGR = Agreeableness, CON = Conscientiousness, EXT = Extraversion, NEU = Neuroticism, OPE = Openness to experiences

Table 7 Standardized path coefficients and significance of the models for healthy eating

Results for healthy eating only					
Factors	AGR	CON	EXT	NEU	OPE
Competition	**0.26**	0.12	–	–	**− 0.31**
Cooperation	**0.24**	**0.17**	0.11	− 0.12	− 0.11
Normative Influence	**0.20**	0.11	–	–	**− 0.33**
Personalization	**0.26**	**0.17**	0.12	**− 0.15**	**− 0.16**
Reward	**0.25**	0.10	0.14	− 0.10	**− 0.21**

Bolded coefficients are $p < 0.001$, non-bolded are $p < 0.05$ and '–' represents non-significant coefficients, where negative values represent demotivation and positive values represent motivation
AGR = Agreeableness, CON = Conscientiousness, EXT = Extraversion, NEU = Neuroticism, OPE = Openness to experiences

5.4 The effects of personality traits on the effectiveness of persuasive strategies

We developed structural models for each domain, with the personality traits as the exogenous constructs, see Fig. 3. In the following sections, first, we present the quantitative results from our models and supporting qualitative comments showing the relationship between the persuasive strategies and user personality traits in both healthy eating and smoking cessation domains separately (to answer RQ4). This is followed by a comparison of the effectiveness of the strategies across the two domains for the five personality traits (to answer RQ5).

5.4.1 Relationship between personality traits and persuasive strategies in smoking cessation (RQ4)

Generally, in the smoking cessation domain, the results from the structural model show that people's personalities influence the persuasiveness of individual strategies

(Table 6), where negative values represent demotivation by a strategy and positive values represent motivation by a strategy. In this section, we discuss and compare the persuasiveness of the strategies for people of different personality factors in the smoking cessation domain.

Competition

The *competition* strategy builds on the desire of individuals to compete with each other and prove to themselves and others that they are better. Our results show that for smoking cessation, *Competition* only motivates behaviour for people high in agreeableness ($\beta = 0.26, p < 0.001$). These findings are supported by qualitative comments from the participants that are high in agreeableness to justify their ratings.

"*The app makes it* ***fun****trying to quit smoking by allow us to compete against each other.*" [P17], "*The competition aspect of this app would make me more inclined to participate. I* ***enjoy****competition in apps*." [P95].

This comment suggests that people high in agreeableness preferred the strategy because it makes the system *fun* and increases their *enjoyment* and user experience. On the other hand, competition demotivates behaviour for people who are open to experiences ($\beta = -0.26$, $p < 0.001$) and high in neuroticism ($\beta = -0.10$, $p < 0.05$), which implies that it would likely motivate people closed to experiences and emotionally stable people. Their primary reason is that they do not like competing in gamified health-related apps and would rather compete in entertainment games. This is evident from the following comments are from participants high in neuroticism.

"*I don't like apps with a competitive aspect unless they are* ***actual games***." [P1] "*How many points others get doesn't motivate me at all.*"[P113].

Cooperation

The *cooperation* strategy builds on the desire of humans to work together towards achieving goals. Our results revealed that this strategy appeals to people who are high in agreeableness, conscientiousness, and extraversion ($\beta = 0.27$, $p < 0.001$), ($\beta = 0.10$, $p < 0.05$), ($\beta = 0.12$, $p < 0.05$), respectively. One reason why the strategy is preferred is that people do not like disappointing others, hence working with others make them *accountable* and *committed* to their health behaviour goal, as evident in the following comments from people who are high in agreeableness, conscientiousness, and extraversion respectively:

"*I like the idea of having another person to keep you* ***accountable***." [P370] "*I think the cooperation aspect makes it* ***more compelling****than just a social network kind of thing. I'd like to work with a team to beat another team*" [P544]. "*I would not want to* ***let my partners down****on the app*"*[P36].*

The *cooperation* strategy does not appeal to neurotic people and is negatively associated with people who are open to experiences, as is shown by comments from people high in neuroticism:

"*I'm not motivated by the actions of others nor am I interested in earning points*." [P382]. "*It isn't personal and not tailored to me, I like to do things on my own*" [P222].

The comments show that these personality factors, especially neurotic people, would not prefer to work with other people. It is evident since neurotic people have more tendency to be shy, anxious, angry, and depressed.

Normative influence

The *normative influence* strategy, which provides a means of gathering people with similar goals to facilitate behaviour performance, appealed to people high in agreeableness ($\beta = 0.24$, $p < 0.001$) and extraversion ($\beta = 0.10$, $p < 0.05$), which implies that it may likely demotivate people low in agreeableness and introverted people. From participants' comments, the strategy motivates people high in extraversion and agreeableness mainly because stories from other users give them a feeling of *hope*, *determination, and* serve as a kind of peer support, motivating them to work towards overcoming their smoking addiction, as can be seen in the following comments from people high in agreeableness and extraversion respectively:

"*Reading others' success and how they accomplished it would give me* ***hope****that I also could do it*." [P391]. "*I am a big believer of* ***peer support****. I also know some groups are more useful than others.*" [P198].

However, this strategy showed no appeal to people with neurotic and conscientious personality factors and demotivates people who are open to experiences, ($\beta = -0.39$, $p < 0.001$). The reasons for these results can be seen in the comments by people open to experience below:

"*Too many stories like this on the internet, I would not sign up for it*." [P281]. "*All these tips are well-known for every smoker have a place to read them is not helpful*" [P270].

The two comments suggest that *normative influence* may not motivate these personalities because they feel the stories are common and there is nothing special about them anymore that will motivate them to quit smoking; therefore, seeing them in the app would have no impact on them.

Personalization

The *personalization* strategy, which involves tailoring system features and contents to user preferences, appeals to people high in agreeableness, conscientiousness, and extraversion ($\beta = 0.18$, $p < 0.001$), ($\beta = 0.10$, $p < 0.05$), and ($\beta = 0.17$, $p < 0.001$). Some reasons why *personalization* appeals to these personalities is that it makes the system *simple*, gives users some *flexibility*, *offer tangible* and *manageable goals* in line with user's ability and behavioural pattern, as pointed out in the following comments by people high in agreeableness and conscientiousness:

"*The proposal of a* ***flexible plan****increases my interest in the application, in addition, I can see that its use is* ***simple***." [P402] "*I like* ***tangible goals****. Its not cold turkey but decreasing cigs, which seems more* ***manageable***." [544].

On the other hand, the *personalization* strategy is negatively associated with people high in neurotic tendencies and people open to experience, ($\beta = -0.10$, $p < 0.05$), ($\beta = -0.21$ $p < 0.001$), respectively. These personality traits pointed out that creating a personalized plan and acting on the plan are two different things. They did not see the need for a personalized plan if they are not motivated to act on them, as shown in the following comments by people high in neurotic tendencies and people open to experience respectively:

"*I don't think some simple words would motivate me enough to keep using this app*" [P351]. "*This is just giving a plan……. why do I need app for this…*" [P381].

Reward

The *Reward* strategy, which incentivizes users for achieving specific milestones towards the desired behaviour, appeals to people high in agreeableness and extraversion ($\beta = 0.19$, $p < 0.001$) and (0.11, $p < 0.05$), respectively. Some reasons for the preference for *reward* is that it gives users a sense of *accomplishment, motivate and encourage* them, make them exercise some *self-control* and be *determined,* as can be seen from the following comments by people high in agreeableness and extraversion, respectively:

"*I would use this app every day. I love apps with rewards and a sense of* ***accomplishment****. This would* ***encourage****me to participate and use the app*." – [P95] "*Rewards* ***motivate****everyone to put in their best. Having such a feature in the app can help me be more* ***self-control****and* ***determined****to quit smoking*" [P343].

Surprisingly, *reward* is not a significant motivator for conscientious people and may demotivate behaviour for neurotic people and people that are open to experience, ($\beta = -0.11$, $p < 0.05$) and ($\beta = -0.27$, $p < 0.001$) respectively. A reason for the negative association with reward is that these personalities have no appreciation for badges as rewards in general, they feel badges are meaningless, as shown in these comments by people high in neuroticism:

"*Virtual badges just really aren't that interesting to me personally*" – [P120] "*I hate these badges and don't want them at all. I don't want badges that mean nothing to me*." [P447].

Reward needs to be carefully thought out to ensure that they are meaningful to the users else they lose their value or excitement factor.

5.4.2 The relationships between personality and persuasive strategy in healthy eating (RQ4)

In the healthy eating domain, the results from the structural model show that people's personalities influence the persuasiveness of individual strategies (Table 7), where negative values represent demotivation by a strategy and positive values represent motivation by a strategy. In this section, we discuss and compare the persuasiveness of the strategies for people of different personality traits in the healthy eating domain.

Competition

Our results show that for the healthy eating domain, *Competition* motivates behaviours for people high in agreeableness ($\beta = 0.26$, $p < 0.001$) and conscientiousness ($\beta = 0.12$, $p < 0.001$). Some reasons for the preference for *competition* by these personality factors is that it *challenges* and *motivates* people, makes them *work harder* and be more *determined*, as shown in the comments by people high in agreeableness and conscientiousness:

"*This app would motivate me to eat healthier because it would make me want to* ***work harder****and be at the top of the leaderboard*." [P17], "*Setting up a* ***challenge****with your co-workers/peers can help keep you* ***motivated****and achieve your goal with more*

dedication." [P153] "*I believe that the competition and the goals would attract* ***my attention****and make me be* ***focused***"[P90].

