Video Games and Virtual Reality as Persuasive Technologies for Health Care: An Overview

Yang-Wai Chow[1], Willy Susilo[1]*, James G. Phillips[2], Joonsang Baek[1], and Elena Vlahu-Gjorgievska[3]
[1]*Institute of Cybersecurity and Cryptology, School of Computing and Information Technology*
University of Wollongong, Australia
{caseyc, wsusilo, baek}@uow.edu.au
[2]*Department of Psychology, Auckland University of Technology*
Auckland, New Zealand
james.phillips@aut.ac.nz
[3] *Centre for Persuasive Technology and Society, School of Computing and Information Technology*
University of Wollongong, Australia
elenavg@uow.edu.au

Abstract

Over the last two decades, persuasive technology has gained much of interest and attention. One of the major disciplines of focus for persuasive technology is health care. The vast majority of persuasive technologies for health care are predominantly based on web and mobile platforms. Nevertheless, video games and virtual reality are recognized as effective persuasive platforms, as computer simulation is a platform for enabling users to observe the immediate and long term relationships between cause and effect. As such, the use of these persuasive technologies, can potentially facilitate change in a person's attitudes or behaviors. This paper considers persuasive technology in the form of video games and virtual reality as a means to change attitudes and/or behaviors in the area of health care. The role of these types of computer simulation, their advantages and challenges, along with the incorporation of persuasive strategies in the design of such interactive simulations are discussed in relation to health care.

Keywords: Health Care, Persuasive Technology, Video Games, Virtual Reality

1 Introduction

Since the introduction of Captology [1], the field of persuasive technology has gained much interest and attention within the research community and among practitioners alike. Captology is an area of research that explores challenges and opportunities of using computing technology for persuasive purposes. Persuasive technology has been defined as technology, more specifically as interactive information technology, which is designed for intentionally changing the attitudes and/or behaviors of its users without deception or coercion [2]. There have been a variety of diverse areas that have employed the use of persuasive technology, including the retail industry [3], the military [4], for training and education [5, 6], as well as for health care [7, 8, 9].

Instances of persuasive technology can be seen in everyday life. The Internet is rife with websites designed in such a way that they can motivate or sometimes persuade people to change their attitudes and/or behavior. For example, websites like Amazon.com and eBay do not only process orders but also attempt to persuade people to make purchases, and to divulge personal information and preferences [7].

Journal of Wireless Mobile Networks, Ubiquitous Computing, and Dependable Applications, 8:3 (September), pp. 18-35
*Corresponding author: School of Computing and Information Technology, University of Wollongong, Northfields Avenue, Wollongong, NSW 2522, Australia, Tel: +61-2-4221-5535

This is achieved through a complex process of offering suggestions after analyzing user preferences, previous transactions, interests and patterns from other users, etc.

One of the major areas that has seen the use of persuasive technology is health care and promoting healthier lifestyles. However, it has been observed that research into health care information and management systems has mainly focused on electronic medical records, health information libraries and tele-monitoring, while applications focusing on patients' behavioral change have received less attention [10]. Among persuasive applications focusing on behavioral change, researchers have adopted persuasive technology for promoting alcohol and smoking cessation [11], encouraging physical activity [12], providing motivation to exercise [13], interventions for mental health [14], promoting healthy eating [15], and so on.

The vast majority of these persuasive technologies for health care are predominantly based on web and mobile platforms [11, 9]. This is because users are easily reachable through the web, Internet, mobile and other associated technologies, and as such these platforms create opportunities for persuasive interaction [16, 17]. While these platforms have shown great potential and have led to positive outcomes, nonetheless these are by no means the only forms of persuasive technology. As such, to maximize the potential for behavioral change in health care, researchers and practitioners should explore diverse avenues of technology.

Computer simulation is a tool that can persuade people to change their attitudes or behaviors by making them observe causal relationships between events [2]. The field of serious games is a discipline within the broad area of video games that heavily relies on the use of simulation to achieve its intended goals. It has been noted that serious games can impact a wide range outcomes, including those involving perception, cognition, behavior, affective and motivation [18]. As such, by adopting persuasive principles and strategies in its design, serious games can potentially provide an ideal platform for changing attitude and behavior [19]. Furthermore, there is a growing area of research on developing methodologies for incorporating persuasive principles in system design. For example, persuasive design models [10, 17] attempt to examine and describe how best to design persuasive systems. With adequate planning, such persuasive principles and strategies can be implemented in the design of video games to create an interactive platform for persuasion.

In addition, virtual reality is a simulation technology that can immerse the user in an interactive three dimensional computer generated virtual environment. This creates the feeling of presence by presenting the users' senses with an illusion of reality [20]. In light of this, virtual reality undoubtedly presents a platform that can be harnessed for the purposes of changing the attitudes and behaviors of its users. Nevertheless, researchers have observed that even though virtual reality is a powerful simulation tool for users to experience the changes resulting from their actions in intense, lively and memorable ways, research on the use of virtual reality as a form of persuasive technology is not common [21].

This paper considers persuasive technology in the form of computer simulation as a means to change attitudes and behaviors in the area of health and health care. In particular, two key disciplines of computer simulation, namely, video games and virtual reality, are examined and discussed in relation to their applications and potential as persuasive technologies. Furthermore, the advantages and challenges, along with the incorporation of persuasive strategies in the design of such interactive simulations are discussed in relation to health care.

2 Persuasive Technology and Health Care

Persuasive technology can certainly impact attitudes and behaviors in the area of health. Figure 1 depicts the concept of "Captology", as the intersection between computing technology and persuasive intent [1, 2]. Chatterjee and Price [7] describe persuasive technology in health care as an intersection of three

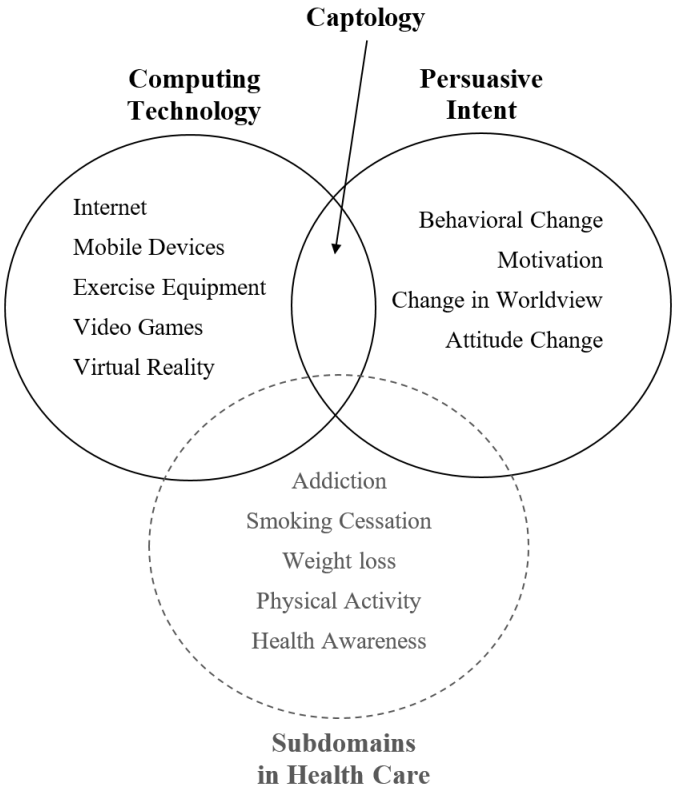


Figure 1: Captology, the intersection between computing technology and persuasive intent.

domains. The first is technology, which is the driver of persuasive change; the second, is persuasion strategies that must be employed to motivate, and to make attitude and/or behavior change happen; and the third, involves the various subdomains within health care, like healthy living, physical activity, alcohol and smoking cessation and weight loss, to name a few [7]. However, what makes the design and development of persuasive technologies for health care difficult is that the intersection between these domains is not well understood.

