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Design and Evaluation of a Serious Digital Game to Discourage Indoor Tanning among Young Adults

A Theory-Based, Collaborative Approach

Soyoon Kim*
Assistant Professor, Department of Communication Studies, University of Miami
Soyeon Ahn
Professor, Department of Educational and Psychological Studies
Sung Eun Park
Postdoctoral Associate, School of Universal Comupting, Construction, and Engineering Education

This study examined the feasibility of implementing a digitalized serious game as an innovative health communication tool to prevent indoor tanning among young adults. In an interdisciplinary, collaborative design process, the main game elements were strategically developed to shape the outcome, normative, and control beliefs known to influence indoor-tanning behavior based on behavioral prediction theories. An online experiment with 501 young adults in the United States was conducted to evaluate the game's effectiveness relative to conventional intervention modalities that have been widely used for health communication interventions. Results showed little evidence demonstrating the merit of using a digital game over traditional intervention tools, such as a health website or brochure, in influencing critical indoor-tanning beliefs. In addition, the game was among the most effective tools in discouraging future indoor tanning intention for female participants, but appeared to be the least effective tool for male participants and those who had previously tanned indoors. This study offers useful guidance for researchers and practitioners who are

* First and Corresponding Author, Soyoon.Kim@Miami.Edu

interested in the potential of serious games as an alternative health-intervention tool and suggests caution in assuming universal effects of using the new media platform without considering differences within the seemingly homogeneous group of young individuals.

KEY WORDS Serious Digital Games • Game-Based Learning • Health Communication • Indoor Tanning • The Theory Of Planned Behavior

1. Introduction

Skin cancer has been on the rise worldwide (Cronin et al., 2018; Jordan et al., 2020). The high and increasing incidence of skin cancer has been a major health concern in the United States, Canada, and European countries, representing a significant healthcare cost burden for its treatment (Gordon et al., 2020; Bentzen et al., 2013; Whiteman et al., 2016). A growing incidence of both melanoma and non-melanoma skin cancer has also been reported in other countries, such as South Korea, where the incidence of skin cancer has not historically been a significant public health issue (Lee et al., 2019; Oh, 2018). This global increase in skin cancer highlights the need for more research on the risk factors and intervention strategies. Epidemiologic research consistently demonstrates that the use of UV-emitting tanning devices is associated with significantly increased risk for melanoma, basal cell carcinoma, and squamous cell carcinoma (Nilsen et al., 2016). Notably, the growing use of indoor tanning facilities among young adults has been reported as an important cause for the recent increase in skin cancer incidence in different countries, including the United States (Lazovich et al., 2013; Robinson et al., 2008; O'Sullivan et al., 2019). While indoor tanning is considered a strong risk for skin cancer at any age, evidence suggests that younger people are particularly vulnerable to its carcinogenic effects: The use of indoor tanning equipment before 35 years of age significantly increases the risk of both melanoma and nonmelanoma skin cancers (Ferrucci et al., 2012; Watson et al., 2013; Boniol et al., 2012). Problematically, younger people are

likely to be attracted to the immediate, appearance-enhancing benefits of indoor tanning advocated by the tanning industry without understanding the critical associations between skin cancer and indoor tanning (Levine et al., 2005; Noar et al., 2015). Moreover, their tendency to resist conventional, didactic health education messages that are perceived as threats to their autonomy makes it difficult for health intervention planners to address this health concern (Burgoon et al., 2002; Wakefield et al., 2010).

One important alternative approach to existing health communication strategies, which have received growing attention over recent years, is the use of serious games (Knutz et al., 2015; Wendorf & Kim., 2020). A serious game—also referred to as game-based learning (Hamari et al., 2016; Prensky, 2001, 2003)—is a specific type of game designed primarily for learning and training purposes within a wide variety of serious contexts, including education, public health, advertising, and military settings (Baranowski et al., 2008; Ritterfeld et al., 2009). Because of the entertaining nature of games and the prevalence of digital devices, serious digital games that use computer-based entertainment technology to teach, train, or change behavior are now popular in a wide range of health contexts (Asbell-Clarke et al., 2021; Boyle et al., 2016). Despite increased interest in the potential of serious digital health games, there are still many health intervention areas, including indoor tanning prevention, in which the efficacy of these games as innovative health intervention methods remains unexplored. Moreover, there have been mixed findings in the literature, demonstrating positive, non-existing, and negative effects of serious digital games on cognitive and behavioral health outcomes (Connolly et al., 2012; DeSmet et al., 2015). Finally, how target audience members' individual characteristics might influence these mixed findings has not been sufficiently examined. The present research is designed to address these gaps by designing and evaluating a serious digital health game as a tool to discourage indoor tanning use among young adults. Given that this study examines the effectiveness of the interactive

platform in leading to intended health intervention outcomes such as behavioral intention change, behavioral predictions theories (Ajzen & Fishbein, 1980; Fishbein & Ajzen, 1975, 2010) were used to provide a consistent framework throughout the development and evaluation of the game. In the following sections, we describe how the theoretical constructs (i.e., specific indoor tanning beliefs known to influence indoor-tanning behavior) have been transformed for use in the design of the game's main elements. Next, we report the results of an evaluation study to examine the game's relative effectiveness to conventional intervention tools in achieving desired changes in beliefs and intentions related to indoor tanning.

2. Review of the Literature

1) Serious Digital Games as an Interactive Health Intervention Platform

Over the past decade, there has been growing interest in the use of serious games as an innovative communication tool for learning and behavioral change (Boyle et al., 2016; Zhou et al., 2020). Among their various applications, serious games for health focus on promoting psychological, behavioral, and clinical health by integrating educational goals with entertaining elements of game play (Baranowski, 2014; Baranowski et al., 2016). While sharing basic characteristics with traditional games, serious games played on digital devices (i.e., serious digital games) are further characterized by their enhanced interactive features using computer technology, such as feedback on game choices made, responsive game narrative, and/or simulation (Baranowski et al., 2016). These interactive features that lead to fun and engaging gameplay experience are regarded as important characteristics that shape the persuasive

potential of serious digital games as a unique modality for health education and promotion (Gilliam et al., 2014; Kharrazi et al., 2012; Vorderer et al., 2006).

Interactivity in digital games is generally defined as a game's ability to allow players to engage in reciprocal and concurrent communication, such as receiving appropriate feedback about their performance at appropriate times (Klimmt et al., 2007; Ritterfeld et al., 2009; Weber et al., 2014), or as a game's capacity to provide players control over various game elements, such as adjusting game settings, customizing game characters, and personalizing game goals and sequences (Calleja, 2007; Weber et al., 2014). For example, an interactive health game that uses virtualization technologies to create an immersive game environment allows the players to safely obtain health knowledge and skills by actively participating in reality-based decision-making situations embedded in interactive game stories (Apperley, 2006; Sitzmann, 2011; Sundar, 2007). Such interactive features have been considered a unique property of serious digital games, distinguishing the platform from other health intervention modalities that lack those features or use fewer of them (DeSmet et al., 2015; Klimmt et al., 2007).