Interestingly, *competition* is not a significant motivator for neurotic and extroverted people while it is negatively associated with people who are open to experience, ($\beta = -0.31, p < 0.001$). Some reasons why this strategy is unappealing and negatively associated with this personality is their belief that *competition* (leaderboard) is a *scam* due to the tendency of people to *cheat* whenever competition is introduced. Again, seeing some really high scores earned by others which may seem unattainable *demotivates*, as shown in one of the comments by people high in neuroticism.

"*Leaderboards are a* ***scam****. There's always some jerk who has 10,000 times more points than everyone else and it is apparent they're* ***cheating****. Nothing* ***deflate****s an honest person more than seeing* ***unattainable results****by the person holding first place.*" [P123] "*I don't know, (there is)* ***nothing motivating****about it to continue.*"[P44].

Therefore, it is important that developers of persuasive systems set up mechanisms to prevent cheating in the system. The systems should be able to monitor the activities of users to detect dubious and malicious actions of users to trick the system.

Cooperation

The *Cooperation* strategy for the healthy eating domain appealed to people high in agreeableness, conscientiousness, and extraversion ($\beta = 0.24, p < 0.001$), ($\beta = 0.17, p < 0.001$), and ($\beta = 0.11, p < 0.05$), respectively. The participants believe that working together with other people would make them more *accountable, focused* and *incentivized* as can be seen from the comments by people high in agreeableness and extraversion, respectively:

"*I think that the combination of teaming up with someone would hold a person more* ***accountable****. The bonus points are another great way to create* ***incentives****to change*."[P47] "*The idea of teaming up with someone is great*."[P553].

On the other hand, *cooperation* demotivates neurotics and people who are open to experience, ($\beta = -0.12, p < 0.05$) and ($\beta = -0.11, p < 0.05$), respectively. A major reason for the negative association with *cooperation* by these personalities is that they feel that working with people especially *strangers demotivates* and is *challenging* as can be seen by the comments from people high in neurotics and open to experience, respectively:

"*Working with others particularly those I do not know,* ***does not motivate****me and might even* ***de-motivate****me to use the app*." [P471] "*There should not be any* ***challenges****. it's our duty to flow the healthy diet*." [P72].

Some participants prefer not to work with others, especially strangers, while some believe that the challenges it introduces are just unnecessary, maybe because of the pressure of not disappointing their partners.

Normative influence

Normative influence appealed to people high in agreeableness ($\beta = 0.20, p < 0.001$) and conscientiousness ($\beta = 0.11, p < 0.05$). Similar to the smoking domain, participants feel that the testimonies of other people would highly *encourage* them to pursue their healthy eating goals, make them *feel less alone*, and gives them the opportunity to *share their success stories*, as shown in the comments from people high in agreeableness and conscientiousness:

"*Testimonies like the above can encourage me not to get easily* ***discouraged****in my quest to eat healthily*." [P343] "*This app would help me to feel* ***less alone****in achieving my endeavours to lose weight*" [P546] "*Would very much like to* ***share my so-called success story****with others…*" [P535].

The strategy is not a significant motivator for neurotic and extraverted people, and it demotivates behaviour for people who are open to experiences ($\beta = -0.33$, $p < 0.001$). Below are some of the comments against the *normative influence* strategy by these personalities:

"*I don't know that I want to read about other users. They could just be company* ***marketing pushes instead of real users***" [P204] "*Could be* ***Fake News"*** [P515] "*I am sorry, but I feel social media is* ***detrimental to bad habits****since it is one. I feel like a community share space like this would make me hesitate to post especially if I had strong opinions on healthy versus non-healthy foods.* ***Social media deters me from following food plans***." [P471].

As can be deduced from these comments, some of the reasons for not preferring this strategy is participants' scepticism about the stories presented. They are worried about the *authenticity of the stories*, they may just be marketing strategies by companies to make them buy health products or just *fake news*. They also believe that forums like this resemble social media and may be *detrimental to healthy habits*. This is in line with one of the characteristics of neurotic people, they tend to be more self-conscious than other traits. Also, people are sceptical about social media and sharing their healthy eating stories there, as illustrated by P471.

Personalization

The *personalization* strategy appealed to people high in agreeableness, conscientiousness, and extraversion, ($\beta = 0.26, p < 0.001$), ($\beta = 0.17, p < 0.001$), and ($\beta = 0.12, p < 0.05$) respectively in the healthy eating domain. The main reason for the positive association with this strategy by these personalities is that it *convinces* them, make them *more aware* of their behaviours, and *offer personalized goal* that makes them *thrive*, as can be seen in the comments from people high in extraversion and conscientiousness:

"*Simply putting the goals in an easily viewed format* ***might convince****me to be* ***more aware****of what I am eating*." [P113]. "*I* ***thrive****when faced with a* ***goal-orientated****interface like this. It looks good*." [P256].

On the other hand, *personalization* is negatively associated with neurotic people and people who are open to experiences in the healthy eating domain, ($\beta = -0.15$, $p < 0.001$) and ($\beta = -0.16$ $p < 0.001$) respectively. These participants feel that just presenting them with personalized healthy eating goals and suggestions would *not be motivating enough* for them to adopt the healthy eating behaviour while some participants were *sceptical* about their *privacy and losing control with the tracking*, since the app collects their personal information for the personalization purposes, as illustrated in the comments from people high in neuroticism:

"*Telling me what my goal should be* ***does nothing to actually motivate****me towards it. I could always figure out what calories or fats or whatever I should be taking in but it still doesn't do much to help me actually put anything into practice.*" [P447] "*Basically I* ***don't believe tracking apps****, that's why I stop using fitness bands. All things should be our* ***control only***." [P72].

5.5 Differences in the effectiveness of strategies across domains for the personalities (RQ5)

To answer RQ5, Table 8 shows a comparison of the effectiveness of the five persuasive strategies between the two domains for the five personality traits. The highlighted pairs of coefficients are significantly different for the personality type across the two domains—healthy eating (E) and smoking cessation (S), where negative values represent demotivation by a strategy and positive values represent motivation by a strategy.

5.5.1 Agreeableness

For people high in the agreeableness trait, the results from examining for significant differences in path coefficient (β) using the well-established approach (Clogg et al. 1995; Orji et al. 2013c; Sánchez 2009) show that only the *personalization* strategy showed a significant difference in its effectiveness across the two domains for this personality type. While *personalization* is generally effective for agreeable people in both domains, it is significantly more effective for people who are high in agreeableness in the healthy eating domain compared to the smoking cessation domain. In general, all the strategies except *personalization* are equally effective at promoting healthy eating and discouraging smoking for people high in agreeableness, see Table 8.

5.5.2 Conscientiousness

There are significant differences in the effectiveness of all strategies across the two domains for conscientious people. *Competition*, *Normative influence*, and *Reward* are

Table 8 Standardized path coefficients and significance of the models

Factors	AGR	CON	EXT	NEU	OPE
Competition-S	0.26	**–**	–	**– 0.10**	**– 0.26**
Competition-E	0.26	**0.12**	0.–	**–**	**– 0.31**
Cooperation-S	0.27	**0.10**	0.12	**–**	**– 0.21**
Cooperation-E	0.24	**0.17**	0.11	**– 0.12**	**– 0.11**
Normative influence -S	0.24	**–**	**0.10**	–	– 0.39
Normative Influence -E	0.20	**0.11**	**–**	–	– 0.33
Personalization- S	**0.18**	**0.10**	0.17	– 0.10	– 0.21
Personalization- E	**0.26**	**0.17**	0.12	– 0.15	– 0.16
Reward- S	0.19	**–**	0.11	– 0.11	– 0.27
Reward-E	0.25	**0.10**	0.14	– 0.10	– 0.21

Bolded paired coefficients are significantly different $p < 0.05$ and '–' represents non-significant coefficients. "…E = Eating Behaviour"; "…S = Smoking" where negative values represent demotivation and positive values represent motivation

AGR = Agreeableness, CON = Conscientiousness, EXT = Extraversion, NEU = Neuroticism, OPE = Openness to experiences, "…E = Eating Behaviour"; "…S = Smoking"

significantly effective for promoting healthy eating for people high in the conscientious personality factor but are not significant for promoting smoking cessation for the same personality factor. On the other hand, *Cooperation* and *Personalization* although are positively associated with behaviour change in both healthy eating and smoking cessation domains, they are significantly more effective for promoting healthy eating for people high in conscientious personality traits, as shown in Table 8.

5.5.3 Extraversion

Only *Normative Influence* shows a significant difference between the two domains for people with the extraversion personality trait. Interestingly, *normative influence* is significantly effective for extraverted people in the smoking cessation domain but not effective in the healthy eating domain. *Competition* is not effective for this personality factor in any domain, as shown in Table 8.

5.5.4 Emotionally stable (opposite of Neuroticism)

Competition and *Cooperation* show significant differences across the two domains for people who are high in emotional stability (opposite of Neuroticism). *Competition* is significantly effective for promoting smoking cessation while it is not significant in the healthy eating domain for this personality type. On the other hand, *Cooperation* is significantly effective in the healthy eating domain but not significant in the smoking cessation domain for emotionally stable people, as shown in Table 8.

5.5.5 Closedness to experiences (opposite of openness)

This personality trait shows significant differences in their association with the *Competition* and *Cooperation* strategies across the two domains. *Competition* although effective for the two domains is significantly more effective in the healthy eating domain than in the smoking cessation domain for people high in closedness to experience. Similarly, *Cooperation* is effective in the two domains but it is significantly more effective for promoting smoking cessation than in the healthy eating domain, as shown in Table 8.