As for the role of video games and virtual reality as persuasive technologies for health care, Fogg [2] described the "functional triad" that can be used as a framework for categorizing or thinking of persuasive technologies based on their roles. Figure 2 illustrates the functional triad. These functional roles are based on computing technologies from the user's point of view, and employ different means of persuasion. Fogg [2] suggested three roles that interactive computing technologies can play; namely, its roles as "tools", "media", and "social actors", each of which can be combined with other roles. These interactive computing roles empower persuasive technologies, and are elaborated in the context of video games for health care as follows:

- Role as a tool: This role makes the target behavior easier to perform by facilitating the user's capabilities. In video games, this can be achieved by presenting instructions or guiding people through a process in an interactive manner, and presenting motivational results through in-game calculations and measurements. For example, rather than reading about and an attempting to visualize processes from text and static images on printed media, games create opportunities to present this information in an attractive visual and audio form which is easier to understand.

- Role as a medium: This allows people to explore the cause and effect relationship between events

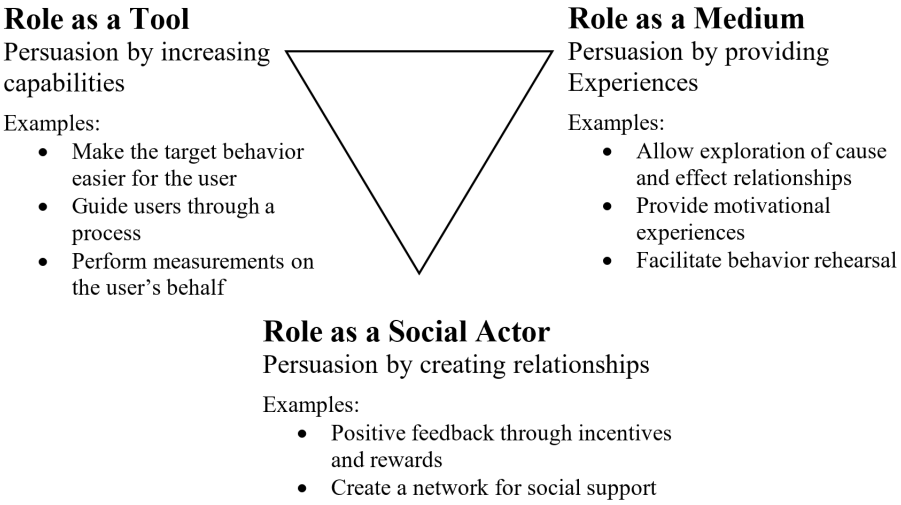


Figure 2: The functional triad, which represent roles of computing technologies that persuade via different means.

or activities, provide motivating experiences, and facilitate the rehearsal of behaviors. Many video game features are directly linked to cause and effect relationships; performing an action in an interactive game results in immediate feedback informing the user of the outcome of that action. In addition, games are designed for replayability, where some form of incentive is present to urge the user to repeat an activity.

- Role as a social actor: Persuasive intent is conveyed by rewarding users through positive feedback, this helps to shape the target attitude or behavior. In addition, it makes social support readily available. A typical video game feature is to provide rewards for accomplished tasks, thus generating positive feedback. Furthermore, games can be designed to provide a social network of support by allowing users to share information with other users, or even to cooperate within the game environment.

In health care applications, persuasive interactive technologies are likely to play more than one role at the same time. Chatterjee and Price [7] gives an example of a simple tool that can measure calories, and at the same time rewards the user upon attaining a personal goal. The application can also leverage social support by sharing information with other users through the Internet, which can impact motivation and behavior change.

Video games and virtual reality simulations can easily be designed to incorporate such features in a software application. In fact, many of them can be comfortably be designed to fulfill all three roles at once. Furthermore, video games and virtual reality are interactive forms of computer simulation that can portray the immediate relationship between cause and effect, and are therefore ideal platforms for presenting this information to a user in a vivid and attractive manner. Since the game should be designed to integrate these features within the game context, this information will appear as a natural part of the game and will not distract the user from the in-game tasks or activities to be performed.

3 Computer Simulation

The technology context plays an important role in computer mediated persuasion. Therefore, it is vital to have a through understanding of specific technological platforms, applications and features underlying

persuasive technology [17]. This section presents computer simulation technology in terms of video games and virtual reality, along with their adoption in the area of health and health care.

3.1 Video Games

Video games have often attracted negative sentiments in the media and the general public. Among the negative connotations of video games, some have perceived video games as promoting violence, gender stereotype and potentially resulting in addiction [22]. In fact, there has even been the perception that playing video games excessively can harm the health and negatively affect player attitudes [23]. However, despite the concerns linked to video games, many have found that playing games can have positive effects on players [24, 25].

3.1.1 Serious Games

Serious games have been defined as video games that are primary designed for a purpose other than for mere entertainment [26]. While there is no agreed understanding of what the term serious games means [27], one of the earliest and widely-accepted definitions expresses clearly that serious games have deliberate educational purposes, in addition to the goal of providing users with entertaining experiences [28]. While this does not necessitate that serious games should only contain educational, instructional or training activities, it has been suggested that the pedagogical aspect is what sets them apart from entertainment games [4, 26]. Serious games and simulations have been researched and developed to provide education and training, to conduct human performance engineering, and to be used in the area of health, strategic communications and public policy, etc. [4].

While playing video games can be linked to a range of cognitive, perceptual, behavioral, affective and motivational impacts and outcomes, Connolly et al. [18] found that the most common outcomes resulting from serious games were related to knowledge acquisition/content understanding followed by affective and motivational outcomes. For this reason, there has been an increase in use of serious games to foster learning among educators, training practitioners, policymakers, health care professionals and advertisers [18, 26].