Research suggests that the enhanced interactivity of digital games can motivate players to put forth effort to reach and sustain an enjoyable and gratifying state with little concern about their surroundings (Bachen et al., 2016; Shafer & Carbonara, 2015). This pleasurable absorption in an intrinsically interesting activity, such as digital gameplay, has been described using different terms, including playfulness (Klimmt & Vorderer, 2003; Webster et al., 1993), flow (Csikszentmihalyi, 1975, 1990), presence (Lombard & Ditton, 1997; McMahan, 2003), or immersion (Brown & Cairns, 2004; Cheng et al., 2015). According to the literature on the role of game flow and immersion, the enjoyable and immersive experiences prompted by interactivity can increase game-play motivation (Bachen et al., 2016; Moreno & Mayer, 2002) and enhance

various learning outcomes (Hamari et al., 2016). However, counter evidence has also been reported. For example, Admiraal and colleagues(2011) found that while immersive gameplay experience increased students' game performance, it had no significant effects on science learning. Moreover, although there is evidence that playing digital games has small to moderate effects on improvement of health-related outcomes (Bailey et al., 2012; Noar et al., 2009; Rodriguez et al.,2014), other studies reported non-existent or even negative effects of digital games on desired health outcomes (e.g., Huss et al., 2003; Panic et al., 2014, Vorderer et al., 2001). For instance, Wei (2017) found that there was no advantage in using an interactive intervention platform in producing intended beliefs or intentions associated with drunk driving. Another study showed that an interactive game was less effective than traditional media in leading children to choose healthy snacks (Panic et al., 2014). The negative effects of enhanced game interactivity and engagement on intended cognitive and behavioral outcomes explained by the concept of limited cognitive capacity (Kahneman, 1973; Lang, 2000), which posits that humans as information processors can process only a limited amount of information at one time without becoming overloaded. From this perspective, the large amount of available mental resources allocated to engaging with interactive game features may result in a shortage of cognitive resources to further process the game's health content (Vorderer et al., 2001). While interactive serious health games seek to provide engaging and entertaining experiences to attract players, an equally important goal is to deliver intervention messages that would lead to intended persuasion and health outcomes (Shafer & Carbonara, 2015; Lyons et al., 2014). In light of these mixed findings, the impacts of interactive digital health games in achieving intervention outcomes, such as attitudinal and behavioral change, requires additional investigation.

2) Achieving the Intervention Goals of Serious Health Games: Behavioral Predication Theories

Choosing to engage or not engage in a health behavior can be driven by different beliefs. In terms of the present study, decisions about indoor tanning use are commonly associated with the beliefs that it either improves or harms one's appearance (Bowers & Moyer, 2019; Myrick et al., 2017). For example, if young women believe that tanned skin is a sign of beauty and good health and indoor tanning would help them increase their physical attractiveness, then they are more likely to use indoor tanning; on the other hand, if they believe that indoor tanning would lead to skin damage and wrinkles, they may be less willing to engage in the behavior (Choukas-Bradley et al., 2019; Occa et al., 2020). In addition, studies reported that indoor tanning behaviors could be associated with social needs and acceptance, particularly among young adults, a group known to be sensitive to peer norms and approval (Gambla et al., 2017; Noar et al., 2014). Thus, in order to achieve the intervention goal of a serious game aiming to discouraging indoor tanning behavior, the content of the game can designed to influence the specific beliefs that would lead to the intended change. The theory of reasoned action (TRA; Fishbein & Ajzen, 1975) and its successor, the theory of planned behavior (TPB; Ajzen, 1991; Ajzen & Fishbein, 1980), provide a useful theoretical framework in this regard.

According to these theories, the performance of a given behavior is primarily guided by the strength of the person's intention to perform that behavior. TRA and TPB further postulate that this intention is determined by three factors—attitude, subjective norm, and perceived behavioral control—which are guided by different kinds of beliefs (Fishbein & Ajzen, 1975; Fishbein & Yzer, 2003). In particular, the theories suggest that attitude is a function of the person's beliefs about positive and negative consequences of performing the behavior (i.e., behavioral beliefs or outcome beliefs), and subjective norm,

which refers to a person's perception about social pressure to perform or not to perform the behavior, is determined by the person's beliefs about the normative expectations of others important to the person (i.e., normative beliefs). While the original definition of subjective norm mainly concerned perceptions about what should or ought to be done (i.e., social approval), another aspect of normative beliefs that emphasizes perceptions about what other people are doing (i.e., prevalence or popularity) was incorporated into the conception to increase its predictive power (Fishbein & Ajzen, 2010; Rivis & Sheeran, 2003). The latter type of normative beliefs has been labeled as *descriptive norm* to be distinguished from the former, called *injunctive norm* (see Cialdini, Reno, & Kallgren (1990) or Cialdini (2007) for more discussions of the two types of norms). Finally, the performance of a given behavior is affected by perceived behavioral control, which refers to a person's perception of the ease or difficulty of performing the behavior of interest (Ajzen, 1991). Perceived behavioral control is thought to be guided by beliefs about the presence of factors that may facilitate or impede performance of the behavior (i.e., control beliefs). As a general rule, the more favorable the attitude and subjective norm, and the greater the perceived behavioral control a person has, the stronger the person's intention to perform the behavior in question should be (Ajzen & Fishbein, 1980; Ajzen, 2006).

3) The Present Study and Hypotheses

The integration of a theoretical framework, such as the behavioral prediction theories, into a serious game design process has been emphasized by a number of researchers to identify critical determinants of a targeted behavior and to maximize the game's effectiveness (Baranowski et al., 2008; Kato, 2012; Lwin et al., 2016). Although crucial work has been conducted following this suggestion (e.g., Bul et al., 2015; Spook et al., 2015), more examples of a theory-based,

collaborative game development and evaluation process are needed to offer useful guidance for serious game researchers and designers. Thus, we used the constructs of behavioral prediction theories as a consistent framework throughout the development and evaluation of the digital game to achieve and assess the intervention goals of the game. Specifically, given that the game's health content was designed to influence the critical beliefs known to shape indoor tanning intention among the target audience, we first examined the following hypotheses:

Compared to participants who were not exposed to any intervention content (i.e., the control group),

- **H1a:** participants who played the serious game would report more negative outcome beliefs about using indoor tanning.

- **H1b and c:** participants who played the serious game would report weaker normative beliefs about the social approval (H1b) and prevalence (H1c) of indoor tanning among their peers.

- **H1d:** participants who played the serious game would report stronger control beliefs that they can control their indoor tanning behavior.

Additionally, researchers have pointed out that the conflicting findings regarding the effectiveness of serious digital games might partly result from the inconsistent use of comparison groups in previous game research (All et al., 2016; Wendorf & Kim, 2020). For example, in some studies, a group playing a serious digital game was compared to a control group receiving no intervention (e.g., Brown et al., 1997; Peng, 2009); in contrast, other studies used a control group consisting of participants who were assigned to other intervention modalities (e.g., Panic et al., 2014; Sward et al., 2008). While

valuable, the former approach can only provide limited insights based on the comparison between people who are exposed to certain educational content through a serious game and those who are not exposed to any learning content at all. Furthermore, as reviewed above, there have been conflicting findings regarding the effectiveness of interactive digital game in leading to intended intervention outcomes (Connolly et al., 2012; Huss et al., 2003), suggesting that interactive features in digital games could distract from educational content rather than facilitate its processing (Panic et al., 2014; Vorderer et al., 2001). In order to more rigorously examine the merit of using serious digital games as an effective health intervention tool, further investigation is needed to examine whether a serious digital game is more effective in producing targeted intervention outcomes than conventional health intervention tools that mainly focus on delivering educational content while lacking or having fewer interactive and entertaining features. Thus, in the present study, we compared the digital game to a control group and to two other intervention conditions—an interactive website and a text-based brochure—in terms of their effects on the specific beliefs underlying behavioral change:

- **RQ1a:** Is there a difference in the effects of the digital health game and other intervention tools in leading to intended outcome beliefs?

- **RQ1b and c:** Is there a difference in the effects of the digital health game and other intervention tools in leading to intended injunctive norms (RQ1b) and descriptive norms (RQ1c)?

- **RQ1d:** Is there a difference in the effects of the digital health game and other intervention tools in leading to intended control beliefs?

Finally, it is also important to examine individual characteristics of the target

audience (young adults) that may influence the effectiveness of the serious digital game in discouraging indoor tanning. Because of the high prevalence of indoor tanning among females aged 18 to 25, previous indoor-tanning intervention research tended to focus mainly on young female indoor tanners (Boniol et al., 2012). However, scholars have highlighted the need to incorporate gender as an important factor when developing and evaluating skin cancer prevention programs for young adults due to the growing incidence of melanoma and the popularity of indoor tanning among male young adults (Balshill, 2017; Holman et al., 2014; Kann et al., 2014). Research has also shown important differences between male and female young adults regarding health problems associated with the indoor tanning use. For example, Mosher & Danoff-Burg (2010) reported that self-reported mental health issues and substance abuse behaviors were positively associated with indoor tanning among males, while these behaviors were not associated with indoor tanning among women. Investigating the role of gender in evaluating the effectiveness of a serious game is also important due the two groups' different preferences and motivations related to gameplay. For instance, research has shown that girls generally enjoy playing educational games and focus on attaining learning objectives, whereas boys generally prefer games with violent themes and focus on competition and entertainment (Blumberg & Sokol, 2004; Kaufman, Sauvé, & Renaud, 2011).