5.6 Summary of the Personality and Persuasive strategy relationships

Overall, agreeableness, extraversion, and conscientiousness personality factors emerged as the personality types that are most responsive to the persuasive strategies overall. Openness and neuroticism emerged as the least responsive, with openness being negatively related to all the strategies while neuroticism is negatively associated with most of the strategies. In general, the strategies are more effective in the healthy eating domain overall than the smoking cessation for different personality types.

6 Discussion

According to the Persuasive System Design (PSD) model (Oinas-Kukkonen and Harjumaa 2009), the effectiveness and generalizability of persuasive strategy implementations are dependent on a lot of user and usage context-related factors, including the target domains of behaviour change and user personality traits. So far, research attention has majorly focused on investigating user-related factors that impact the effectiveness of the persuasive strategies and hence inform the tailoring of persuasive gamified systems to various users and user groups. In line with this, research has investigated the impact of user characteristics such as age groups (Oyibo et al. 2017b; Velsen et al. 2019), gender groups (Oyibo et al. 2017b; Vries et al. 2017), gamer types (Orji et al. 2013c), gamification user type (Orji et al. 2018), and personality types (Anagnostopoulou et al. 2017; Orji et al. 2017d). However, little or no research has investigated how and whether usage factors, such as differences in the application domain, impacts the effectiveness of the strategies for different personality types. Our research is the first to investigate the combined effect of user-dependent factors (personality types) and usage context-dependent factors (different application domains) to establish the generalizability of the strategies or not and develop guidelines for tailoring persuasive gamified systems that take both the target user personality and application domains into account.

Overall, our study shows that the effectiveness of persuasive strategies is domain-dependent. This implies that a persuasive strategy implemented identically across multiple domains may likely not have the same persuasive effect on users in each domain. The usage context or domain of persuasion plays an important role in the effectiveness of persuasive systems since every context always possesses some peculiarity that may confound the potential of persuasive strategies in promoting behaviour change. This further emphasises the importance of tailoring persuasive systems not only to users but also to the context of usage.

We also observe that the personality factors of users can greatly contribute to the effectiveness of persuasive strategies. This highlights the important role that personality factors play in determining the effectiveness of persuasive strategies for certain individuals. For example, McElroy et al. (McElroy et al. 2007) posit that "firms that can understand their customers' personality and buying behaviour will have a competitive advantage in the marketplace" (McElroy et al. 2007). Furthermore, we have shown that even when persuasive strategies are implemented the same way across two domains, personality factors may still cause significant variations in the effectiveness of the majority of the persuasive strategies employed. This implies that a persuasive system targeted at one domain and designed for a specific user that is high in a personality factor may not be effective for the same user if the system targets another domain. Our findings highlight the need to consider the application domain alongside the people's personalities for tailoring persuasive gamified systems. Our findings can inform design decisions on which persuasive strategy to employ and which to avoid when designing persuasive gamified systems for people of different personalities targeting distinct domains.

In the following sections, we discuss how our findings can be applied in developing persuasive gamified systems (targeting a specific domain or multiple domains) to

appeal to the audience of a specific personality trait and a broader audience with various personality traits.

6.1 Designing for users with a specific personality type across multiple domains

Although our results show that significant differences exist with respect to the effectiveness of the strategies across domains for people of various personality factors, it also reveals occurrences where the effectiveness of the strategies generalizes across domains for various personalities. Here, we discuss opportunities and design implications for employing the strategies to design systems across domains for various personalities.

Our results show that people high in agreeableness perceive all the strategies as effective irrespective of the domain of application (although at varying degrees). This is in line with previous research that found that the agreeableness personality factor is the most responsive to the persuasive strategies overall in the area of risky alcohol behaviour change (Anagnostopoulou et al. 2017; John and Srivastava 1999; Orji et al. 2017d). It also aligns with the characteristics of this personality trait. They tend to be more compliant, modest, and tender-minded, tolerant, considerate of both people and new ideas. Therefore, to design persuasive gamified systems targeting any domain to appeal to people who are high in agreeableness, designers could employ *competition, cooperation, personalization, reward,* and *normative influence*, listed in decreasing order of preference to motivate behaviour change. There are various ways these strategies can be integrated and operationalized in persuasive gamified apps. For example, *competition* can be implemented as *leaderboards* that display high scores or *status* that shows the *rank* or *levels* of players. *Reward* can be operationalized in a way that players receive *virtual items* such as *points* or *badges* and can level up and gain new abilities (Fritz et al. 2014; Ganesh et al. 2014; Katule et al. 2016). *Personalization* can be implemented using either system-controlled or user-controlled adaptation approaches. The system-controlled approach automatically adjusts system features to better suit and support users, while the user-controlled approach provides customizable features but relies on the user to adapt the features as they desire to suit them (Findlater and McGrenere 2004; Orji et al. 2017a). It can be operationalized in various ways including as *personalized goal recommendation* (Dantzig et al. 2018; Marcu et al. 2018), *personalized activity* recommendation (He and Agu 2014), *personalized motivational content* (Dantzig et al. 2018; Schafer et al. 2018*), personalized Intervention timing* (Francillette et al. 2018) or a combination of them (Aldenaini et al. 2020b).

Similarly, our results also show that *cooperation* and *personalization* are perceived as positive by people high in conscientiousness irrespective of the domain. *Cooperation* is effective for this personality factor due to their tendency to be orderly and self-disciplined. To effectively work together with people, orderliness is required. Therefore, to design persuasive gamified systems to appeal to people who are high in consciousness, designers could employ *cooperation* and*personalization* to promote behaviour change irrespective of the target domain.

For extraverted people, our results show that *cooperation, personalization* and *reward* are strong motivators of behaviour change across domains. Therefore, when designing persuasive gamified systems to appeal to people high in extraversion, designers should employ the *cooperation, personalization* and *reward* strategy irrespective of the domain.

With respect to the most effective strategy for designing persuasive gamified systems to appeal to each personality type across the two domains; *Competition* is the most effective for designing for agreeableness across the two domains, *Cooperation* and *Reward* are equally effective for designing for conscientious people across domains, and *Personalization* emerged as the most effective strategy for designing for people high in extraversion. These strategies should be preferred to any other strategy (investigated in this paper) for designing systems across domains for the distinct personality types.

In line with previous research (Orji et al. 2017d), our findings reveal that all the personality factors showed variability in the effectiveness of persuasive strategies. Extraversion, agreeableness, conscientiousness is significantly and positively related with most strategies while openness is negatively associated with all the strategies. Therefore, to achieve personality-based tailoring, 'it is necessary to differentiate participants based on these traits (at least)' (Orji et al. 2017d).

6.2 Designing persuasive systems tailored to both specific personality types and domain

Domains of persuasive technology can broadly be divided into two depending on their behavioural change objectives: (1) Persuasive systems for promoting safe behaviours such as healthy eating; (2) Persuasive systems for discouraging risky behaviours such as smoking cessation.

Although designing persuasive gamified systems to cater for a broader audience is the conventional approach because it saves time and resources required to create separate or adaptive systems for a diverse audience, however, there are situations in which tailoring persuasive gamified systems for personalized user experience is appropriate. In line with this, research has shown that tailoring persuasive gamified systems increases their persuasive appeal and effectiveness (Kaptein et al. 2012b; Orji et al. 2013c). Tailoring allows designers to design system elements that are specifically effective for a target personality trait in a target domain. Our results highlight opportunities where the tailoring of persuasive strategies to both the personalities and application domain might be appropriate. In this section, we discuss opportunities and design implications for tailoring to both personalities and domains based on findings.

For extraversion, our results reveal that the major difference between promoting healthy eating behaviour and smoking cessation is their preference for the *normative Influence* strategy. People high in extraversion have a strong preference for normative influence in smoking cessation. However, normative influence is not significant for this personality in healthy eating. That means that people high in extraversion are more likely to be motivated to adopt healthy eating behaviour by persuasive gamified applications employing the *normative influence*, however, they may not be motivated to

quit smoking by applications employing the *normative influence* strategy. Therefore, to design persuasive gamified applications for promoting healthy eating behaviour targeted at people high in extraversion, designers could employ the *normative influence* strategy. However, *normative influence* may not be effective for promoting smoking cessation for this personality, so designers could avoid it.

Similarly, our results show that people high in conscientiousness differ significantly across the two domains with respect to their preference for all the five strategies. Although both *Cooperation* and *Personalization* emerged to be effective across the two domains, they are more effective for promoting healthy eating than for smoking cessation for people high in conscientiousness. However, a major differentiator between the two application domains for people high in conscientiousness is their preference for the *Competition*, *Reward* and *Normative Influence* strategies. These strategies are significantly associated with conscientiousness in healthy eating and therefore is more likely to be motivated by systems employing these strategies. However, these strategies are not significant for promoting smoking cessation for people high in conscientiousness. Therefore, to design persuasive gamified applications to promote healthy eating behaviour for people high in conscientiousness, designers could employ the *Competition*, *Reward* and *Normative Influence* strategy. However, these strategies may not be effective for promoting smoking cessation for this personality, designers should probably avoid using them.

For people high in agreeableness, our results show that although *Personalization* showed to be effective in both domains, they are more effective for promoting healthy eating than for smoking cessation. The *personalization* strategy is one of the most effective strategies for promoting healthy eating and smoking cessation among agreeable people, although it is less effective in smoking cessation. Therefore, although designers could employ the *Personalizatio*n strategy when designing persuasive gamified systems across domains, they should be among the top priority in healthy eating domains and should be emphasized.