In addition, other than for learning and skill acquisition, there is great interest in the potential for serious games to facilitate change in attitude and/or behavior [19]. This is in part due to the fact that learning serious games involves enabling users to apply their current knowledge in a game environment in order to acquire new skills through their own determination to defeat contextual challenges presented by the game [22, 26]. Designing games to change attitudes or encourage behavioral change is a difficult task, as behavior is a complicated and intricate process that is influenced by a variety of different factors [29]. Nevertheless, there are existing theoretical models for persuasive design that are relevant for developing games of a persuasive nature [22].

3.1.2 Games for Health

While games have been developed for different application fields, it has been suggested that serious games are notably effective in some specific disciplines. In particular, one of the most relevant domains is health care [30]. Serious games have been developed in the area of health and health care for various purposes. This includes games for increasing users' knowledge, awareness and understanding about illness and health problems, supporting patient rehabilitation and therapy, motivating physical activity and for encouraging healthy living and lifestyles [31]. The effectiveness of serious games and its application in the area of health has been the topic of much research, and in general, these studies have found that games have the potential to produce positive effects and outcomes [32, 33, 34].

As an example of an effective computer game for increasing users' knowledge about illnesses and health problems, researchers developed a game called "Re-Mission" to allow young people with cancer actively be involved in their own treatment [35]. The development of this game was motivated by the fact that it has been shown that the self management and treatment of adolescents with chronic illnesses have resulted in poor outcomes. One of the factors for this has been attributed to the lack of interest in personal care, along with the lack of knowledge about the illness. The research concluded that video games can serve as an effective platform for education about health and health care [35].

Similar results have been reported in other studies. For example, it has been reported that a health education game, which was used as a clinical tool for children and teenagers with cancer, was capable of teaching children about the disease and was successful as a vehicle for initiating discussion among the patients, their parents and medical staff. In addition, this game had a high acceptance rate among the patients [36]. In another study, two versions of a game for teenagers to enhance their self-management of diabetes mellitus was developed. One version of the game explicitly referred to diabetes content, while in the implicit version, no diabetes content was referred to. The study reported that higher diabetes self-efficacy was attained when diabetes content was explicitly addressed in the game [37]. Other researchers have also explored the use of games for scenario based medical retraining, and found that it supports the retention of knowledge and skills for a certain period, and that it also positively engages and motivates participants [38].

There has also been much interest on exercise games, or "exergames", for health, as the entertainment and motivational aspects of such games can help maintain physical activity and fitness. Various studies have reported on the benefits of exergaming for people of all age groups [39, 40, 41]. It has been argued that although some of these games, like commercial dance games, can be categorized as entertainment games, they are also capable of changing behavior [22].

3.1.3 Persuasive Games

Unlike serious games which primary purpose may arguably be to educate and facilitate learning, persuasive games aim to change attitudes and behaviors through a new way of presenting information in video games, called procedural rhetoric. Bogost [19] defined procedural rhetoric as persuasion via rule-based representations and interactions in video games. Akin to how verbal rhetoric is a way for presenting verbal arguments aimed at influencing the listeners' opinions, procedural rhetoric is mainly a visual based method for conveying arguments in an interactive and procedural way to persuade users to change their opinions [22]. It has been argued that this unique persuasive power can only be presented through video games and is not supported in other forms of computational persuasion [19].

Since behavior usually the result of a variety of influencing factors, it is resistant to change [29]. A video game that was theoretically grounded on behavioral science, called "Escape from Diab", was developed by game designers and behavioral scientists to address the health problem of Type 2 diabetes and obesity among youth [29]. The aim of the game was to adopt behavioral science insights to guide game design decisions and to produce a game that would promote behavior change through interventions in diet and physical activity. Since designing games for behavior change is a difficult task, the researchers adopted a process to change mediators, rather than attempting to change behaviors directly. It was theorized that changing the mediators would in turn lead to behavior change [29].

A study that was conducted to assess and analyze the outcome of playing "Escape from Diab", in conjunction with another persuasive game, "Nanoswarm: Invasion from Inner Space", on children's diet and physical activity, found that children playing these video games noticeably increased their daily vegetable and fruit consumption [42]. However, it did not increase their water consumption, physical activity, or their body composition. The study concluded that more research is required to come up with the optimal design of video game components for maximizing behavior change [42].

A subsequent study on the same game found that in-game stories can serve as powerful instruments for health interventions. The level of story immersion, in other words, the experience of being drawn into the story, which is affected by ethnic similarity between video game characters, was found to be a contributing factor to the players' immersion that consequently results in several health outcomes [43]. Orji et al. [44] proposed that persuasive games should not adopt an "one-size-fits-all" approach in its design, as players have different personalities and what motivates one type of player may in fact demotivate behavior in others. Models for categorizing the persuasive receptiveness of players have been proposed, and it has been suggested that a personalized approach to game design will best persuade particular types of players [44].

Video games developed on mobile platforms can also contribute to behavior change due to the ubiquitous nature of mobile devices. For example, Buttussi and Chittaro [45] developed a user-adaptive and context-aware fitness game for mobile phones. The aim of this mobile game is to motivate and train outdoor jogging at an appropriate intensity. Mobile phones will likely become a major technological tool for persuasion, and the intent of designing the game for mobile phones is because they are ubiquitous and well suited for persuading users to perform regular exercise. Furthermore, the motivational nature can be enhanced through social dynamics by allowing users to share information with other users [45].

3.2 Virtual Reality

Virtual reality is a simulation technology that aims to immerse the user in a virtual environment by presenting the users' senses, mainly visual and auditory, and possibly haptic, with an illusion of reality. Immersive virtual environments attempt to creates the sense of "presence" within a three-dimensional virtual world generated by a computer. Presence refers to the phenomenon of "being there", feeling and behaving as if the user is in the virtual environment [20].

In immersive head mounted display virtual reality, the user wears a display device where images of the virtual environment are presented in a way that covers the user's visual field. By using tracking equipment to measure head position and orientation, images of the virtual environment can be updated based on where the user is currently looking in the environment. The illusion of realism and depth in the scene is created by presenting the user with a pair of stereoscopic images, one for each eye, rendered from slightly different viewpoints based on binocular disparity. Furthermore, with information about the user's head position and orientation in the virtual environment, the intensity of audio feedback can dynamically be adjusted with position based panning. Depending on the sophistication of the system, other sensors can also be used to provide hand and finger interaction, e.g., using data gloves, and haptic feedback. Due to their specific characteristics, it has been suggested that immersive virtual environments can be a more effective persuasion channel, as compared with classical media [46].

Chittaro and Zangrando [21] presented results on a study of different methods for providing negative feedback for persuasive purposes. This was done through simulated experiences in virtual reality. The persuasive goal of their research was focused on awareness of personal fire safety issues and attitude changes towards smoke in building evacuation. Their results showed that immersive virtual reality can be an effective platform for changing attitudes with regard to personal safety. They also suggest that negative affect can be used for beneficial persuasive purposes, and that the level of emotional intensity of the employed feedback technique plays a significant role in attitude change [21].