In addition, young adults with a history of indoor tanning (i.e., indoor tanners) may respond differently to anti-indoor tanning messages than those without it. There is strong evidence in the literature that young individuals who have previously engaged in an unhealthy behavior that is discouraged by an intervention message tend to develop resistance to the message's recommendation (Crano et al., 2008; Miller et al., 2006). According to the psychological reactance theory (Brehm & Brehm, 1981; Dillard & Shen, 2005), individuals are likely to develop aversive psychological responses when their freedom to act is eliminated or threatened by external factors. In particular,

the period of young adulthood is a vulnerable one, with substantial psychological changes represented by a strong need for autonomy. Within this context, using an indoor tanning facility while downplaying its risk is one of many consequential unhealthy choices that young individuals can make (Choi et al., 2010). Thus, the anti-indoor tanning messages embedded in the serious game can be more easily perceived as a threat to the autonomy of young adults who have already engaged with the behavior, leading to the development of psychological reactance. This reactance can manifest as the development of more positive attitudes toward the discouraged behavior and/or more intention to perform the behavior in the future. To our knowledge, however, no studies have examined the potential influence of these target characteristics on the effects of a serious digital game in an indoor tanning prevention context. This research gap shaped our last research questions:

- **RQ2a:** Is there an interaction effect of intervention type and target audience gender on indoor tanning intention?

- **RQ2b:** Is there an interaction effect of intervention type and target audience's history of indoor tanning use on indoor tanning intention?

3. Methods

1) Design of the Study Material: A Serious Game Intervention

A pilot digital game called *Dreamy* was developed by an interdisciplinary team of health communication researchers, game designers, professional writers, and illustrators as a tool to prevent indoor tanning use among young adults. Preliminary research, including literature review and focus group interviews

with the members of the target audience, was conducted to identify socio-demographic and psychological factors associated with the group's indoor tanning behavior. In addition, the formative research was used to identify an appropriate game type and scenario that could appeal to the target audience based on their media-use patterns and preferences. For example, according to a recent report (Smith & Anderson, 2016), online dating usage by 18- to 24-year-olds has increased nearly threefold since 2013, comprising the largest percentage of online dating website/app usage (27%). Our focus group interviews also indicated a notable increase in the popularity of online dating sites and/or mobile dating apps such as Match.com, Tinder, and Coffee Meets Bagel. Based on this preliminary research, Dreamy was designed as a role-playing, online dating simulation game that places the player into conversations with potential dates. Frequent meetings were held between the team members to integrate the principles of behavioral-prediction theories into the main elements of the game to achieve the health-intervention objective of the game, while not interfering with engaging and entertaining gameplay experience. Important game elements, including the game dialogue and characters, were presented to advisory groups for feedback. Usability tests on the initial game prototype were also performed to obtain a qualitative evaluation of the game's various aspects, including whether the game's interface and play process were intuitively understandable and engaging, whether players were able to navigate the game without a critical issue, and whether each element of the game functioned smoothly. In the present study, a revised game prototype was used to examine its effects on targeted beliefs associated with indoor tanning. The overall collaborative process of game development and evaluation is illustrated in Figure 1.

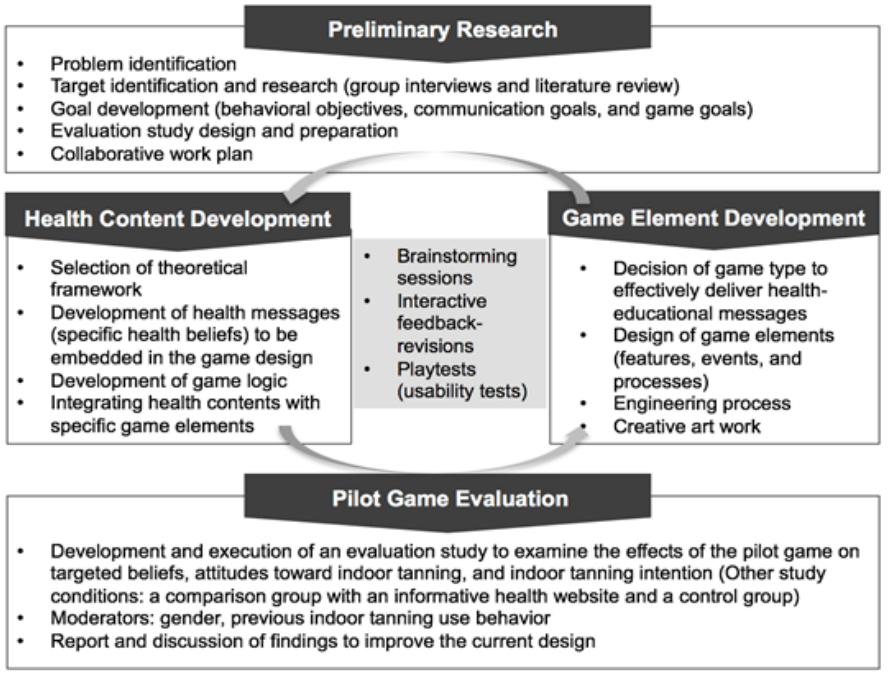

Figure 1. Collaborative Game Design and Evaluation Process

Based on the behavioral prediction theories reviewed earlier, the game's health content was developed to influence various beliefs about indoor tanning by emphasizing the following: (1) the negative consequences (physical, mental, and social harms) of indoor tanning (behavioral/outcome beliefs), (2) social disapproval of indoor tanning (injunctive normative beliefs), (3) misperceptions about the prevalence of indoor tanning among peers (descriptive normative beliefs), and (4) autonomy over or confidence in the ability to manage indoor tanning (control beliefs). To identify an exhaustive list of these indoor tanning beliefs, the comprehensive indoor tanning expectations scale (CITE: Noar et al., 2014, 2015), which identifies various expectations associated with indoor tanning, as well as the U.S. Food and Drug Administration (FDA) factsheets, which present detailed information about the dangers and popular misperceptions

of indoor-tanning use, were used (see Appendix A for the entire list of the target beliefs and measurement items used to develop and evaluate the game).

The theory-based health contents were transformed and placed into interactive game features designed to provide engaging and entertaining gameplay experience. In the game, the player is given a 30-day trial to the dating service, where they exchange messages with potential dates and make consequential choices that determine the direction of their future conversations and relationships. At the beginning of the game, the player is asked to create his or her own avatar. Once the player has created a customized character, a love ambassador from Dreamy Dating Service explains how to use the service. If the player winks at a potential match, he or she receives a greeting message from the non-player-controllable (NPC) game character, which includes their profile information. Character profiles appearing in the greeting messages are designed to show the character's personality and life values. While there are different NPC characters with varying appearances and backgrounds, all NPC characters are designed to present indoor tanning beliefs devised based on the TPB and CITE constructs. Importantly, although a player is given the ability to choose a particular type of NPC character (e.g., a potential date holding pro- or anti-tanning attitudes) and determine whether to continue a conversation with the character, the progress of every conversation was programmed to subtly expose the player health contents developed to present the true dangers of indoor tanning and correct widespread misperceptions about the benefits of indoor tanning.

In addition to the conversations, the player is invited to visit a tanning salon and subsequently receives an invitation from a dermatologist for a skin health check during game play. The player can choose whether or not to go to the tanning salon or dermatologist in response to their invitations. After a tanning session, the player's immediate health risk is determined based on the level of tanning intensity selected at the session. Post-tanning comments from the dermatologist

are set by the determined risk level in order to provide customized health messages. If the player gets an excessive level of tan, the player could learn about its harmful effects by observing his or her avatar's skin change and/or getting feedback during a follow-up dermatologist visit (see Figure 2 for the screen shots of the tanning salon and dermatologist visits).

