Using Virtual Doppelgängers to Increase Personal Relevance of Health Risk Communication

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Abstract. Virtual doppelgängers are human representations in virtual environments with photorealistic resemblance to individuals. Previous research has shown that doppelgängers can be effective in persuading users in the health domain. An experiment explored the potential of using virtual doppelgängers in addition to a traditional public health campaign message to heighten the perception of personal relevance and risk of sugar-sweetened beverages. Both virtual doppelgängers and an unfamiliar virtual human (i.e., virtual other) used in addition to a health pamphlet were effective in increasing risk perception compared to providing just the pamphlet. Virtual doppelgängers were more effective than virtual others in increasing perceived personal relevance to the health message. Self-referent thoughts and self presence were confirmed as mediators.

Keywords: Agents, Avatars, Health Technology, Virtual Environments, Presence.

Sugar-sweetened beverages (SSBs) have recently garnered much negative attention with the increasing concern for rising rates of obesity [1]. A flood of health promotion campaigns has been launched in an effort to counteract the prevalence of SSB consumption and some governments have even proposed a ban on large sized soft drinks in an attempt to assist the battle against obesity. Virtual health agents provide us with novel ways to address this health issue. Specifically, this study investigated how the use of virtual doppelgängers, or agents designed to look like the self [2], can be used to effectively change health behaviors.

1 Communicating Health Risk – Challenges for Personal Relevance

Perhaps one of the greatest challenges that health promotion campaigns face is communicating risks in a personally relevant way. Personal relevance is the extent to which an issue or topic has important personal consequences and/or intrinsic importance [3]. Some scholars have noted that there lies a social distance between the individual and the risk presented in the mediated message wherein the individual does not feel that the risk is relevant to the self, leading him or her to discredit the personal

T. Bickmore et al. (Eds.): IVA 2014, LNAI 8637, pp. 1–12, 2014.

relevance of the message [4]. This challenge is magnified by the tendency of individuals to underestimate the self's susceptibility to various health conditions relative to others [5].

In an effort to overcome this barrier, the focus of health message strategies has been placed on tailoring messages to individuals rather than expecting the same broad message to work for everyone [6,7]. By formulating messages that address individual differences, studies have demonstrated that the tailoring approach is more effective in promoting desired health behavioral outcomes compared to interventions targeted to an audience segment [6]. Tenets of the elaboration likelihood model [3] suggest that personal relevance is increased by way of tailoring, and that increased relevance, in turn, leads to greater attention and persuasion. Thus, increasing the perceived personal relevance of a health message seems to be critical in the promotion of desirable health behaviors and tailored messages seem to be significantly more successful at increasing the relevance compared to traditional means of audience targeting [6].

Computer-tailored messages vary in their modality, level of personalization, and richness [8]. Much of the existing research on tailoring has focused on emails, web portals, and text messaging. Virtual health agents provide novel ways to deliver tailored health information, however [9]. The current experiment aims to extend the state of research on computerized tailoring by using virtual human representations within immersive virtual environments as a tailoring strategy to maximize the perceived personal relevance of a health message, and ultimately, risk perception. By shedding light on the underlying mechanisms that render health messages personally relatable and drive effective risk perceptions, the current study aims to yield findings that are easily translatable to a wide range of health contexts.

2 Virtual Doppelgängers as a Tailoring Strategy

Virtual doppelgängers represent the user within immersive virtual environments (IVEs) and are created with digital photographs of the participant so that they bear photorealistic resemblance to the self [2]. Thus, by using virtual doppelgängers that share striking physical similarities with the self to depict realistic future negative consequences, participants may feel as if the negative consequence is actually happening to him or her. Watching the threat discussed in a health message actually occur to a virtual entity that looks like the self is likely to decrease the underestimation of the self's vulnerability to the risk.

Virtual agents are becoming popular across a variety of health contexts [9, 10, 11,12,13]. In some cases, health interventions using virtual human agents have been successfully tested for effectiveness in promoting health behaviors (e.g., [14,15]). Although interactive in nature, these virtual agents did not take advantage of tailoring and were presented as a single and generic identity for all users, often posing as guides or coaches. Given the success of tailoring in health messages as well as the success of virtual agents in health behavior change, combining both concepts to produce a tailored virtual agent for each user may combine the advantages of both intervention strategies to yield synergistic effects.