Studies have shown that it is possible to use virtual reality as an affective medium, i.e. a medium that is capable of eliciting different emotions from interaction with its contents [47]. Riva et al. [47] reported that there is a link between presence and emotions in virtual environments. They demonstrated that interaction with "anxious" and "relaxing" virtual environments was able to elicit emotions of anxiety and relaxation in the users. Another study by Banos et al. [48] showed that it is possible to induce users with different moods in virtual reality. For this reason, immersive virtual reality technology has

been employed in a variety of therapeutic phobic and fear conditioning studies. Virtual reality exposure therapy is a form of behavioral therapy that has been used to treat anxiety disorders, fear of flying, social phobia, panic disorder, post traumatic stress disorder, along with a number of other phobias [49, 50, 51, 20].

In the area of health care, virtual reality has been used for treating substance use disorders [52]. The diagnosis and treatment of such disorders include abstinence treatment for smoking, drug and alcohol cravings. Studies have shown that virtual reality is an effective platform for exposure therapy in the handling of such disorders in a simulated virtual environment [52]. Moreover, research has shown that there is a direct relationship between the triggering of a craving and the level of presence experienced in a virtual environment [53].

It has been suggested that to be more effective, technologically enhanced health solutions should be designed to work side by side with traditional approaches [54]. Virtual reality presents the possibility of creating new, immersive environments for enhancing motivation, where patients, medical personnel and health professionals can be trained while playing [55]. As such, the use of virtual reality has been explored in many areas of health, including for prevention, harm reduction, rehabilitation, training, exercise and fitness [55, 56].

4 Advantages and Challenges

The use of video games and virtual reality as persuasive technologies for health care provides a number of advantages over traditional technologies. This section discusses the various benefits presented by these forms of interactive computer simulations, along with their issues and challenges.

4.1 Advantages

Video game and virtual reality technologies empower the creation of interactive computer simulations. When used as a persuasive platform, these technologies give rise to several advantages. The following are some of the most prevalent benefits:

- **Interactivity** is an inherent property of video games and virtual reality. As such, these forms of interactive computer simulations are ideal for presenting users with cause and effect relationship between events or activities. For example, in immersive virtual reality, users can interact with the content in a virtual environment in real-time. This can promote and enhance a user's understanding of the cause and effect relationship between their actions and outcomes. Thus, with appropriate design, developers can create memorable first-hand experiences for persuasive purposes.

- **Multimodality** refers to communication via a number of different modes. Video games and virtual reality simulations allow for the presentation of content in a computer generated virtual environment through a combination of visual, auditory, haptic, and possibly other sensory modalities [57]. As such, the nature of these interactive simulations provide compelling and attractive game features that can be used to create entertaining experiences, while at the same time delivering specific information and messages. It has been shown that multimodality and interactivity both individually contribute to educational outcomes [57].

- **Accessibility** is a major contributing factor to why many current persuasive technologies for health care are developed on web and mobile platforms. This is because these platforms are widely available and easily accessible, and thus creates opportunities for persuasive interaction [16, 17]. Accessibility is vital for health care applications that are especially targeted for the rural community [58]. With advances in computing and mobile technology, mobile devices are now equipped

with graphics accelerators and multi-core processors that can comfortably meet the requirements of complex video games. In addition, there is now a growing popularity of implementing immersive virtual reality simulations on mobile devices. By developing these interactive simulations on mobile devices, these applications can reach wider groups of people.

- **Intuitiveness**. Another advantage of video games and virtual reality applications is that they are intuitive and easy to learn. Many individuals already have some form of experience with games, and their prior experience from other games can often be ported over, with minor adjustments, to new games. Games are designed to be usable and there are established and widely accepted game design rules for making games user friendly. Hence, even if a person has limited knowledge and experience of games, it will not take much effort for a person to learn how to play a game.

- **Entertainment**. One of the drivers of attitude and/or behavior change is tied to the motivation of the user. No matter how persuasive a message may be, without the motivation to use a system or to rehearse a behavior, the intent of the message will significantly diminish. Video games and virtual reality applications allow for the creation of attractive and entertaining experiences, which are effective in motivating user involvement [19, 18]. In addition, such computer simulations can be developed to target a range of diverse age groups, as health and health care issues affect the young and the old.

4.2 Issues and Challenges

While the use of video game and virtual reality technologies as persuasive platforms provides several advantages, there are also various issues and challenges that need to be considered. A number of these are described here. In fact, these are open challenges that future research should seek to address to develop a better understanding of the field.

- **Design**. One of the main, and possibly most difficult, challenges in the use of video games and virtual reality as persuasive technologies, lies in the design of such systems to promote attitude and/or behavior change. The fundamental question that needs to be addressed is how such systems can reliably be designed to persuade in a consistent manner. This is far from an easy task, as behavior is the result of multiple influencing factors and is therefore usually resistant to change [29]. Furthermore, it is difficult to predict how a persuasive design feature in a game or virtual environment will affect a user's attitude or behavior. While research in social psychology has developed theoretical models of attitude and behavior change that can be adopted in simulation design [22], these theories are not widely applied in game design and their effects and outcomes in video games and virtual reality simulations are not fully understood. As such, the question of how to adopt these theoretical models to design computer simulations to reliably facilitate attitude and/or behavior change is an open challenge. These is discussed further in Section 5.

- **Evaluation**. Another open challenge in relation to employing video games and virtual reality as persuasive technologies, is the question of how to evaluate or measure the effectiveness of the persuasive system in achieving its goal of attitude and/or behavior change. Techniques that can be adopted to evaluate the influence of persuasive systems in a consistent manner, can be used to compare between different persuasive technologies and applications. In addition, effective evaluation techniques are essential to inform the design and development of future persuasive systems. Effective techniques to measure the outcomes of a persuasive system will add to the knowledge and understanding of persuasive guidelines and strategies that can be incorporated into the design of such systems. The assumption whereby one can simply rely on the interactive and

entertaining nature of video games and virtual reality to motivate lifestyle change is not reliable and not good practice.

- **Personalization**. People have different personalities, outlooks, preferences, etc. and may respond to the same stimulus differently. As such, it has been argued that there should be a certain degree of personalization in interactive simulations to cater for diverse users [44]. Otherwise, what may be effective for some users, may not affect other users or may even result in adverse reactions due to differences in personalities and how people view the world. However, it is difficult to be able to fine turn video game and virtual reality experiences to suit a large range of diverse users. Nevertheless, there has been some research on how different personalities react to experiences in virtual environments, and these should be taken into account during the planning and development stages [59, 44].

- **Negative Sentiment**. One of the issues to do with video games is the negative sentiment and social stigma associated with them. Video games have often been seen in negative light for things like video game violence, addiction, gender stereotyping, etc. [22]. Nevertheless, there are potential benefits that can come from such games if one were to look beyond the negative impacts. For example, research has shown that even indirect communication in the form of graphic messages in violent video games can have a persuasive effect [60]. Studies have also shown that the cooperative playing of violent video games can positively affect the social and cooperative behaviors of the players [61].