Figure 2. Screenshots of the Tanning Salon Visit (top) and Dermatologist Visit (bottom)

The last component of the game play—an epilogue—is also designed to teach the long-term consequences of engaging in indoor tanning practices. In the epilogue, a short story with either a happy or sad ending is presented based on lifestyle/dating choices the player made during the game. The story reminds the player that the success in getting a date, or the improved physical attractiveness obtained by making unhealthy choices (e.g., continuous indoor tanning use), does not always guarantee a happy relationship in the long term.

Through the dating-simulated game environment, the players could safely obtain accurate knowledge about indoor tanning risks and learn the short-term and long-term consequences of making unhealthy practices in an accelerated manner.

2) Study Materials for Comparison Groups (Other Intervention Methods)

To assess the effectiveness of Dreamy, we included two other forms of widely used intervention platforms as comparison conditions—a health website and an educational reading material. The two health communication tools were chosen because they naturally differ from a digital game in their levels of interactivity and entertainment features, while having the ability to present the same health contents in order to create comparable study conditions. For example, the information-oriented health website allows participants to experience some level of interactivity, but the interactivity is mostly based on technical functions such as hyperlinks and feedback buttons, which are different from the story-based interactivity that can be experienced in the simulated digital game (see Zhou et al., 2020). Also, the reading material shares a similar story-telling component with the game but lacks technical interactivity features. To create comparable health contents across the study conditions, all study materials were developed based on the same set of health information obtained from CITE and the FDA's fact sheets, which presents educational content related to the specific indoor-tanning beliefs guided by the constructs of behavioral prediction theories, as listed in Appendix A. For the health website, the FDA's webpage that presents a variety of indoor tanning information included in the FDA's fact sheets was used (https://www.fda.gov/consumers/consumer-updates/indoor-tanning-risks-ultraviolet-rays). For the reading material, the same health information shown on the webpage was

incorporated into a brochure format with slight modifications to include personal stories demonstrating the negative consequences of using indoor tanning. To provide a concrete example, the descriptive normative belief item #1 in Appendix A ("I think that most of my friends are using tanning beds.") was derived from the information included the FDA's webpage ("Young adults make up a growing number of tanning bed customers…"). This perception about the prevalence of the behavior was also used to develop the content of the game narrative ("We workout together. A lot of my friends also go indoor tanning together…") and to select the stories included in the brochure ("I'm surrounded by people who have always loved tanning salons…"). Finally, the control group, consisting of participants who were not exposed to any intervention modalities, was included as a baseline.

3) Study Procedure and Participants

Study participants were recruited by a professional survey solution service which provides online samples in partnership with over 20 panel providers (https://www.qualtrics.com). Potential participants who meet the study's eligibility criteria—U.S. residents between the ages of 18 and 25 who speak and understand English—received an invitation emails with brief information about the study's purpose, time required, and incentive offered. Eligible participants who expressed interest in participation were directed to an online consent page that included details of the study. After responding to several pre-intervention questions about demographics (age, gender, and ethnic background) and previous indoor tanning experience, participants were randomly assigned to one of the four study groups described above. Participants then played the game, navigated through the website, read the brochure, or, in the case of the control group, moved directly to the next phase. After performing their assigned tasks, participants completed a post-intervention questionnaire that

included their evaluations of the study materials, beliefs (behavioral, normative, and control beliefs) about indoor tanning, and intention to tan indoors. At the end of the study, participants were thanked and directed to a completion page to receive the study's incentive. After several quality checks with the collected data (N = 576), such as excluding participants who reported that they had experienced technical issues, who spent a considerably shorter or longer amount of time than others based on the examination of the distribution of the participants' study completion times, and who provided unvarying responses across different measurement items, the number of participants remained in each study condition was as follows: Dreamy (n = 234), a health website (n = 115), a brochure with story (n = 137), and a control condition (n = 90).

4) Measures

Behavioral beliefs were operationalized as beliefs about the negative outcomes of indoor tanning that consist of three sub-dimensions: health threats, appearance harms, and discomfort, adopted from CITE's negative outcome expectation measures (Noar et al., 2015). Measurement items for each of the three dimensions were modified based on the content of the FDA fact sheet describing the physical and psychological dangers associated with indoor tanning. Health threat was assessed using eleven items, including "Indoor tanning can cause skin cancers including melanoma" and "Indoor tanning can lead to blinding eye diseases if eye protection is not properly used." Appearance harms were measured with three items, including "Indoor tanning causes the skin to lose elasticity and wrinkle prematurely." Feeling of discomfort was also assessed by three measurement items, including "I would feel uncomfortably hot and sweaty in the tanning booth." All items were scored on a 7-point scale with anchors 1 (strongly disagree) to 7 (strongly agree). A composite score for each

of the three dimensions was computed by averaging ratings from the measurement items after checking their inter-item reliabilities: health threats (11 items, α health threat = .94), appearance harms (3 items, α appearance harms = .81), and discomfort (3 items, α discomfort= .85).

For the assessment of normative beliefs about indoor tanning, both injunctive norms and descriptive norms were measured using 7-point scales ranging from 1 (strongly disagree) to 7 (strongly agree). Injunctive norms were measured with four items (e.g., "I believe that my close friends think I should not use indoor tanning/go to tanning salons"), and descriptive norms were measured by two items, including "I think that most of my friends are using tanning beds." Reliabilities across the four measurement items for injunctive norms and the two items for descriptive norms were α descriptive= .80 and α descriptive= .94 (Pearson correlation between the two items = .89), respectively.

Perceived behavioral control about indoor tanning was measured by three items rated on a 7-point scale, including "I am confident I can avoid using indoor tanning beds," and "Whether I use indoor tanning or go to a tanning salon is entirely up to me." We computed a composite score of the control beliefs after checking reliability across the three items (α control= .86). Appendix A shows the list of behavioral, normative, and control beliefs and measurement items used to develop and assess the educational content of Dreamy.

Behavioral intentions to tan indoors were measured with three items (e.g., "I intend to use indoor tanning facilities"), using a 7-point scale ranging from 1 (strongly disagree) to 7 (strongly agree). Ratings on these measures were averaged to create a single composite score of indoor tanning intention with high inter-item reliability (α intention= .96). Correlations, means, and standard deviations for the main study variables across the five study conditions are presented in Table 1.

Table 1. Correlations, Means, and Standard Deviations for Outcome Variables across Condition

	Mean	SD	1	2	3	4	5	6	7	8
1	5.42	1.37	(.94)							
2	5.41	1.40	0.63**	(.81)						
3	5.29	1.55	0.52**	0.53**	(.85)					
4	5.13	1.48	0.42**	0.45**	0.42**	(.80)				
5	3.14	1.94	−0.10**	−0.01**	−0.17**	−0.10*	(.94)			
6	5.77	1.50	0.42**	0.40**	0.46**	0.48**	−0.26**	(.86)		
7	2.75	1.52	−0.28**	−0.26**	−0.48**	−0.25**	0.50**	−0.34**	(.93)	
8	2.28	1.77	−0.21**	−0.14**	−0.33**	−0.14**	0.56**	−0.32**	0.70**	(.96)

Note. * $p < .05$; ** $p < .01$; 1: Health threats; 2: Appearance harms; 3: Discomfort; 4: Injunctive norms; 5: Descriptive norms; 6: Control beliefs; 7: Attitudes; 8: Intentions. Reliability for each outcome variable measured by Cronbach's alpha is shown in the diagonal.

5) Analytical Approaches

To test our set of hypotheses and research questions, a series of between-subject factor(s) Univariate Analysis of Variance (ANOVA) or Multivariate Analysis of Variance (MANOVA) were conducted using SPSS. A MANOVA was used to examine whether a significant group difference exists on the linear combination of multiple but intercorrelated outcome variables, while controlling for the inflation of type I error rate. All the underlying assumptions for MANOVA—normality, homogeneity of variance-covariance matrices across groups, linearity, and multicollinearity—were evaluated. If any of the aforementioned assumptions were violated, Pillai's trace, known to be robust for the violation of the underlying assumption (Tabachnick & Fidell, 2013), was used as a test statistic for MANOVA. Otherwise, Wilk's Lambda was used for testing the significance of effects. To identify which specific level(s) of an independent variable are significantly different from one another in terms of their effects on a specific outcome variable, post-hoc analyses using Tukey method were conducted with an alpha level of .05 for each outcome variable. Also, ANOVA was used to examine

whether a significant group difference exists on an outcome variable. The underlying assumptions for ANOVA were first evaluated. When homogeneity of variance assumption was violated, a more stringent alpha level of .05 was used to test the significant group difference in ANOVA. When significant group difference was found in ANOVA, a follow-up analysis using Tukey method was performed in order to identify the specific pair of groups that exhibited significant difference on an outcome.