Surprisingly, our results show that people high in openness and neuroticism are unlikely to be motivated to adopt healthy behaviours by employing any of the five strategies investigated in this paper. This is in line with previous research (Orji et al. 2017d). A possible explanation is that the most commonly used strategies are not appropriate for people high in openness and neuroticism (Orji et al. 2017d). Hence, persuasive researchers should explore openness and neuroticism-oriented strategies. It is also that persuasion may not work for these personality traits as persuasion may not work for everyone, "there is a limit to what and who can be persuaded to adopt healthy behaviour using the persuasive strategies." (Orji et al. 2017d). Therefore, for people high in openness and neuroticism personality type, persuasion may not be an effective approach for motivating behaviour change irrespective of the domain.

There are many ways our results can be used to inform the tailoring of persuasive gamified systems design, we have highlighted a few here as examples. Table 8 details the relations between the strategies and personality traits across healthy eating and smoking cessation domains. It could guide design choices for tailoring persuasive gamified systems considering both the personality type and the application domains.

6.3 Other design implications

The *reward* strategy is one of the most frequently employed strategies in persuasive gamified systems. Our findings reveal that reward is not an effective strategy for people high in conscientiousness in the smoking cessation domain and is likely to demotivate behaviours for people high in openness and neuroticism in both healthy eating and smoking cessation domains. Our qualitative results show that these personalities feel that rewards such as achievement badges and points as used in many persuasive gamified apps has no real-world value. The negative comments against *rewards* are centred around the fact that there is *no real-world value*, which makes the app unrealistic, hence incapable of motivating them to change their behaviour as shown in comments: "*Badges* ***don't offer anything of value****. You can't do anything with badges. They're a waste of time.*" – [P123] "*I do not think it will motivate me, showing what we earn in badges it is just like a game* ***not realistic***"- [P171] "*The rewards are okay, but they don't really seem to do anything other than tell me that I did something some number of times.*" [P118]. This is in line with previous research that found that reward was not effective for some user types (Orji et al. 2014). In fact, the use of rewards especially tangible rewards to motivate behaviour change has been a controversial issue in the literature. Research has pointed out the potential of (tangible) reward (such as money) to redirect the intention of any behaviour and refocus the benefit to the real value of the reward (Colineau and Paris 2011; Orji et al. 2013a). Therefore, when designing persuasive gamified systems for people high in openness and neuroticism, designers can avoid using the reward strategy entirely or find a way to tie the reward to something meaningful to the user. However, designers should avoid offering money as a reward to create meaning and motivate behaviour change. Recent research has shown that offering money as a form of *reward* will either not have any effect or be detrimental to behaviour change, decreases intrinsic motivation (Cherubini et al. 2020).

Our findings show that cooperation demotivates neurotics and people who are open to experience. Based on our qualitative results, a major reason for the negative association with cooperation by these personalities is that they feel that working with people especially *strangers demotivates* and is *challenging* as can be seen by the comments below:

"*Working with others* ***particularly those I do not know****,* ***does not motivate****me and might even* ***de-motivate****me to use the app*."[P471] Some participants prefer not to work with others especially strangers, while some believe that the challenges it introduces are just unnecessary, maybe because of the pressure of not wanting to disappoint their partners. Therefore, we suggest that when designing for persuasive gamified apps targeting people who are open to experience and neurotics, designers should avoid cooperation and if they have to use it, they should provide mechanisms to allow users to choose friends and family they would like to work with. Previous research shows that some people prefer to work with strangers in their behaviour change journey (Orji et al. 2017d). Our findings extend this previous research by showing that people who are open to experience and neurotics are not part of those who prefer to work with strangers**.**

On the other hand, *personalization* is negatively associated with emotionally unstable people (neurotic) and people who are open to experiences irrespective of the domains. According to our qualitative results, these participants feel that providing just personalized content, goals, and suggestions would not be enough to motivate them to adopt the desired behaviour while some participants were *sceptical* about their *privacy and losing control with the tracking* often associated with personalization. This suggests that the personalization strategy may need to be implemented alongside other complementary strategies that are more likely to engage users and motivate them towards behaviour change. Therefore, designers should employ personalization together with complementary strategies to motivate behaviour change. Research has shown that social support strategies such as *competition* and *cooperation* work well with other strategies (Burke et al. 2009). To overcome privacy concerns and loss of control due to tracking associated with system-controlled personalization, we suggest that when designing for conscientious and openness individuals, designers should employ the user-controlled approach that provides some personalization affordances but allows the user to use them to personalize systems to suit their preferences. This gives them control and eliminates or minimizes the need for tracking their personal data.

Our results show that *competition* is not a significant motivator for neurotic and extraverted people while it is negatively associated with people who are open to experience Some reasons why this strategy is unappealing and negatively associated with these personalities is their belief that competition (leaderboard) is a *scam* due to tendency of people to *cheat* whenever competition is introduced. Again, seeing some really high scores earned by others which may seem unattainable *demotivates*, as shown in the comment below.

"*Leaderboards are a* ***scam****. There's always some jerk who has 10,000 times more points than everyone else and it is apparent they're* ***cheating****. Nothing* ***deflate****s an honest person more than seeing* ***unattainable results*** *by the person holding first place.*" [P123].

Therefore, we recommend that when employing competition in persuasive gamified systems, designers implement mechanisms to deter or reduce people from cheating and build people's trust in the system. "One way to reduce cheating is to automatically monitor users' behaviours using various sensors (that are capable of monitoring health behaviours in real-time) and avoid self-reporting of behaviours." (Orji et al. 2019). This can easily be achieved in behaviours such as physical activity but for those behaviours that cannot be automatically monitored, we recommend that designers emphasize the intrinsic benefit of behaviours to an individual's self. This may reduce the urge to cheat to outperform others and promote the desired behaviour (Orji et al. 2019). Again, designers should ensure fair comparison in persuasive gamified systems employing the *competition* strategy by not comparing dissimilar people. Pairing and matching people who are very distinct in ability and performance may be detrimental to behaviour change. It can lead to unbalanced *competition,* which may make the continuously winning relax (downward comparison) and the losing partner give up due to the wide performance margin. They can pair people at the same behaviour change stage or implement mechanisms to balance their performance and goals to match their levels.

6.4 Limitations

Our study was based on self-reported data of the participants' perceived persuasiveness of these strategies based on the prototype implementations. Previous work shows personalized application based on self-report was effective in motivating actual behaviour in various domains: eating, eCommerce, snacking, physical activity (Kaptein et al. 2012b; Orji et al. 2017b). Both explicit measures (self-assessment of strategies) and implicit measures (actual responses) are effective approaches to tailoring persuasive applications (Kaptein et al. 2012b). However, we acknowledge that the actual persuasiveness of these strategies may differ when implemented in apps and used over long periods. Therefore, we plan to examine the persuasiveness of the recommended strategies deployed in actual persuasive gamified systems targeting multiple domains and used over an extended period of time.

Although our study is based on the popular implementation of each strategy from the literature, there is a possibility that some less popular implementations may be more effective in some domains and for distinct personality types. Finally, while our results benefitted from a large-scale study of two distinct domains (smoking and eating) of behaviour change, it may not generalize to other behaviour domains and therefore should be applied with caution in these domains.

7 Conclusion

This paper investigated for possible application domain-dependent variations on the effectiveness of persuasive strategies for people belonging to different personality types, based on a large-scale study of 568 people. It contributes to the advancement of knowledge in the HCI field by showing that the effectiveness of persuasive strategies varies depending on both the application domain and target user personalities. Our research is the first to investigate the combined effect of user-dependent factors (personality types) and usage context-dependent factors (application domains) to establish the generalizability of the strategies or not, and develop guidelines for tailoring persuasive gamified systems that take both the target user personality and application domains into account. As a secondary objective, we provide qualitative insights based on users' comments to explain why distinct strategies may motivate behaviours for people belonging to a particular user type in one domain and demotivate others. Through our study, we uncovered the limitations of the untailored approach and tailored approaches that consider only the user characteristics but not the target application domains and presented recommendations for designing persuasive gamified systems that appeal to the personalities across domains and for tailoring to appeal to the personalities in a specific domain.

Our findings reveal that agreeableness emerged as the personality type that shows the least variability with respect to their response to the persuasive strategies across distinct domains, while conscientiousness showed the most variability. These must be taken into account to achieve application domain and personality-type-driven tailoring. Our findings could guide designers in making informed decisions on the strategies to employ and those to avoid when designing tailored persuasive and gameful systems.

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Availability of data and materials Not applicable.

Code availability Not applicable.

Declarations

Conflict of interest On behalf of all authors, the corresponding author states that there is no conflict of interest.