5 Persuasive Design

While there are many studies on the use of serious games for health care and how this increases motivation, learning and knowledge retention, etc., researchers have shown that persuasive factors that can potentially affect attitude or behavior change in video games and virtual reality are not fully understood [42, 62, 44]. There are few fixed guidelines on how to design effective persuasive games [62]. Many games developed for health care are based on ad-hoc game designs that implicitly assume that the use of interactive game media itself will give rise to motivation and cultivate a user's interest in the subject matter. This heavily relies on the underlying assumption that presenting information through the attractive and interactive form of a game will naturally result in learning and knowledge retention, which will subsequently lead to behavior change.

However, the reality is not that simple because human behavior itself is complicated. Even carefully designed video games developed with the clear purpose of behavior change, may not fully achieve all the desired outcomes [42, 29]. Researchers have asserted that one of the contributing factors to this is that most persuasive games are designed based on a one-size-fits-all approach, but what works for some personalities may have adverse effects on others [44]. This highlights the necessity of applying persuasive strategies and design principles, which are founded on prior experience and theoretical models of persuasion, attitude and behavior change, in the design of these interactive simulations. Table 1 provides examples of existing research of persuasive design.

Video games and virtual reality simulations lend themselves well to persuasive design models, as with careful planning, many of these persuasive strategies can be incorporated into the setting, interface, goals, tasks, etc. of these games. Oinas-Kukkonen and Harjumaa [17] describe a persuasive systems design model for developing and evaluating persuasive systems in general. Based on this, Orji et al. [44] identified ten commonly used persuasive strategies that are of particular relevance to persuasive game design. These strategies/principles are presented in Table 2 and discussed in the context of their implementation in video games and virtual reality.

Table 1: Examples of research on persuasive design.

Reference	Research Summary
Khaled et al. [62]	This research discusses the design of a persuasive game to promote smoking cessation. The authors describe five categories that were considered in their game design, namely, managing player attention, balancing "replayability" with reality, player control vs. system control, identity issues, and target audience.
Fogg [63]	This paper written by a pioneer of captology and persuasive technology. It details a general eight step design process for persuasive technology that was developed from prior experience and successful industry practice.
Oinas-Kukkonen and Harjumaa [17]	The framework of a Persuasive Systems Design (PSD) model is described in this work. Among other things, this work analyzes seven postulates governing persuasive systems and provides a list of twenty eight persuasive design principles.
Wiafe et al. [64]	This work proposes a model, called the 3D-RAB model, which represents the relationship between various attitude and behavioral factors in three dimensions. The aim of this model is for analyzing and selecting suitable persuasive techniques based on the nature of users or use over time.
Oinas-Kukkonen [10]	The aim of this work is to provide a foundation for studying Behavior Change Support Systems (BCSSs). Part of this work discusses the design process for building such systems. In addition, this paper also provides a list of previous work in BCSS studies pertaining to persuasive system design.
Orji et al. [44]	This work examines the commonly used one-size-fits-all approach in the design of persuasive games. Based on their findings, the authors contend that video games should be designed based on a personalized approach to cater for diverse users. The paper also maps persuasive design strategies to common game features.
Nacke et al. [59]	This paper explores the diversity of gamers and describes seven different archetypes of gamer personalities (seeker, survivor, daredevil, mastermind, conqueror, socializer and achiever).

Table 2: Examples of persuasive strategies.

Strategy	Description	Discussion
Customization	This is a strategy to give users the opportunity to adjust a system's contents and functionality according to their needs and personal preferences.	An example of this would be to allow the players to customize his/her virtual character, otherwise known as the user's avatar. Research has shown that ethnic similarity between the players and video game characters can contribute to engagement and immersion [43].

- continues on the next page

- continued from the previous page

Strategy	Description	Discussion
Simulation	This provides a medium that allows a user to observe the causal relationship between their actions and the outcomes.	It has been observed that this strategy is not often employed in the design of health games [44]. Successful commercial video games are all about cause and effect. Performing an action in the virtual environment will result in an immediate outcome, which can either be positive or negative. The long term effects of actions can also be modeled in video games and virtual reality simulations to demonstrate the eventual outcomes as a result of accumulated actions or prior in-game decisions.
Self-monitoring and feedback	This strategy allows users to keep track of the own behavior, which can be achieve when supplied with both past and present game states.	Well design feedback mechanisms are a fundamental requirement and a widely recognized cornerstone of good game and virtual reality design. Feedback allows players to monitor and track their progress. It shows the results of actions performed in the virtual environment, which leads to users being able to predict outcomes and avoids requiring users to guess what happened.
Suggestion	This is a strategy for introducing and assigning specific tasks to users, in order to achieve favorable behavior outcomes.	Providing in-game hints and affordances is another well recognized feature of good game design. This helps to guide users to achieve desired tasks and avoids users becoming lost or stuck, not knowing what to do or how to progress.
Personalization	This offers content and services, which can be tailored for users in such a way that suits a users' characteristics and preferences.	Many personalizable features can be incorporated into virtual environments, including personalized controls, avatars, user interfaces, voice acting, and so on. These settings are saved and restored every time the user logs into the virtual environment.
Praise	This gives clear positive feedback through images, sounds, words, symbols, etc. to the user who has successfully carried out the target behavior.	This is associated with in-game mechanisms for providing positive feedback and can also be linked to in-game rewards. To contrast this, negative feedback can also be used to dissuade a user from performing an undesirable behavior. Research has shown that negative feedback can also be used as a means of "beneficial persuasion" [21].

- continues on the next page

- continued from the previous page

Strategy	Description	Discussion
Reward	This is a mechanism for providing virtual rewards and incentives for users upon successfully completion of the target behavior.	Note that this is one of the commonly used strategies and very much a part of games. Games need to provide rewards for successful accomplishment of tasks, otherwise, there would be no incentive to play the game or perform those tasks. In addition, the reward mechanism also creates incentive for users to repeat behavioral tasks and aim to succeed. The amount of incentive, i.e. reward, in games can be adjusted to commensurate with the level of success in correctly fulfilling a task or achieving a goal.
Comparison	This provides a way for the user to compare his/her performance with that of other users'.	Video games and virtual reality applications in their role as social actors, can provide mechanisms where users can share information with other users to create a social support network. In the absence of these mechanisms, these interactive simulations can still provide a benchmark for a user to compare his/her level of performance with an accepted or ideal benchmark.
Competition	This enables the user to compete with others.	Many video games are designed to be multiplayer games. This does not necessarily mean that the players must co-exist in the same game environment, as players can compete with each other based on shared information such as high scores, or in-game rewards or wealth. Games can also be developed with artificial intelligence, where players can compete with in-game computer controlled characters.
Cooperation	This requires users to collaborate to achieve a shared goal and also rewards them for achieving the objectives as a group.	This can be provided through multiplayer game design or even with game artificial intelligence, in the form of computer controlled characters that can cooperate with the user.