4. Results

1) Descriptive Statistics

The total number of participants included in the final analyses were 501 (46.1% male, mean age of 21.02 with a range from 18 to 24 years old). Most participants were identified as White (n = 310, 61.9%), followed by Hispanic (n = 74, 14.8%), Black/African American (n = 63, 12.6%), Asian (n = 40, 8%), and others (e.g., Native Hawaiian or other Pacific Islanders). The number of participants in each study condition was as follows: Dreamy [n = 193, Male = 40], a health website [n = 103, Male = 43], an informative brochure with story [n = 123, Male = 21], and a control condition [n = 82, Male = 21]. Of those participants who had indoor tanning experience, there were 57 (30%) in the digital game condition, 35 (34%) in the website condition, 38 (31%) in the brochure condition, and 30 (37%) in the control condition. As shown in Table 1, correlation coefficients among the main outcome variables across all the study conditions appeared to be consistent with the theory (TRA and TPB)-suggested directions at statistically significant levels. The more negative outcome beliefs (health threats, appearance harms, discomfort) and perceived disapproval from friends and parents, the less perceived prevalence of indoor tanning among peers, and the greater control

beliefs a participant had, the weaker intention to engage in indoor tanning the person was likely to report.

2) Effects of Playing Dreamy on Specific Beliefs Underlying Behavioral Change

The total number of participants included in the final analyses were 501 (46.1% male, mean age of 21.02 with a range from 18 to 24 years old). Most participants were identified as White (n = 310, 61.9%), followed by Hispanic (n = 74, 14.8%), Black/African American (n = 63, 12.6%), Asian (n = 40, 8%), and others (e.g., Native Hawaiian or other Pacific Islanders). The number of participants in each study condition was as follows: Dreamy [n = 193, Male = 40], a health website [n = 103, Male = 43], an informative brochure with story [n = 123, Male = 21], and a control condition [n = 82, Male = 21]. Of those participants who had indoor tanning experience, there were 57 (30%) in the digital game condition, 35 (34%) in the website condition, 38 (31%) in the brochure condition, and 30 (37%) in the control condition. As shown in Table 1, correlation coefficients among the main outcome variables across all the study conditions appeared to be consistent with the theory (TRA and TPB)–suggested directions at statistically significant levels. The more negative outcome beliefs (health threats, appearance harms, discomfort) and perceived disapproval from friends and parents, the less perceived prevalence of indoor tanning among peers, and the greater control beliefs a participant had, the weaker intention to engage in indoor tanning the person was likely to report..

We hypothesized that participants who played Dreamy would report more negative outcome beliefs about using indoor tanning compared to those who were assigned to a control group (H1a). In addition, we suggested a research question to compare the effectiveness of the digital game on the negative outcome beliefs to other intervention modalities (RQ1). The Box's M of 121.81

indicated that the homogeneity of variance-covariance matrices assumption was violated (F(18, 481862.58) = 6.69, p < .01), so Pillai's trace was used as a test statistic for MANOVA. Results from the one-way MANOVA suggested that there was a significant multivariate omnibus effect of intervention type on the linear combination of negative outcome beliefs (health harm, appearance harm, and discomfort) (Pillai's Trace = .09, F(9, 1491) = 4.82, p < .01, η_p^2 = .03). Follow-up analyses using an alpha of .017 (.05/3) indicated that appearance harms significantly differ by the type of intervention modalities (F(3, 497) = 5.94, p =.001, η_p^2 = .04), but the modality type did not have significant impacts on health threats (F(3, 497) = 2.27, p = .08, η_p^2 = .01) and discomfort (F(3, 497) = 2.27, p = .07, η_p^2 = .01). As shown in Table 2, although participants who played the game reported higher appearance harm scores than those who were in the control condition, results of a post-hoc pairwise comparison analysis indicated that the difference was not statistically significant, rejecting H1a. The post-hoc analysis further revealed that participants who browsed the FDA's website reported significantly higher level of appearance harms than other intervention methods, including the digital game (*Mdiff* = .48, *SE* = .17, p = .03), addressing RQ1a.

With regard to the effects of intervention type on normative beliefs about indoor tanning, we hypothesized that, compared to those who were not exposed to any interventions, players of Dreamy would perceive a higher level of social disapproval about indoor tanning (injunctive norm, H1b) and a lower level of indoor tanning prevalence or popularity (descriptive norm, H1c). The Box's M of 6.45 indicates that the homogeneity of variance-covariance matrices assumption was met (F(9, 1091099.45) = 0.71, p = .70), so Wilk's Lambda was used as a test statistic for MANOVA. Results suggested that the multivariate omnibus effect of intervention type was not significant for the linear combination of normative beliefs, indicating that participants who played the

game did not significantly differ from the control group in their reported injunctive and descriptive norms (Wilk's Λ = .99, $F(6, 992) = 0.62$, p = .72). Thus, H1a and H1b were rejected. In order to further explore the merit of using the interactive platform, we also compared the effectiveness of the digital game on the injunctive norms (RQ1b) and descriptive norms (RQ1c) to other intervention modes. The results showed no statistically significant differences in the social disapproval and prevalence perceptions across the different conditions.

Table 2. Means and Standard Deviations of Beliefs by Intervention Type

Outcome variables	Dreamy (n = 193)	Website (n = 103)	Brochure (n = 123)	Control (n = 82)
Negative beliefs				
Health threats	5.41 (1.24)	5.69 (1.26)	5.21 (1.75)	5.39 (1.10)
Appearance harms	5.23 (1.36)	5.71 (1.29)	5.68 (1.45)	5.08 (1.44)
Discomfort	5.33 (1.51)	5.47 (1.36)	5.33 (1.88)	4.89 (1.55)
Normative beliefs				
Social disapproval	5.11 (1.46)	5.23 (1.39)	5.04 (1.56)	5.17 (1.52)
Perceived popularity	3.17 (1.98)	3.31 (1.99)	3.16 (1.95)	2.85 (1.80)
Control beliefs	5.61 (1.61)	5.76 (1.45)	5.85 (1.50)	6.04 (1.28)

The last hypothesis and research question concerned the relative effectiveness of playing a digital game, compared to a control group (H1d) and other intervention tools (RQ1d), in creating stronger beliefs that people can control their indoor tanning behavior. The homogeneity of variance assumption was violated ($F(3, 497) = 4.31$, p = .005) in Levene's test. Therefore, the alpha level of .025 was used to test the significance of main effect in ANOVA. Results from one-way ANOVA suggest no significant effect of intervention type on control beliefs ($F(3, 497) = 1.76$, p = .15), rejecting H1d. With regard to RQ1d, while not statistically significant, participants who were in other intervention conditions and the control group reported stronger control beliefs about indoor tanning compared to those who played the game (see Table 2).

3) Effects of Intervention Types and Target Characteristics on Behavioral Intentions

Finally, a three-way ANOVA was performed to examine whether the effects of intervention type on behavioral intention would vary according to the gender (RQ2a) and previous tanning experience (RQ2b) of young adults who participated in the study. Table 3 describes the means and standard deviations of indoor tanning intention by intervention type and target characteristics.