Appendix

The Cronbach's alpha, composite reliability, AVE, and HTMT of the model for the two domains (measurement validity and reliability checks)

Validity and reliability checks for the smoking cessation and healthy eating domain

	Smoking cessas-ion	Healthy eating	Smoking cessasion	Healthy eating	Smoking cessas-ion	Healthy eating
Variables	Cronbach alpha	Cronbach alpha	Composite reliabil-ity	Composite reliabil-ity	AVE	AVE
Threshold	≥ 0.7	≥ 0.7	≥ 0.7	≥ 0.7	≥ 0.5	≥ 0.5
Competition	0.918	0.911	0.938	0.933	0.753	0.736
Cooperation	0.888	0.857	0.918	0.897	0.691	0.636
Normative Infl	0.918	0.908	0.938	0.932	0.752	0.732
Personalization	0.877	0.820	0.910	0.874	0.670	0.580
Reward	0.908	0.893	0.931	0.921	0.730	0.699

HTMT values for smoking cessation

	Agr	Con	Ext	Neu	Ope	Com	Coo	Norm	Per	Rew
Agr										
Con	0.303									

	Agr	Con	Ext	Neu	Ope	Com	Coo	Norm	Per	Rew
Ext	0.256	0.205								
Neu	0.320	0.237	0.260							
Ope	0.203	0.124	0.273	0.265						
Com	0.392	0.220	0.253	0.291	0.385					
Coo	0.419	0.264	0.299	0.279	0.343	0.852				
Norm	0.384	0.188	0.296	0.294	0.505	0.686	0.730			
Per	0.345	0.256	0.332	0.295	0.351	0.622	0.803	0.685		
Rew	0.342	0.209	0.284	0.298	0.396	0.831	0.855	0.718	0.753	

Agr = Agreeableness, Com = Competition, Con = Conscientiousness, Coo = Cooperation, Ext = Extraversion, Neu = Neuroticism, Nor = Normative Influence, Ope = Openness, Per = Personalization, Rew = Reward

HTMT values for healthy eating

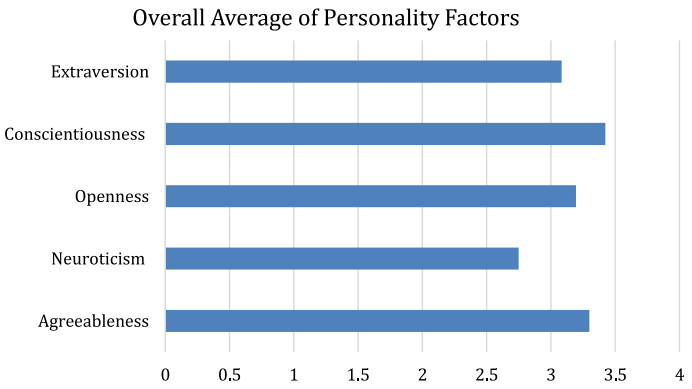
	Agr	Con	Ext	Neu	Ope	Com	Coo	Norm	Per	Rew
Agr										
Con	0.303									
Ext	0.256	0.205								
Neu	0.320	0.237	0.26							
Ope	0.203	0.124	0.273	0.265						
Com	0.400	0.266	0.247	0.256	0.417					
Coo	0.398	0.323	0.287	0.314	0.259	0.705				
Norm	0.449	0.282	0.297	0.276	0.462	0.676	0.643			
Per	0.463	0.356	0.342	0.38	0.340	0.595	0.809	0.651		
Rew	0.405	0.266	0.323	0.312	0.356	0.788	0.729	0.679	0.739	

Agr = Agreeableness, Com = Competition, Con = Conscientiousness, Coo = Cooperation, Ext = Extraversion, Neu = Neuroticism, Nor = Normative Influence, Ope = Openness, Per = Personalization, Rew = Reward

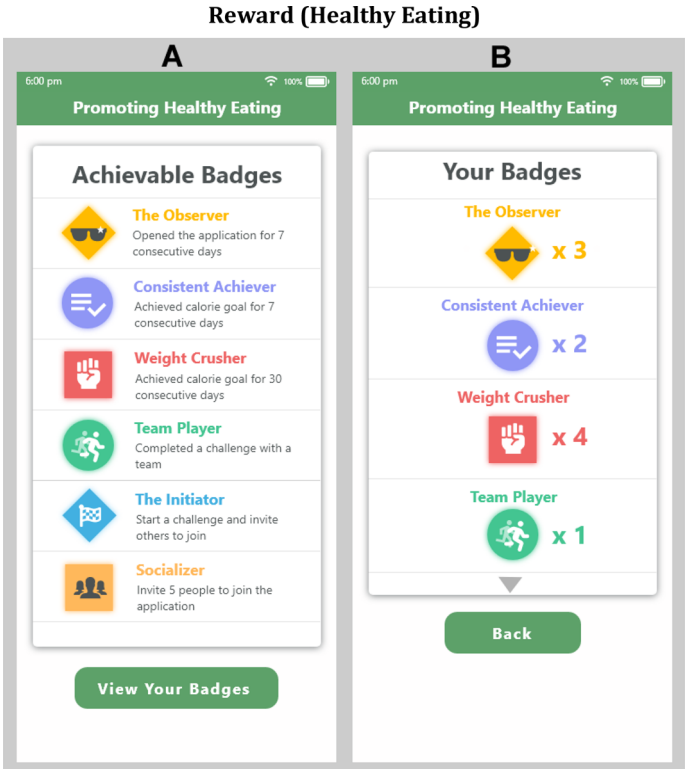
Personality factor questions

On a scale of 1 to 5, to what extent do you agree with the following statements. Please circle select the number that correspond to your response to each question

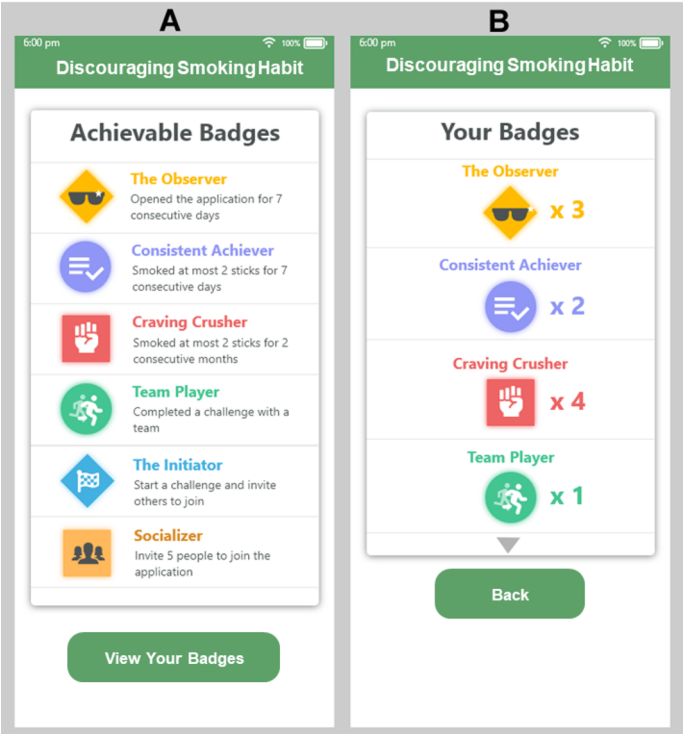
I see myself as someone who	*Personality factor*	1 Strongly dis-agree	2 Disagree	3 Neutral	4 Agree	5 Strongly agree
1. is reserved	*Extraversion (Reversed)*	1	2	3	4	5
2. is generally trusting	*Agreeableness*	1	2	3	4	5
3. tends to be lazy	*Conscientiousness (Reversed)*	1	2	3	4	5
4. is relaxed, handles stress well	*Neuroticism (Reversed)*	1	2	3	4	5
5. has few artistic interests	*Openness (Reversed)*	1	2	3	4	5
6. is outgoing, sociable	*Extraversion*	1	2	3	4	5
7. tends to find fault with others	*Agreeableness (Reversed)*	1	2	3	4	5
8. does a thorough job	*Conscientiousness*	1	2	3	4	5
9. gets nervous easily	*Neuroticism*	1	2	3	4	5
10. has an active imagination	*Openness*	1	2	3	4	5



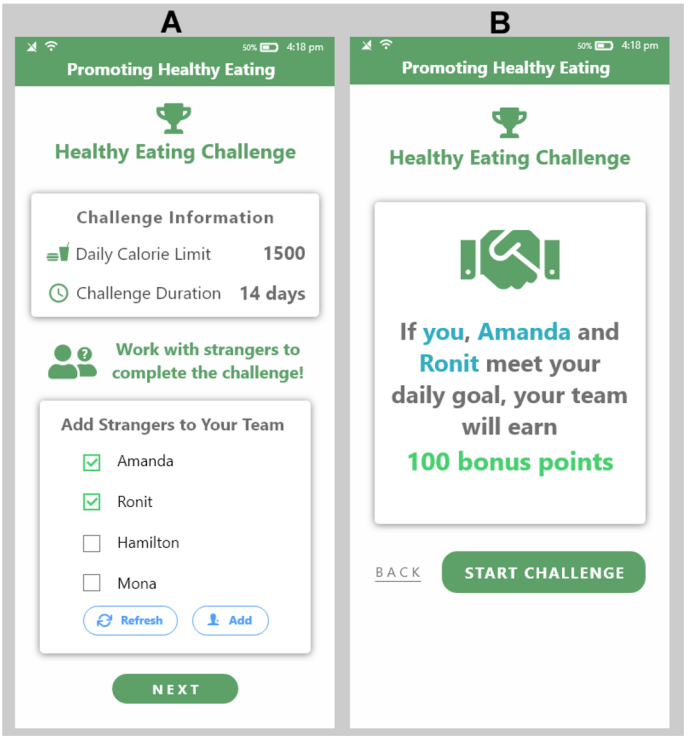
Screenshot of all persuasive strategy implementations