While this is by no means an exhaustive list of persuasive strategies and in-game/virtual environment features, it provides a subset of the most relevant strategies for facilitating attitude and behavior change. Games should also be designed to accommodate different personalities [44]. The work by Kaptein et al. [65] examines the individual differences on persuasion in affecting behavioral outcomes in the health domain. Good commercial games are designed with multiple features that cater for diverse groups of people with different personalities. For example, some people are goal orientated, others may be challenge orientated, some enjoy thinking and solving puzzles, while others like to explore things and situations. Nacke et al. [59] describe seven different types of gamer personalities. This should also be considered for the design of persuasive games and virtual reality simulations.

In addition, evaluation and testing is a key part of system design for ensuring the success of a software application. Oinas-Kukkonen [10] describes an outcome/change design matrix to be used in conjunction with the persuasive system design model [17] for evaluating software designed to change behaviors or attitudes. This provides a guide for analyzing the persuasive potential of a system's design and can be applied to the design of interactive computer simulations.

6 Conclusion

This paper discusses the role of computer simulations in persuasive technology. In particular, this paper considers video games and virtual reality as a means to change attitudes and/or behaviors in the area of health care. These interactive computer simulations can create compelling, attractive and entertaining experiences, while at the same time delivering specific information and messages to the users. Nevertheless, the challenge of being able to reliably design such systems to promote attitude or behavior change remains a difficult task. As such, it is vital to based the design of such systems on persuasive design principles and strategies that are grounded on theoretical behavior change models. Furthermore, the effects and outcomes of these design principles and models on behavior change is still an open challenge that needs to be addressed, in order to provide greater insight on how to effectively design persuasive video games and virtual reality applications for health care.

Acknowledgments

The authors would like to thank the anonymous reviewers for their invaluable feedback and suggestions on improving this paper.

References

[1] B. J. Fogg, "Persuasive computers: Perspectives and research directions," in *Proc. of the SIGCHI Conference on Human Factors in Computing Systems (CHI'98), Los Angeles, California, USA*. ACM, April 1998, pp. 225–232.

[2] B. J. Fogg, *Persuasive Technology: Using Computers to Change What We Think and Do*. Morgan Kaufmann, 2002.

[3] T.-L. Huang and F. H. Liu, "Formation of augmented-reality interactive technology's persuasive effects from the perspective of experiential value," *Internet Research*, vol. 24, no. 1, pp. 82–109, January 2014.

[4] M. Zyda, "From visual simulation to virtual reality to games," *Computer*, vol. 38, no. 9, pp. 25–32, September 2005.

[5] L. Chittaro and R. Sioni, "Serious games for emergency preparedness," *Computers in Human Behavior*, vol. 50, pp. 508–519, September 2015.

[6] B. Orland, N. Ram, D. Lang, K. Houser, N. Kling, and M. Coccia, "Saving energy in an office environment: A serious game intervention," *Energy and Buildings*, vol. 74, pp. 43–52, May 2014.

[7] S. Chatterjee and A. Price, "Healthy living with persuasive technologies: Framework, issues, and challenges," *Journal of the American Medical Informatics Association*, vol. 16, no. 2, pp. 171–177, March 2009.

[8] S. S. Intille, "A new research challenge: persuasive technology to motivate healthy aging," *IEEE Transactions on Information Technology in Biomedicine*, vol. 8, no. 3, pp. 235–237, September 2004.

[9] J. Matthews, K. T. Win, H. Oinas-Kukkonen, and M. Freeman, "Persuasive technology in mobile applications promoting physical activity: a systematic review," *Journal of Medical Systems*, vol. 40, no. 3, pp. 72–85, March 2016.

[10] H. Oinas-Kukkonen, "A foundation for the study of behavior change support systems," *Personal Ubiquitous Computing*, vol. 17, no. 6, pp. 1223–1235, August 2013.

[11] T. Lehto and H. Oinas-Kukkonen, "Persuasive features in web-based alcohol and smoking interventions: A systematic review of the literature," *Journal of Medical Internet Research*, vol. 13, no. 3, p. e46, July 2011.

[12] W. Zhu, "Promoting physical activity through internet: A persuasive technology view," in *Persuasive Technology: 2nd International Conference on Persuasive Technology, PERSUASIVE 2007, Palo Alto, California, USA*. Springer Berlin Heidelberg, April 2007, pp. 12–17.

[13] L. Boratto, S. Carta, G. Fenu, M. Manca, F. Mulas, and P. Pilloni, "The role of social interaction on users motivation to exercise: A persuasive web framework to enhance the self-management of a healthy lifestyle," *Pervasive and Mobile Computing*, vol. 36, no. April, pp. 98–114, 2017.

[14] G. Wildeboer, S. M. Kelders, and J. E. W. C. van Gemert-Pijnen, "The relationship between persuasive technology principles, adherence and effect of web-based interventions for mental health: A meta-analysis," *International Journal of Medical Informatics*, vol. 96, pp. 71–85, December 2016.

[15] R. Orji, J. Vassileva, and R. L. Mandryk, "Lunchtime: a slow-casual game for long-term dietary behavior change," *Personal and Ubiquitous Computing*, vol. 17, no. 6, pp. 1211–1221, August 2013.

[16] M. M. Cassell, C. Jackson, and B. Cheuvront, "Health communication on the internet: An effective channel for health behavior change?" *Journal of Health Communication*, vol. 2, no. 1, pp. 71–79, January 1998.

[17] H. Oinas-Kukkonen and M. Harjumaa, "Persuasive systems design: Key issues, process model, and system features," *Communications of the Association for Information Systems*, vol. 24, no. 1, p. 28, 2009.

[18] T. M. Connolly, E. A. Boyle, E. MacArthur, T. Hainey, and J. M. Boyle, "A systematic literature review of empirical evidence on computer games and serious games," *Computers & Education*, vol. 59, no. 2, pp. 661–686, September 2012.

[19] I. Bogost, *Persuasive Games: The Expressive Power of Videogames*. The MIT Press, 2007.

[20] M. V. Sanchez-Vives and M. Slater, "From presence to consciousness through virtual reality," *Nature Reviews Neuroscience*, vol. 6, pp. 332–339, April 2005.

[21] L. Chittaro and N. Zangrando, "The persuasive power of virtual reality: Effects of simulated human distress on attitudes towards fire safety," in *Proc. of the 5th International Conference on Persuasive Technology (PERSUASIVE'10), Copenhagen, Denmark*. Springer Berlin Heidelberg, June 2010, pp. 58–69.

[22] E. Boyle, T. M. Connolly, and T. Hainey, "The role of psychology in understanding the impact of computer games," *Entertainment Computing*, vol. 2, no. 2, pp. 69–74, 2011.

[23] E. Brox, L. Fernandez-Luque, and T. Tollefsen, "Healthy gaming – video game design to promote health," *Applied Clinical Informatics*, vol. 2, no. 2, pp. 128–142, April 2011.