Table 3. Means and Standard Deviations of Behavioral Intention by Intervention Type and Target Characteristics

Outcome variables	Dreamy (n = 188)	Website (n = 102)	Brochure (n = 122)	Control (n = 81)
By gender				
Male (n = 236)	2.80 (1.95)	2.28 (1.54)	2.00 (1.50)	3.05 (1.95)
Female (n = 257)	1.81 (1.47)	2.03 (1.75)	1.99 (1.65)	2.08 (1.66)
By indoor tanning history				
Yes (n = 160)	3.79 (2.00)	2.31 (1.68)	2.32 (1.86)	3.04 (1.62)
No (n = 333)	1.94 (1.52)	2.04 (1.67)	1.85 (1.54)	1.90 (1.76)

The homogeneity of variance assumption is violated ($F(15, 477) = 4.06$, $p < .001$) in Levene's test. Therefore, a more stringent alpha level of .025 was used to test the significance of main and interaction effects in ANOVA. Results from a three-way ANOVA (intervention types' gender' indoor tanning history) yielded a significant main effect of intervention types ($F(3, 477) = 4.02$, $p = .008$, $\eta_p^2 = .03$), gender ($F(1, 477) = 8.74$, $p = .003$, $\eta_p^2 = .02$), and indoor tanning experience ($F(1, 477) = 24.17$, $p < .001$, $\eta_p^2 = .05$) on indoor tanning intention. In addition, there were significant two-way interaction effects of intervention type by gender ($F(3, 477) = 3.10$, $p = .026$, $\eta_p^2 = .02$) and intervention type' indoor tanning experience ($F(3, 477) = 5.50$, $p = .001$, $\eta_p^2 = .03$) on indoor tanning intention, although the former interaction effect

was only marginally significant at the p level of .025. The two-way interaction of gender and tanning experience ($F(1, 477) = .08$, $p = .68$) and the three-way interaction of intervention type, gender, and indoor tanning experience ($F(3, 477) = 1.38$, $p = .25$) showed no significant effects on indoor tanning behavior. As higher-order effects supersede the lower-order effects, only follow-up analyses for the significant two-way interaction effects of intervention methods and the target characteristics on the outcome variable were reported here.

Figure 3 illustrates the two-way interaction effect of intervention type and gender on indoor tanning intention scores, addressing RQ2a. Overall, male participants reported stronger indoor tanning intention than females, but this difference was especially pronounced among those who played the game and those who were not exposed to any intervention messages. As shown in Figure 3, male participants who played the game reported one of the strongest indoor tanning intention scores, while those who read the brochure with personal stories reported the weakest intention to tan indoors. Pairwise comparisons

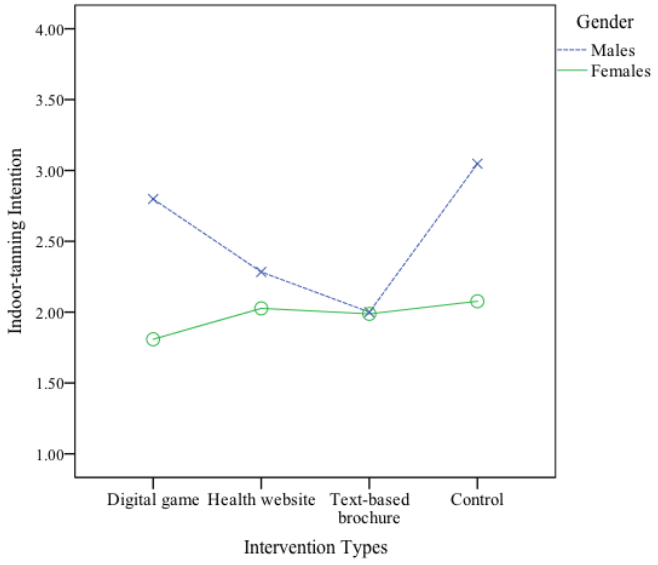

Figure 3. Interaction Effects of Intervention Type and Gender on Indoor Tanning Intention

showed that the difference in indoor tanning intention scores between the game and brochure conditions was statistically significant (M_{diff} = 1.26, SE = .34, p = .001). For female participants, on the contrary, those who played the digital game reported the lowest indoor tanning intention, although the score was not statistically different from indoor tanning intention scores reported by other intervention conditions.

Figure 4 shows the interaction effect of intervention type and previous indoor tanning experience on indoor tanning intention, addressing RQ2b. As shown in Figure 3, participants who had previously tanned indoors generally reported stronger indoor tanning intention than those without previous experience, and this difference was especially pronounced among those who played the game. Among the participants who had previous indoor tanning experience, those who played the digital game reported the strongest indoor tanning intention scores, followed by those who were in the control condition. Pairwise comparisons further indicated that the mean indoor tanning intention

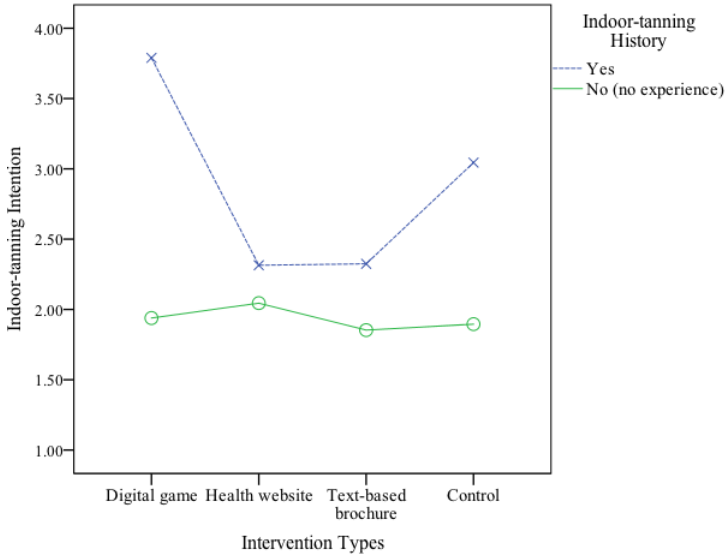

Figure 4. Interaction of Intervention Type and Indoor Tanning Experience on Indoor Tanning Intention

score reported from the game condition was significantly higher than intention scores reported from other intervention groups, including the website condition (M_{diff} = 1.17, SE = .39, p = .016) and the brochure with story condition (M_{diff} =1.46, SE = .39, p = .001). Conversely, for participants who had never tanned indoors, no significance differences emerged in indoor tanning intention scores reported by the different study conditions.

5. Discussion

1) Summary of Findings and Implications

With the advanced interactivity and entertaining narrative components, serious digital games have been regarded as a potentially more advantageous medium than traditional health intervention modalities, particularly for reaching younger people who having grown up with the Internet and mobile technology (Lieberman, 2006). To empirically test the expected merit of the platform, we designed a serious digital game as a tool to address the growing use of indoor tanning facilities among young adults and examined its effectiveness relative to conventional intervention tools, including a health website and a text-based brochure. Although the game was carefully designed using behavioral-change theory principles and interdisciplinary collaborations, the study's results showed little evidence supporting the expected advantage of the new platform. The impact of Dreamy was not significantly different from other conventional intervention modalities in influencing participants' beliefs about the negative outcomes of indoor tanning (behavioral beliefs), social disapproval and popularity of the behavior (normative beliefs), and the extent to which they have control over indoor tanning behavior (control beliefs). Moreover, compared to conventional intervention modalities designed to discourage indoor

tanning, playing the digital game led to a stronger intention to use indoor tanning among the subgroups of participants who were male and who had previous experience with indoor tanning.

One possible reason for the ineffectiveness of the digital game found in this study could partially from the known challenge in balancing two integral, but often conflicting, goals of serious digital games: education and entertainment. As a number of game researchers have pointed out, maintaining entertaining game-play experience while delivering educational messages is not an easy task (Buday, 2015; Shafer, 2012). To avoid an overt presentation of the game's educational intent, we granted the players an agency (i.e., control)—the ability to select and interact with realistic game characters representing diverse perspectives on indoor tanning and lifestyle choices, including incorrect and unhealthy ones. The game was programmed to naturally give players a variety of opportunities to modify their incorrect knowledge about the benefits of indoor tanning and learn its true dangers, even when they mainly interact with a non-player character who presents information against the game's intended health message and keeps making unhealthy choices. Although this design was deliberately chosen to increase the entertainment and interactive aspects of the game experience, some of the participants in the gameplay condition might have exclusively enjoyed interacting with game characters presenting pro-tanning messages and minimized opportunities to interact with other game characters expressing anti-tanning messages.