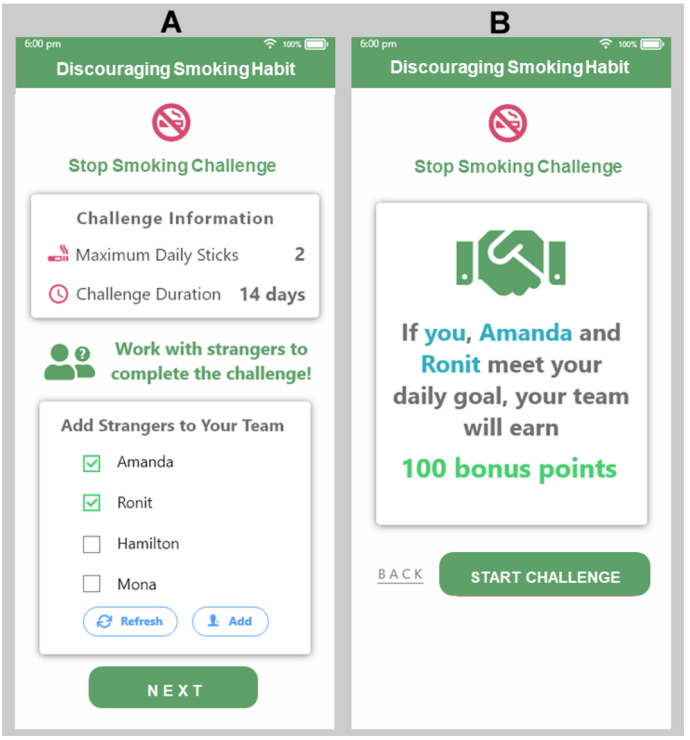
Reward (Smoking Cessation)



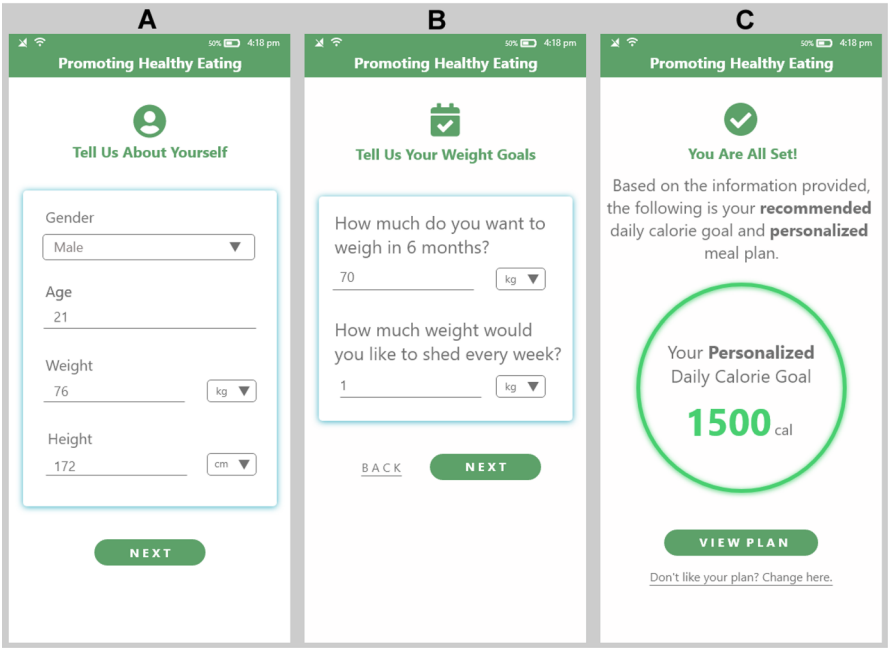
Cooperation (Healthy Eating)



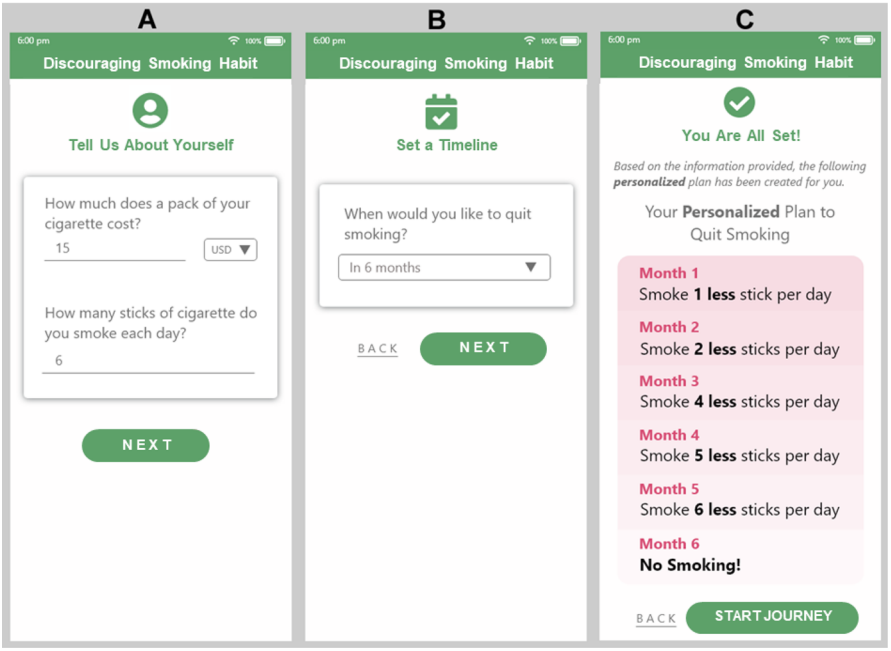
Cooperation (Smoking Cessation)



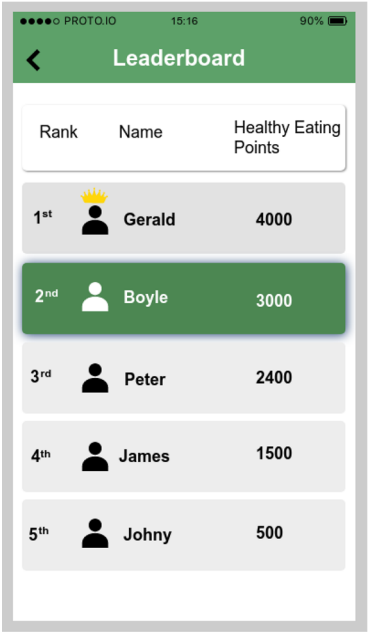
Personalization (Healthy Eating)



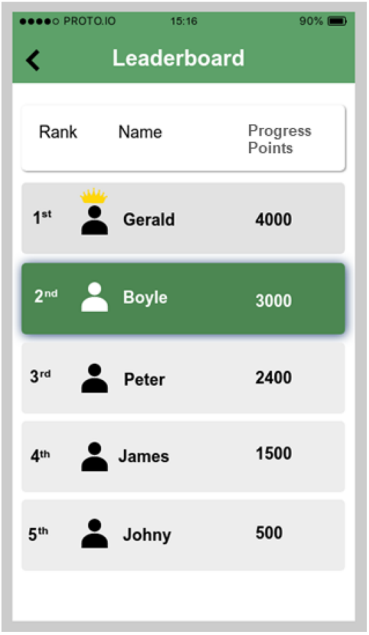
Personalization (Smoking Cessation)



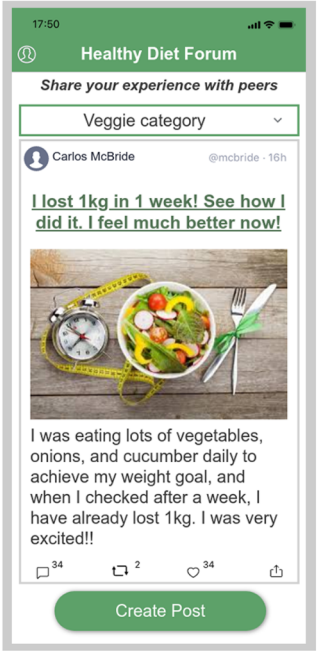
Competition (Healthy Eating)



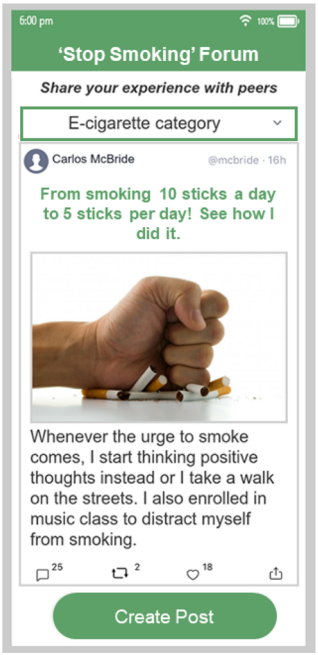
Competition (Smoking Cessation)



Normative Influence (Healthy Eating)



Normative Influence (Smoking Cessation)



References

Adolf, J., et al.: Measurement invariance within and between individuals: a distinct problem in testing the equivalence of intra- and inter-individual model structures. Front. Psychol. (2014). https://doi.org/10.3389/fpsyg.2014.00883

Aldenaini, N., Alqahtani, F., Orji, R., Sampalli, S.: Trends in persuasive technologies for physical activity and sedentary behavior: a systematic review. Artif. Intell. Front. (2020a). https://doi.org/10.3389/frai.2020.00007

Aldenaini, N.F., et al.: How effective is personalization in persuasive interventions for reducing sedentary behavior and promoting physical activity: a systematic review. Persuasive 2020, Adjunct proceedings of the 15th Int. conference on Persuasive Technology (2020b)

Alkiş, N., Taşkaya Temizel, T.: The impact of individual differences on influence strategies. Pers. Individ. Differ. **87**, 147–152 (2015). https://doi.org/10.1016/j.paid.2015.07.037

Almonani, E., et al.: Mobile game approach to prevent childhood obesity using persuasive technology. In: 2014 International Conference on Computer and Information Sciences, ICCOINS 2014—A Conference of World Engineering, Science and Technology Congress, ESTCON 2014—Proceedings

Alqahtani, F., et al.: Apps for mental health: an evaluation of behavior change strategies and recommendations for future development. Front. Artif. Intell. (2019). https://doi.org/10.3389/frai.2019.00030

Anagnostopoulou, E., et al.: Exploring the links between persuasion, personality and mobility types in personalized mobility applications. In: Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics) (2017).