[24] K. Durkin and B. Barber, "Not so doomed: Computer game play and positive adolescent development," *Journal of Applied Developmental Psychology*, vol. 23, no. 4, pp. 373–392, November 2002.

[25] C. J. Ferguson, "The good, the bad and the ugly: A meta-analytic review of positive and negative effects of violent video games," *Psychiatric Quarterly*, vol. 78, no. 4, pp. 309–316, December 2007.

[26] W. S. Ravyse, A. S. Blignaut, V. Leendertz, and A. Woolner, "Success factors for serious games to enhance learning: a systematic review," *Virtual Reality*, vol. 21, no. 1, pp. 31–58, March 2017.

[27] T. Marsh, "Serious games continuum: Between games for purpose and experiential environments for purpose," *Entertainment Computing*, vol. 2, no. 2, pp. 61–68, 2011.

[28] C. C. Abt, *Serious games*. Viking Press, 1970.

[29] D. Thompson, T. Baranowski, R. Buday, J. Baranowski, V. Thompson, R. Jago, and M. J. Griffith, "Serious video games for health: How behavioral science guided the development of a serious video game," *Simulation and Gaming*, vol. 41, no. 4, pp. 587–606, August 2010.

[30] F. Bellotti, B. Kapralos, K. Lee, P. Moreno-Ger, and R. Berta, "Assessment in and of serious games: An overview," *Advances in Human-Computer Interaction*, vol. 2013, p. Article ID 136864, 2013.

[31] D. J. Skiba, "Games for health," *Nursing Education Perspectives*, vol. 29, no. 4, pp. 230–232, July 2008.

[32] G. Blakely, H. Skirton, S. Cooper, P. Allum, and P. Nelmes, "Educational gaming in the health sciences: systematic review," *Journal of Advanced Nursing*, vol. 65, no. 2, pp. 259–269, Decmeber 2008.

[33] P. M. Kato, "Video games in health care: Closing the gap," *Review of General Psychology*, vol. 14, no. 2, pp. 113–121, June 2010.

[34] A. DeSmet, D. V. Ryckeghem, S. Compernolle, T. Baranowski, D. Thompson, G. Crombez, K. Poels, W. V.

Lippevelde, S. Bastiaensens, K. V. Cleemput, H. Vandebosch, and I. D. Bourdeaudhuij, "A meta-analysis of serious digital games for healthy lifestyle promotion," *Preventive Medicine*, vol. 69, pp. 95–107, December 2014.

[35] I. L. Beale, P. M. Kato, V. M. Marin-Bowling, N. Guthrie, and S. W. Cole, "Improvement in cancer-related knowledge following use of a psychoeducational video game for adolescents and young adults with cancer," *Journal of Adolescent Health*, vol. 41, no. 3, pp. 263–270, September 2007.

[36] K. Gerling, A. Fuchslocher, R. Schmidt, N. Krämer, and M. Masuch, "Designing and evaluating casual health games for children and teenagers with cancer," in *Proc. of the 10th International Conference on Entertainment Computing (ICEC'11), Vancouver, Canada*, J. C. Anacleto, S. Fels, N. Graham, B. Kapralos, M. S. El-Nasr, and K. Stanley, Eds. Springer Berlin Heidelberg, October 2011, pp. 198–209.

[37] A. Fuchslocher, J. Niesenhaus, and N. Krämer, "Serious games for health: An empirical study of the game "balance" for teenagers with diabetes mellitus," *Entertainment Computing*, vol. 2, no. 2, pp. 97–101, 2011.

[38] F. Buttussi, T. Pellis, A. C. Vidani, D. Pausler, E. Carchietti, and L. Chittaro, "Evaluation of a 3d serious game for advanced life support retraining," *International Journal of Medical Informatics*, vol. 82, no. 9, pp. 798–809, September 2013.

[39] C. O'Donovan and J. Hussey, "Active video games as a form of exercise and the effect of gaming experience: a preliminary study in healthy young adults," *Physiotherapy*, vol. 98, no. 3, pp. 205–210, September 2012.

[40] L. M. Taylor, R. Maddison, L. A. Pfaeffli, J. C. Rawstorn, N. Gant, and N. M. Kerse, "Activity and energy expenditure in older people playing active video games," *Archives of Physical Medicine and Rehabilitation*, vol. 93, no. 12, pp. 2281–2286, December 2012.

[41] A. Mills, M. Rosenberg, G. Stratton, H. H. Carter, A. L. Spence, C. J. A. Pugh, D. J. Green, and L. H. Naylor, "The effect of exergaming on vascular function in children," *The Journal of Pediatrics*, vol. 163, no. 3, pp. 806–810, September 2013.

[42] T. Baranowski, J. Baranowski, D. Thompson, R. Buday, R. Jago, M. J. Griffith, N. Islam, N. Nguyen, and K. B. Watson, "Video game play, child diet, and physical activity behavior change: A randomized clinical trial," *American Journal of Preventive Medicine*, vol. 40, no. 1, pp. 33–38, January 2011.

[43] A. S. Lu, D. Thompson, J. Baranowski, R. Buday, and T. Baranowski, "Story immersion in a health videogame for childhood obesity prevention," *Games for Health Journal*, vol. 1, no. 1, pp. 37–44, January 2012.

[44] R. Orji, J. Vassileva, and R. L. Mandryk, "Modeling the efficacy of persuasive strategies for different gamer types in serious games for health," *User Modeling and User-Adapted Interaction*, vol. 24, no. 5, pp. 453–498, December 2014.

[45] F. Buttussi and L. Chittaro, "Smarter phones for healthier lifestyles: An adaptive fitness game," *IEEE Pervasive Computing*, vol. 9, no. 4, pp. 51–57, October 2010.

[46] D. Grigorovici, *Persuasive Effects of Presence in Immersive Virtual Environments*. IOS Press, 2003, pp. 191–207.

[47] G. Riva, F. Mantovani, C. S. Capideville, A. Preziosa, F. Morganti, D. Villani, A. Gaggioli, C. Botella, and M. A. niz, "Affective interactions using virtual reality: The link between presence and emotions," *CyberPsychology & Behavior*, vol. 10, no. 1, pp. 45–56, February 2007.

[48] R. M. Banos, V. Liano, C. Botella, M. Alcaniz, B. Guerrero, and B. Rey, "Changing induced moods via virtual reality," in *Proceedings of the 1st International Conference on Persuasive Technology for Human Well-being (PERSUASIVE'06), Eindhoven, The Netherlands*. Springer-Verlag Berlin Heidelberg, May 2006, pp. 7–15.

[49] J. Bush, "Viability of virtual reality exposure therapy as a treatment alternative," *Computers in Human Behavior*, vol. 24, no. 3, pp. 1032–1040, May 2008.

[50] R. A. McCann, C. M. Armstrong, N. A. Skopp, A. Edwards-Stewart, D. J. Smolenski, J. D. June, M. Metzger-Abamukong, and G. M. Reger, "Virtual reality exposure therapy for the treatment of anxiety disorders: An evaluation of research quality," *Journal of Anxiety Disorders*, vol. 28, no. 6, pp. 625–631, August 2014.