The game's lack of effectiveness can also be understood in terms of the ongoing discussion about the role of interactivity. In general, interactivity has been considered one of the most essential features that shape the persuasive potential of digital health games (Gilliam et al., 2014; Kharrazi et al., 2012; Sundar & Kim, 2005). However, theoretical arguments related to the notion of limited cognitive capacity (Lang, 2000) and empirical evidence from the literature suggest that enhanced interactivity features may distract users from

focusing on important health information and educational messages embedded in serious games instead of facilitating their ability to achieve the game's intervention goal (deHaan et al., 2010; Panic et al., 2014; Vorderer et al., 2001). The present study's findings support this view, indicating that a digital game equipped with engaging and interactive features does not guarantee superior intervention outcomes compared to traditional health intervention modalities that may lack those features or use less of them.

Relatedly, the findings regarding the moderating effects of gender and previous experience are noteworthy. In particular, the stronger indoor tanning intention reported by male participants compared to female participants might reflect the differential motivations of these two groups and the different aspects of the game that they emphasized during gameplay. As reviewed earlier in this paper, there is evidence that young male players focus on completing entertainment- and competition-oriented game tasks, while young female players focus on exchanging information related to instructional goals (Blumberg & Sokol, 2004; Ching et al., 2000). These differential motivations and focuses might influence how players experience the multifaceted digital game with various attributes. For instance, male participants in the present study might have focused on engaging with features devised to produce entertaining and competitive gameplay experiences, leaving few cognitive resources left to process the indoor tanning-related educational content. In contrast, female players might have focused on the educational messages embedded in the gameplay and assigned cognitive efforts required to achieve the game's intervention goal. Although recent reports have shown that the traditional gender gap in digital game players is shrinking (Entertainment Software Associations, 2015), important differences may remain between males and females in terms of their motivations for playing digital games and their learning outcomes.

In addition, this study found the pilot digital game to be least effective for

reducing indoor tanning intention in participants who had previously tanned indoors, regardless of gender. This finding is consistent with previous findings demonstrating that young individuals who have previously engaged in an unhealthy behavior that is discouraged by a health message tend to develop psychological reactance to the message's recommendation, which is typically manifested as more positive attitudes toward or stronger intention to perform the discouraged behavior (Crano et al., 2008; Miller et al., 2006). Health communication research has shown that traditional intervention messages delivered in a dictating and didactic tone can be perceived by young adults as threats to their autonomy, often resulting in nonexistent or boomerang effects (Burgoon et al., 2002; Cho & Salmon, 2007; Hornik et al., 2003). This evidence has led researchers to consider digital games a preferred platform from which young people can obtain health knowledge and skills without developing psychological reactance (Vorderer et al., 2006). However, the findings of the current study suggest the need to examine the possible exacerbation of boomerang effects when a more entertaining and engaging intervention tool is used to influence individuals prone to developing reactance to health intervention messages.

It is also noteworthy that the players of the game were exposed to both positive and negative aspects of indoor tanning use, although the former (misbeliefs or incorrect information about the benefits of indoor tanning) was designed to be corrected as the game progresses. This particular structure might have functioned as a two-sided message or a refutational appeal, in which the message designer typically presents arguments that are against the message's main claim but then refutes the information in order to inoculate the message recipients against possible counterarguments (Etgar & Goodwin, 1982; Sawyer, 1973). Conflicting evidence exists, but scholars have generally agreed that the effectiveness of the strategy is influenced by a variety of factors, including the amount and presentation order of negative information (Alba,

Hutchinson, & Lynch, 1991; Eisend, 2006; O'Keefe, 1999). For example, a meta-analysis study (Eisend, 2006) showed that the persuasive effects of two-sided advertising messages on attitude toward the ad and purchase intention were significantly reduced when a greater amount of negative information was included and when the negative information was placed first. Applying the same logic, the amount and presentation order of pro-tanning messages that the players were exposed to during the game play might have contributed to the null or negative impact of Dreamy on indoor tanning beliefs and intentions.

Finally, while the present study was conducted within the context of health communication, lessons from this study—including the design decisions made to balance two essential but often conflicting educational and gaming goals of a serious game and their subsequent unexpected consequences—can be applicable to other areas of persuasive communication. For example, in the domain of marketing and advertising, a similar type of tool known as an advergame (Cauberghe & De Pelsmacker, 2010) or gamified advertising (Terlutter & Capella, 2013), which uses an interactive and entertaining game format to achieve its persuasive goal, has been widely used to deliver important product- or brand-related information (Mallinckrodt & Mizerski, 2007). Notably, similar to the conflicting findings regarding the effectiveness of serious health games (e.g., DeSmet et al., 2015; Panic et al., 2014; Rodriguez et al.,2014; Vorderer et al., 2001), mixed evidence has been reported regarding the effectiveness of advergames relative to traditional, non-gamified advertising in achieving their ultimate commercial goals (e.g., Evans et al., 2019; Waiguny et al., 2014). Despite the continuously increasing popularity of advergames as an innovative marketing communication tool, engaging advergame attributes designed to promote interesting, adventurous, and exciting experiences may not ensure the achievement of desired advertising outcomes (Lee & Cho, 2017; van Berlo et al., 2021). While this study is an

initial step toward testing the feasibility of implementing a digital game for indoor tanning prevention, findings from the study also offers important suggestions for the design, evaluation, and target-specific usage of a digital game for various areas of persuasive communication.

2) Limitations and Future Research

The results of this study should be considered with caution due to several limitations. First, one of this study's main findings—the non-existent or detrimental effects of a serious digital game—may be attributed to the way that Dreamy was designed and evaluated as discussed above. To avoid an overt presentation of the game's educational intent and give the players an agency, we developed different types of game characters depicting individuals who have different perspectives on indoor tanning use and life values, including unhealthy ones. Notably, the indoor tanning belief and intention scores that were used to examine the effectiveness of the game were computed based on the aggregated responses from all participants assigned to the game condition, without considering the particular type of game characters a player might have encountered. Although the game was programmed to give all players a variety of opportunities to modify their incorrect knowledge and learn the true dangers of indoor tanning use over the course of game play, regardless of the types of potential dates with whom a player chose to interact, we cannot rule out the possibility that the amount of exposure to a particular character type might have systematically influenced the player's indoor tanning beliefs and/or intention scores. Relatedly, the players of the game had the possibility to be exposed to both positive and negative aspects of indoor tanning use during conversations with game characters. Although the game was designed in a way that the former (i.e., misbeliefs about the benefits of indoor tanning) was always corrected over the game play, the presentation order of positive and

negative information might have influenced the outcomes of the present study as the literature on persuasive effects of two-sided messages indicates (Eisend, 2006). Future research examining the effects of a serious digital game will benefit from examining the potential effects of the amount and/or order of exposure to different types of NPCs (healthy vs. unhealthy).

Next, following the recommendations of previous game evaluation research, we examined the effects of the digital game in comparison with other types of intervention modalities, including a health website and a text-based brochure, in order to increase the internal validity of the study's results. The selection of the three particular intervention modalities was largely based on the assumption that they have inherently different forms and levels of interactivity and narrative features. For example, simulations and an interactive narrative, as used in a digital game like Dreamy, might be considered more advanced forms than the narrative features on a text-based brochure. However, given that a digital game consists of a variety of structural and functional features of interactivity and narrative that may independently or collectively influence persuasion outcomes, an experiment in which the types and/or levels of interactivity and storytelling features were actually manipulated to examine their effects could shed further light on the findings of the present study. In addition, although we carefully designed the study materials to keep the main health content consistent across the three intervention conditions, other features unique to the format of each medium and a participant's preference for the different modalities might have had confounding effects on the results.

Also, several quality check methods were implemented in the present study as described in the method and result section. However, the length of time the participants spent going through the game and other study materials could not be completely controlled during the online experiment. We conducted a post analysis to examine the distribution of the study time in minutes, according to the three experimental conditions. As expected, a slightly longer average study

time for the game condition was observed, given that the game contained more complex features compared to the two other experimental conditions; however, the three study time distributions were almost identical. To further examine the potential confounding effect of the study duration, we also conducted a sensitivity analysis without outliers, whose z score associated with response time is outside of ± 3. We found no substantial change in the results of statistical inference tests reported in the present manuscript. In addition, whether the participants assigned to the game and other conditions actually paid close attention to the game could not be completely controlled in this study. Although such a problem is common in many social science studies that utilize on/offline quasi-experiments and surveys, an intervention of this complexity should be conducted in a more controlled laboratory setting rather than an online experimental setting.