Bang, M., et al.: Persuasive design of a mobile energy conservation game with direct feedback and social cues. Breaking New Ground: Innovation in Games, Play, Practice and Theory - Proceedings of DiGRA (2009)

Bascur, A., et al.: Evitapp: persuasive application for physical activity and smoking cessation. Proceedings (2018). https://doi.org/10.3390/proceedings2191208

Bialosiewicz, S., et al.: An Introduction to Measurement Invariance Testing: Resource Packet for Participants. American Evaluation Association (2013)

Blutner, R., Hochnadel, E.: Two qubits for C.G. Jung's theory of personality. Cogn. Syst. Res. (2010). https://doi.org/10.1016/j.cogsys.2009.12.002

Bogost, I.: Persuasive Games: The Expressive Power of Videogames. The MIT Press (2007)

Brown, S.J., et al.: Educational video game for juvenile diabetes: Results of a controlled trial. Med. Inform, (1997). https://doi.org/10.3109/14639239709089835

Burke, L.E., et al.: Experiences of self-monitoring: successes and struggles during treatment for weight loss. Qual. Health Res. (2009). https://doi.org/10.1177/1049732309335395

Busch, M. et al.: More than sex: the role of femininity and masculinity in the design of personalized persuasive games. In: Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics) (2016)

Chen, Y.X. et al.: Opportunities for persuasive technology to motivate heavy computer users for stretching exercise. In: Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics) (2014).

Cherubini, M., et al.: The unexpected downside of paying or sending messages to people to make them walk. ACM Trans. Comput. Hum. Interact. (2020). https://doi.org/10.1145/3365665

Chin, W.W.: The partial least squares approach for structural equation modeling. Mod. Methods Bus. Res. **295**, 295–336 (1998)

Chittaro, L., Sioni, R.: Turning the classic snake mobile game into a location-based exergame that encourages walking. In: Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics) (2012).

Chiu, M.-C.. et al.: Playful bottle: a mobile social persuasion system to motivate healthy water intake. In: UbiComp '09 Proceedings of the 11th international Conference on Ubiquitous Computing (2009).

Ciocarlan, A. et al.: Actual persuasiveness: Impact of personality, age and gender on message type susceptibility. In: Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics) (2019).

Clogg, C.C., et al.: Statistical methods for comparing regression coefficients between models. Am. J. Sociol. (1995). https://doi.org/10.1086/230638

Colineau, N., Paris, C.: Can beneficial habits be induced through reflection. In: Workshop on User Models for Motivational Systems, Held in Conjunction with the User Modeling, Adaptation and Personalization Conference (2011)
de Vries, R.A.J., et al.: A word of advice: how to tailor motivational text messages based on behavior change theory to personality and gender. Pers. Ubiquit. Comput. (2017). https://doi.org/10.1007/s00779-017-1025-1
Dickinson, A., et al.: Ukko: enriching persuasive location based games with environmental sensor data. In: CHI PLAY '15 Proceedings of the 2015 Annual Symposium on Computer-Human Interaction in Play (2015)
Drozd, F. et al.: Exploring perceived persuasiveness of a behavior change support system: a structural model. In: Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics). LNCS, vol. 7284, pp. 157–168 (2012). https://doi.org/10.1007/978-3-642-31037-9_14
Edney, S., et al.: "Active Team" a social and gamified app-based physical activity intervention: randomised controlled trial study protocol. BMC Public Health (2017). https://doi.org/10.1186/s12889-017-4882-7
Findlater, L., McGrenere, J.: A comparison of static, adaptive, and adaptable menus. In: Conference on Human Factors in Computing Systems—Proceedings (2004)
Fogg, B.J.: How to Motivate & Persuade Users. CHI '03 Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (2003)
Foster, D., et al.: Motivating physical activity at work: using persuasive social media for competitive step counting. In: Proceedings of the 14th International Academic MindTrek Conference: Envisioning Future Media Environments, MindTrek 2010 (2010)
Francillette, Y., et al.: Development of an exergame on mobile phones to increase physical activity for adults with severe mental illness. In: ACM International Conference Proceeding Series (2018)
Fritz, T., et al.: Persuasive technology in the real world: a study of long-term use of activity sensing devices for fitness. In: Conference on Human Factors in Computing Systems—Proceedings (2014)
Fujiki, Y., et al.: NEAT-o-Games: blending physical activity and fun in the daily routine. ACM Comput. Entertain. (2008). https://doi.org/10.1145/1371216.1371224
Gamberini, L., et al.: Saving is fun: designing a persuasive game for power conservation. Resour. Conserv. Recycl. (2010). https://doi.org/10.1016/j.resconrec.2010.03.004
Gamberini, L., et al.: VIDEODOPE: applying persuasive technology to improve awareness of drugs abuse effects. In: Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics) (2007)
Ganesh, S., et al.: FoodWorks: tackling fussy eating by digitally augmenting children's meals. In: Proceedings of the NordiCHI 2014: The 8th Nordic Conference on Human–Computer Interaction: Fun, Fast, Foundational (2014)
Gerlach, M., et al.: A robust data-driven approach identifies four personality types across four large data sets. Nat. Hum. Behav. (2018). https://doi.org/10.1038/s41562-018-0419-z
Ghaban, W., Hendley, R.: How different personalities benefit from gamification. Interact. Comput. (2019). https://doi.org/10.1093/iwc/iwz009
Goldberg, L.R.: The structure of phenotypic personality traits. Am. Psychol. (1993). https://doi.org/10.1037/0003-066X.48.1.26
Graham, C., et al.: Blogging as therapy? Exploring personal technologies for smoking cessation. Health Inform. J. (2009). https://doi.org/10.1177/1460458209345897
Graham, C., et al.: "heh—Keeps me off the smokes...": probing technology support for personal change. In: ACM International Conference Proceeding Series (2006)
Gustafsson, A., et al.: Evaluation of a pervasive game for domestic energy engagement among teenagers. Comput. Entertain. (2010). https://doi.org/10.1145/1658866.1658873
Hair, J.F., et al.: PLS-SEM: indeed a silver bullet. J. Mark. Theory Pract. **19**(2), 139–152 (2011). https://doi.org/10.2753/MTP1069-6679190202
Hair, J.F., et al.: A Primer on Partial Least Squares Structural Equation Modeling (PLS-SEM), 2nd edn. Sage (2017)
Hair, J.F. et al.: When to use and how to report the results of PLS-SEM. European Business Review (2019)
Halko, S., Kientz, J.A.: Personality and persuasive technology: an exploratory study on health-promoting mobile applications. In: Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics) (2010)

Hamari, J., et al. Do persuasive technologies persuade? A review of empirical studies. In: Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics) (2014)
He, Q., Agu, E.: On11: an activity recommendation application to mitigate sedentary lifestyle. In: WPA 2014—Proceedings of the 2014 ACM Workshop on Physical Analytics, Co-located with MobiSys 2014 (2014)
Henseler, J., et al.: Testing measurement invariance of composites using partial least squares. Int. Mark. Rev. (2016). https://doi.org/10.1108/IMR-09-2014-0304
Hirsh, J.B., et al.: Personalized persuasion: tailoring persuasive appeals to recipients' personality traits. Psychol. Sci. (2012). https://doi.org/10.1177/0956797611436349
Hosseini, S., et al.: SilverCycling: evaluating persuasive strategies to promote physical activity among older adults. In: DIS 2018—Companion Publication of the 2018 Designing Interactive Systems Conference (2018)
Huss, K., et al.: Computer game for inner-city children does not improve asthma outcomes. J. Pediatr. Health Care (2003). https://doi.org/10.1067/mph.2003.28
Jia, Y., et al.: Personality-targeted gamification: a survey study on personality traits and motivational affordances. In: Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems (2016)
John, O.P., Srivastava, S. Big Five Inventory (Bfi). In: Handbook of Personality: Theory and Research (1999). https://doi.org/10.1525/fq.1998.51.4.04a00260
Kaipainen, K., et al.: Mindless eating challenge: retention, weight outcomes, and barriers for changes in a public web-based healthy eating and weight loss program. J. Med. Internet Res. (2012). https://doi.org/10.2196/jmir.2218
Kaiser, H.F.: A second generation little jiffy. Psychometrika **35**(4), 401–415 (1970)
Kaptein, M.: Adaptive persuasive messages in an e-commerce setting: the use of persuasion profiles. In: 19th European Conference on Information Systems, ECIS 2011 (2011)
Kaptein, M., et al.: Adaptive persuasive systems: a study of tailored persuasive text messages to reduce snacking. ACM Trans. Interact. Intell. Syst. (2012a). https://doi.org/10.1145/2209310.2209313
Kaptein, M., et al.: Adaptive persuasive systems. ACM Trans. Interact. Intell. Syst. (2012b). https://doi.org/10.1145/2209310.2209313
Kaptein, M., et al.: Personalizing persuasive technologies: explicit and implicit personalization using persuasion profiles. Int. J. Hum. Comput. Stud. (2015). https://doi.org/10.1016/j.ijhcs.2015.01.004
Kaptein, M., Eckles, D.: Selecting effective means to any end: futures and ethics of persuasion profiling. In: Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics) (2010)
Kaptein, M. and Eckles, D. 2012. Heterogeneity in the Effects of Online Persuasion. Journal of Interactive Marketing. (2012). DOI:https://doi.org/10.1016/j.intmar.2012.02.002.
Kaptein, M., et al.: Can you be persuaded? Individual differences in susceptibility to persuasion. In: Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics) (2009)
Kaptein, M., et al. Means based adaptive persuasive systems. In: Conference on Human Factors in Computing Systems—Proceedings (2011)
Karim, A., et al. Mobile application on smoking cessation based on persuasive design theory. In: PACIS 2017 Proceedings (2017)
Karppinen, P., et al. Flow or no flow? A qualitative study of health behavior change support system. In: Proceedings of the Annual Hawaii International Conference on System Sciences (2014)
Kato, P.M., et al.: A video game improves behavioral outcomes in adolescents and young adults with cancer: a randomized trial. Pediatrics (2008). https://doi.org/10.1542/peds.2007-3134
Katule, N., et al.: Leveraging intermediated interactions to support utilization of persuasive personal health informatics. In: ACM International Conference Proceeding Series (2016)
Khaled, R., et al. A qualitative study of culture and persuasion in a smoking cessation game. In: Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics) (2008)
Kupek, E.: Beyond logistic regression: structural equations modelling for binary variables and its application to investigating unobserved confounders. BMC Med. Res. Methodol. **6**(1), 13 (2006). https://doi.org/10.1186/1471-2288-6-13
Marcu, G., et al. Bounce: designing a physical activity intervention for breast cancer survivors (2018). https://doi.org/10.1145/nnnnnnn.nnnnnnn