[51] M. Price and P. Anderson, "The role of presence in virtual reality exposure therapy," *Journal of Anxiety Disorders*, vol. 21, no. 5, pp. 742–751, 2007.

[52] A. Hone-Blanchet, T. Wensing, and S. Fecteau, "Efficacy of virtual reality in triggering the craving to smoke: Its relation to level of presence and nicotine dependence," *Frontiers in Human Neuroscience*, vol. 8, p. article

844, October 2014.

[53] M. Ferrer-Garcia, O. Garcia-Rodriguez, J. Gutierrez-Maldonado, I. Pericott-Valverde, and R. Secades-Villa, "Efficacy of virtual reality in triggering the craving to smoke: Its relation to level of presence and nicotine dependence," *Studies in Health Technology and Informatics*, vol. 154, pp. 123–127, 2010.

[54] E. F. Lopresti, A. Mihailidis, and N. Kirsch, "Assistive technology for cognitive rehabilitation: State of the art," *Neuropsychological Rehabilitation*, vol. 14, no. 1-2, pp. 5–39, March 2004.

[55] G. Gamberini, G. Barresi, A. Majer, and F. Scarpetta, "A game of a day keeps the doctor away: A short review of computer games in mental healthcare," *Journal of CyberTherapy and Rehabilitation*, vol. 1, no. 2, pp. 127–145, January 2008.

[56] M. Ma, L. C. Jain, and P. Anderson, *Virtual, Augmented Reality and Serious Games for Healthcare 1*. Springer, 2014.

[57] U. Ritterfeld, C. Shen, H. Wang, L. Nocera, and W. L. Wong, "Multimodality and interactivity: Connecting properties of serious games with educational outcomes," *CyberPsychology & Behavior*, vol. 12, no. 6, pp. 691–697, December 2009.

[58] D. L. Ramachandran, "Mobile persuasive technologies for rural health," Ph.D. dissertation, EECS Department, University of California, Berkeley, August 2010.

[59] L. E. Nacke, C. Bateman, and R. L. Mandryk, "Brainhex: A neurobiological gamer typology survey," *Entertainment Computing*, vol. 5, no. 1, pp. 55–62, January 2014.

[60] C. N. Burrows and H. Blanton, "Real-world persuasion from virtual-world campaigns: How transportation into virtual worlds moderates in-game influence," *Communication Research*, vol. 43, no. 4, pp. 542–570, June 2016.

[61] D. R. Ewoldsen, C. A. Eno, B. M. Okdie, J. A. Velez, R. E. Guadagno, and J. DeCoster, "Effect of playing violent video games cooperatively or competitively on subsequent cooperative behavior," *Cyberpsychology, Behavior, and Social Networking*, vol. 15, no. 5, pp. 277–280, April 2012.

[62] R. Khaled, P. Barr, J. Noble, R. Fischer, and R. Biddle, "Fine tuning the persuasion in persuasive games," in *Proc. of the 2nd International Conference on Persuasive Technology, (PERSUASIVE'07), Palo Alto, California, USA*. Springer-Verlag Berlin Heidelberg, April 2007, pp. 36–47.

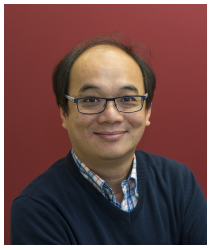
[63] B. J. Fogg, "Creating persuasive technologies: an eight-step design process," in *Proc. of the 4th International Conference on Persuasive Technology (PERSUASIVE'09), Claremont, California, USA*. ACM, April 2009, p. article no. 44.

[64] I. Wiafe, K. Nakata, S. Moran, and S. Gulliver, "Considering user attitude and behaviour in persuasive systems design: The 3d-rab model," in *Proc. of the 19th European conference on information systems (ECIS'11), Helsinki, Finland*, January 2011, p. article 186.

[65] M. Kaptein, J. Lacroix, and P. Saini, "Individual differences in persuadability in the health promotion domain," in *Proc. of the 5th International Conference on Persuasive Technology (PERSUASIVE'10), Copenhagen, Denmark*, ser. Lecture Notes in Computer Science, vol. 6137. Springer-Verlag, June 2010, pp. 94–105.

Author Biography

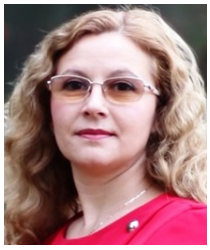
Yang-Wai Chow received his BSc., B.Eng. (Hons.) and Ph.D. from Monash University, Australia, in 2003 and 2007. He is currently a Senior Lecturer in the School of Computing and Information Technology, at the University of Wollongong, Australia. His research interests include virtual reality, interactive real-time interfaces, multimedia security and cyber security.



Willy Susilo obtained his Bachelor Degree in Computer Science from Universitas Surabaya, Indonesia with a "Summa Cum Laude" predicate. He received his Master and Doctor of Philosophy degrees from the University of Wollongong (UOW). His main research interest include cryptography and cyber security. He received a prestigious ARC Future Fellowship from the Australian Research Council. He also received the UOW Researcher of the Year 2016 due to his research excellence. He is the Director of Institute of Cybersecurity and Cryptology, UOW.

James G. Phillips is currently an Associate Professor at Auckland University of Technology. He did his undergraduate training at Adelaide University (honours thesis with Dr. Doug Vickers) and completed his PhD at Flinders University (supervised by Dr. Denis Glencross). After doing some post-doctoral work with Professor George Stelmach on Parkinsons Disease and balance in the elderly he worked for a year at Bendigo College of Advanced Education. From 1990 to 2010 he worked at the Psychology Department at Monash University.

Joonsang Baek received his Ph.D. degree in computer science from Monash University, Australia, in 2004. He received the M.S. in computer engineering from Korea Advanced Institute of Science and Technology-IT Convergence Campus (KIAST-ICC), Korea, in 2000, and received the B.S in mathematics from Pohang University of Science and Technology (POSTECH), Korea, in 1998. He is currently a senior lecturer at School of Computing and Information Technology, University of Wollongong, Australia. His current research interests are in the field of applied cybersecurity and cryptography. Joonsang has published his work in a number of reputable journals and conference proceedings and has served as chairs and program committee members for a number of renowned conferences and workshops.



Elena Vlahu-Gjorgievska received her PhD from the Faculty of Computer Science and Engineering at the "Ss. Cyril and Methodius" University in Skopje, in 2013. From 2007 she was working at the Faculty of Information and Communication Technologies, University "St. Kliment Ohridski" in Bitola, Macedonia. Currently, she is a lecturer in the School of Computing and Information Technology, Faculty of Engineering and Information Sciences at the University of Wollongong, Australia. Her research interests include information systems and e-health. She has participated in several research projects in the field of e-health and published over 10 papers in international journals.