It should also be noted that the type of interactivity expected to vary according to this study's different intervention conditions (and to influence the study outcomes) was a feature- or medium-based interactivity, which is distinguished from another type of interactivity known as *perceived interactivity*. In contrast to the feature-based interactivity determined by the objective attributes of communication circumstances, messages, or medium types (Coyle & Thorson, 2001; Sundar, 2007), perceived interactivity is defined as users' subjective perceptions of a particular communication medium's interactive features (Bucy & Tao, 2007; McMillan & Hwang, 2002; Wu, 2005). For instance, a digital game with various interactive features is generally considered more interactive than a conventional modality that has fewer or none of these formal features, but subjective perceptions about the game's interactivity (i.e., perceived interactivity) may vary according to individual players (Wendorf & Kim, 2020). While the two types of interactivity are closely related, the perception-based interactivity has been suggested as a more direct predictor of gameplay experiences and intervention outcomes than the feature-based

interactivity of a digital game (Thorson & Rodgers, 2006; Yang & Shen, 2018). Thus, factors that are known to influence perceived interactivity, such as individual player preference and ability to recognize, understand, and use interactive features, might have influenced the findings of the present study (Bucy & Tao, 2007; Sundar, 2004). Although important, examining the mediating role of perceived interactivity while controlling for the potential confounders was beyond the scope of the present study. Instead, this study focused on examining the potential effects of a newly developed pilot game on desired indoor tanning beliefs and intentions relative to other intervention methods. A separate work focusing on the roles of perceived interactivity and other intermediate outcomes is underway to further understand the mechanisms underlying the findings of this and other digital game effect studies.

Finally, extrapolation of the findings of the present study should be limited to the particular health behavior and target individuals examined in this study. There is still a wide range of health topics for which the potential of serious digital games remains unexplored. Future research that utilizes a similar theoretical and evaluation framework to our study is necessary for the generalization and refinement of this study's findings. Our data show that gender and previous experience are just a few examples of factors that can influence the effects of serious digital games for young adults. Identification of other conditions that might moderate the effects of serious digital games can help game researchers and designers develop more effective serious digital games.

3) Conclusion

The potential of digital games as effective intervention tools is largely based on the assumption that new communication platforms, which allow more user control and engagement, can amplify the effects of persuasive communication. However, scholars have suggested that such ideas should be empirically tested

rather than assumed (Peng, 2009; Garris et al., 2002). The present study contributes to the literature by empirically testing this assumption through the development and evaluation of a serious digital game as a tool to address a growing health concern affecting the younger generation, suggesting instead that such expectations may overlook important variations in the characteristics of the young generation often seen as a homogeneous group. Importantly, however, we emphasize that such findings should not serve to discredit the potential of a serious digital game, but rather serve to provide reason to consider target characteristics as active factors that influence the effects of digital games. Such an approach will improve upon previous research that tended to employ these types of variables as controls or covariates in analyses of digital game effects. Despite the several limitations discussed above, the real challenges and opportunities involved in designing and evaluating a serious health game discussed in this study as well as the detailed description of the theory-based, collaborative game development and evaluation process offer a useful example and practical guidance for serious game researchers and designers.

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Appendix A.

List of beliefs and measurement items used to develop and assess the educational content of Dreamy and other intervention

Variables		Items
Behavioral/ outcome beliefs (Health threat)	1	Indoor tanning can cause skin cancers including melanoma.
	2	Indoor tanning can lead to blinding eye diseases if eye protection is not properly used.
	3	Sunlamps used for indoor tanning may be more dangerous than the sun.
	4	If you stay under the artificial light too long or at too high an intensity, you can get sunburn.
	5	Indoor tanning is unhealthy.
	6	Tanning beds often exceed UV limits, despite the claims of the salon.
	7	Tanning salons are merely marketing their products and services and not telling you the truth about the danger of indoor tanning.
	8	People who begin indoor tanning during early adulthood have a higher risk of getting melanoma.
	9	The link between indoor tanning and skin cancer is scientifically proven.
	10	Teens are at special risk of developing melanoma.
	11	Vitamin D can be obtained from a healthy diet or a vitamin supplement instead of indoor tanning.
Behavioral/ outcome beliefs (Appearance harms)	1	In addition to the serious risk of skin cancer, tanning can cause premature aging.
	2	Indoor tanning causes the skin to lose elasticity and wrinkle prematurely.
	3	A tan is not the sign of good health. The skin acts in self-defense by producing more melanin, a pigment that darkens the skin.
Behavioral/ outcome beliefs (Discomfort)	1	I would feel claustrophobic in the tanning booth.
	2	I would feel uncomfortably hot and sweaty in the tanning booth.
	3	It would be a waste of money or an unnecessary luxury to tan indoors.
Normative beliefs (Descriptive)	1	I think that most of my friends are using tanning beds.
	2	I think that most of my friends are going to tanning salons pretty often/regularly.
Normative beliefs (Injunctive)	1	I believe that my close friends think I should not use indoor tanning/go to tanning salons.
	2	I don't want to make my close friends worry about my health.
	3	I believe that my parents think I should not use indoor tanning/go to tanning salons.
	4	I don't want to make my parents worry about my health.
Control beliefs	1	I am confident I can avoid using indoor tanning beds.
	2	Whether I use indoor tanning or go to a tanning salon is entirely up to me.
	3	For me avoiding indoor tanning is easy.

국 문 초 록

이론적 기반과 학제간 협력을 바탕으로 한 청장년층의 실내 인공 태닝을 방지하기 위한 기능성 디지털 게임의 개발과 평가에 관한 연구

김소윤 마이애미 대학 커뮤니케이션학과 조교수*
안소연 마이애미 대학 교육심리학과 교수
박성은 플로리다 국제대학 유니버설 건축공학교육학과 박사후 연구원

본 연구는 기능성 디지털 게임이 젊은 연령층에서 실내 태닝을 방지하는데 효과적인 건강 커뮤니케이션 도구로서 쓰일 수 있는지 가능성을 조사해 보고자 수행되었다. 학제간 협력을 통한 게임 개발 과정에서, 게임의 주요 요소들은 행동 예측 이론을 바탕으로 실내 태닝 행동과 연관된 중요한 신념들에 (결과 평가, 규범적 신념, 통제감 등) 영향을 미치도록 개발되었다. 이 기능성 게임이 건강 관련 웹사이트나 교육용 자료와 같이 전통적으로 널리 쓰이는 건강 커뮤니케이션 도구들과 비교해 더욱 효과적인지 평가하기 위해, 501명의 미국 젊은 성인 남, 녀를 대상으로 온라인 실험을 실시하였다. 연구 결과 기능성 게임이 태닝과 관련된 중요한 신념들에 영향을 미치는데 전통적인 도구들보다 더 효과적이라는 통계적 증거는 발견되지 않았다. 또한, 이 게임이 실내 태닝 행동 의도에 미치는 영향에 있어서, 젊은 성인 여성들이나 기존에 실내 태닝 경험이 없는 참가자들 사이에서는 가장 효과적인 도구로 나타난 것과는 달리, 남성이나 실내 태닝 경험이 있는 참가자들 사이에서는 가장 비효과적인 도구로 나타났다. 이 연구는 대안적인 건강 증진 및 교육 도구로서 기능성 디지털 게임의 활용 가능성에 주목하는 연구자와 실무자들에게 유용한 가이드를 제공하며, 이러한 뉴미디어 플랫폼이 젊은이들 사이에서 일괄적으로 긍정적으로 효과를 미칠 것 이라는 가정에 주의를 환기시키는 중요한 함의를 지닌다.

KEY WORDS 기능성 디지털 게임 • 게임 기반 학습 • 건강 커뮤니케이션 • 실내 태닝 • 계획된 행동 이론

* skmn0814@gmail.com, 제1저자, 교신저자