Mason, W., Suri, S.: Conducting behavioral research on Amazon's Mechanical Turk. Behav. Res. Methods (2012). https://doi.org/10.3758/s13428-011-0124-6
Mazzotta, I., et al.: Portia: a user-adapted persuasion system in the healthy-eating domain. IEEE Intell. Syst. (2007). https://doi.org/10.1109/MIS.2007.115
McElroy, J.C., et al.: Dispositional factors in internet use: personality versus cognitive style. MIS q. Manag. Inf. Syst. (2007). https://doi.org/10.2307/25148821
Michie, S., et al.: The behavior change technique taxonomy (v1) of 93 hierarchically clustered techniques: building an international consensus for the reporting of behavior change interventions. Ann. Behav. Med. (2013). https://doi.org/10.1007/s12160-013-9486-6
Ndulue, C., et al.: PHISHER CRUSH: A Mobile Persuasive Game for Promoting Online Security. PERSUASIVE 2020. Lecture Notes in Computer Science. 12064, 223–233 (2020). https://doi.org/10.1007/978-3-030-45712-9_17
Oinas-Kukkonen, H., Harjumaa, M.: Persuasive systems design: key issues, process model, and system features. Commun. Assoc. Inf. Syst. **24**(1), 485–500 (2009)
Okpo, J., et al.: Investigating the impact of personality & cognitive efficiency on the selection of exercises for learners. In: UMAP 2017—Proceedings of the 25th Conference on User Modeling, Adaptation and Personalization (2017)
Opinio: https://surveys.dal.ca/opinio/admin/folder.do. Accessed 19 Aug 2020
Orji, R.O.: Design for Behaviour Change: A Model-Driven Approach for Tailoring Persuasive Technologies. University of Saskatchewan, Saskatoon (2014)
Orji, R., Moffatt, K.: Persuasive technology for health and wellness: state-of-the-art and emerging trends. Health Inform. J. (2018). https://doi.org/10.1177/1460458216650979
Orji, R., et al.: LunchTime: a slow-casual game for long-term dietary behavior change. Pers. Ubiquit. Comput. **17**(6), 1211–1221 (2013a). https://doi.org/10.1007/s00779-012-0590-6
Orji, R., et al.: LunchTime: a slow-casual game for long-term dietary behavior change. Pers. Ubiquit. Comput.ing (2013b). https://doi.org/10.1007/s00779-012-0590-6
Orji, R., et al.: Tailoring persuasive health games to gamer type. In: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems—CHI '13 (New York, New York, USA), p. 2467 (2013c)
Orji, R., et al.: Modeling the efficacy of persuasive strategies for different gamer types in serious games for health. User Model. User-Adapt. Interact. **24**(5), 453–498 (2014). https://doi.org/10.1007/s11257-014-9149-8
Orji, R., et al.: A comparison of system-controlled and user-controlled personalization approaches. In: UMAP 2017a—Adjunct Publication of the 25th Conference on User Modeling, Adaptation and Personalization (2017a)
Orji, R., et al.: Improving the efficacy of games for change using personalization models. ACM Trans. Comput. Hum. Interact. (2017b). https://doi.org/10.1145/3119929
Orji, R., et al.: Improving the efficacy of games for change using personalization models. ACM Trans. Comput. Hum. Interact. **24**(5), 1–22 (2017c). https://doi.org/10.1145/3119929
Orji, R., et al.: Towards personality-driven persuasive health games and gamified systems. In: Conference on Human Factors in Computing Systems—Proceedings (2017d)
Orji, R., et al. Personalizing persuasive strategies in gameful systems to gamification user types. In: Conference on Human Factors in Computing Systems—Proceedings (2018)
Orji, R., et al.: Socially-driven persuasive health intervention design: competition, social comparison, and cooperation. Health Inform. J. (2019). https://doi.org/10.1177/1460458218766570
Oyebode, O., et al.: Persuasive mobile apps for health and wellness: a comparative systematic review, 163–181 (2020)
Oyibo, K., et al.: Investigation of the influence of personality traits on cialdini's persuasive strategies. CEUR Workshop Proceedings (2017a).
Oyibo, K., et al.: Investigation of the persuasiveness of social influence in persuasive technology and the effect of age and gender. In: CEUR Workshop Proceedings (2017b)
Paay, J., et al.: Quitty: using technology to persuade smokers to quit. In: Proceedings of the NordiCHI 2014: The 8th Nordic Conference on Human-Computer Interaction: Fun, Fast, Foundational (2014)
Peng, W.: Design and evaluation of a computer game to promote a healthy diet for young adults. Health Commun. (2009). https://doi.org/10.1080/10410230802676490
Pollak, J.P., et al.: It's time to eat! Using mobile games to promote healthy eating. IEEE Pervasive Comput. **1**, 5 (2010). https://doi.org/10.1109/MPRV.2010.41
Product|SmartPLS

Rammstedt, B., John, O.P.: Measuring personality in one minute or less: a 10-item short version of the Big Five Inventory in English and German. J. Res. Pers. (2007). https://doi.org/10.1016/j.jrp.2006.02.001
Rau, P.L.P., et al.: The effect of personality on online game flow experience and the eye blink rate as an objective indicator. Adv. Hum. Comput. Interact. (2017). https://doi.org/10.1155/2017/4675401
Ring, C.M., et al.: Smart PLS. http://www.smartpls.de Hamburg, Germany (2005)
Sánchez, G.: Partial Least Squares Frequently Asked Questions. Operations Research (2009)
Sarsam, S.M., Al-Samarraie, H.: A first look at the effectiveness of personality dimensions in promoting users' satisfaction with the system. SAGE Open (2018). https://doi.org/10.1177/2158244018769125
Sarstedt, M., Cheah, J.-H.: Partial least squares structural equation modeling using SmartPLS: a software review. J. Mark. Anal. **7**(3), 196–202 (2019). https://doi.org/10.1057/s41270-019-00058-3
Schafer, H., et al. Study on motivating physical activity in children with personalized gamified feedback. In: UMAP 2018—Adjunct Publication of the 26th Conference on User Modeling, Adaptation and Personalization (2018)
Seligman, M.E.P., et al.: The Values in Action (via) Classification of Character Strengths. Ricerche di Psicologia (2004)
Sofia, G., et al. Investigating the role of personality traits and influence strategies on the persuasive effect of personalized recommendations. In: CEUR Workshop Proceedings (2016)
Staiano, A., et al.: The use of competition to elicit vigorous intensity physical activity during: EBSCOhost. J. Fam. Consum. Sci (2018). https://doi.org/10.14307/JFCS110.3.39
The Science of Persuasion - Scientific American: https://www.scientificamerican.com/article/the-science-of-persuasion/ (2004). Accessed 11 Mar 2019
Thomas, R.J., et al.: Can I influence you? Development of a scale to measure perceived persuasiveness and two studies showing the use of the scale. Front. Artif. Intell. (2019). https://doi.org/10.3389/frai.2019.00024
Thomas, R.J., et al. Adapting healthy eating messages to personality. In: Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)
van Velsen, L., et al.: Tailoring persuasive electronic health strategies for older adults on the basis of personal motivation: web-based survey study. J. Med. Internet Res. (2019). https://doi.org/10.2196/11759
Van Dantzig, S., et al.: Enhancing physical activity through context-aware coaching. In: ACM International Conference Proceeding Series (2018)
Yoon, S., Godwin, A.: Enhancing self-management in children with sickle cell disease through playing a CD-ROM educational game: a pilot study. J. Pediatr. Nurs. **33**, 60–65 (2007)

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