Only a few academic studies have explored the possibility of using virtual doppelgängers to persuade users in the health context, but these initial investigations suggest that the virtual doppelgängers may be a powerful vehicle of persuasion. Doppelgängers were more effective in promoting exercise behavior both immediately after and a day after seeing one's doppelgänger exercising [16]. These studies demonstrated that the visual stimulus of seeing a negative consequence occurring to the virtual doppelgänger is much more powerful in modifying attitudes and behaviors compared to seeing a negative consequence occurring to a virtual other (i.e., a virtual human representation of an unfamiliar other). Another study demonstrated that individuals become physiologically more aroused when they see virtual doppelgängers than when they see virtual others [17], which may explain their persuasiveness.

Another way of tailoring these health agents is by showing the consequences of a given health behavior, which can be key to behavior change [18]. IVEs provide a unique opportunity for users to experience the immediate and future rewards and punishments of healthy and unhealthy behaviors. For example, users in one study could watch their own body gain weight as they continuously consumed candy [19]. Another study found that showing one's doppelgänger gain weight from not exercising promoted more exercise behavior than showing a generic agent gaining weight [16].

These earlier findings evidence the potential to use virtual agents as change agents of health behavior by confirming health behavior changes in the real world following exposure to virtual treatments. The current study strives to extend the earlier work by applying virtual doppelgängers in a familiar, everyday healthcare context wherein the virtual doppelgängers may be used alongside more traditional health messages (i.e., pamphlets). Furthermore, the current study focuses on the investigation of underlying mechanisms that drive future health behavior changes. Insight into the perceptual and attitudinal influence factors that underlie behavior change will allow theorists and practitioners to apply the current findings to a wide range of health contexts, above and beyond the consumption of SSBs.

In this study, the first test will be to explore whether tailoring using virtual humans (i.e., both virtual doppelgängers and virtual others) in addition to a traditional healthcare pamphlet will be more effective in increasing risk perception of sugar added beverages compared to the influence of the traditional pamphlet alone. Earlier IVE studies have shown that the persuasive effects of IVE-based messages are stronger compared to traditional print messages [20], and thus we also anticipate that:

H1A: Participants will perceive higher risk when experiencing an IVE after reading a pamphlet compared to the pamphlet-only condition.

H2A: Participants will perceive higher personal relevance when experiencing an IVE after reading a pamphlet compared to the pamphlet-only condition.

In addition, as earlier IVE research demonstrates that virtual doppelgängers are more effective than virtual others in promoting a host of desirable attitudes and behaviors, seeing the negative future consequence of SSB consumption on a photorealistic virtual doppelgänger is anticipated to be more impactful than seeing it on a virtual other:

H1B: Participants will perceive higher risk when the future negative consequence of SSB consumption occurs to a virtual doppelgänger compared to a virtual other.

H2B: Participants will perceive higher personal relevance when the future negative consequence of SSB consumption occurs to their virtual doppelgänger compared to a virtual other.

3 The Mediating Roles of Self Thought and Self Presence

H1 and H2 explore the effectiveness of virtual doppelgängers, but perhaps a more interesting question is about the underlying mechanisms that drive the increase in perceived risk of negative consequences compared to virtual others. Often times, health treatments are found to be successful, but they can be difficult to extend or replicate if it is not clear *why* they are successful. Determining the mechanisms (i.e., mediators) driving increases in risk and relevance will clarify why virtual agents are or are not successful persuaders as well as provide the groundwork to progress theoretical developments on the effects of virtual doppelgängers.

A number of studies have demonstrated that increased perceived personal relevance and risk following messages lead to an increase in behavioral intent [4,5] but not many studies have investigated what drives this increase in perceived relevance. As perceived personal relevance is thought to be the main underlying mechanism driving tailoring effects and one of the main challenges of health message effectiveness [7], the current study will extend earlier research to explore the underlying processes of personal relevance. Thus, by identifying these mediators, we will glean a greater understanding of how and why virtual agents can make health messages seem more relevant to users.

Earlier findings, albeit in an advertising context, have confirmed that experiencing virtual simulations through a virtual human identified as the self triggered more self-referent thoughts (i.e., thinking about the self in relation to the virtual experiences) than experiencing those simulations through a virtual human unidentifiable as the self. These self-referent thoughts encouraged individuals to associate the experiences of the virtual self to the physical self [21] and resulted in stronger persuasive effects. Similarly, we posit that vicariously experiencing the negative consequence of SSB consumption via a virtual doppelgängers in addition to the traditional health message would lead individuals to more self-referent thoughts (i.e., thinking about the self in relation to the negative consequences) than vicariously experiencing the negative consequence via virtual others. Having self-referent thoughts is anticipated to lead to perceptions of personal relevance toward the message:

H3: Self-referent thoughts will mediate the relationship between experimental conditions (virtual doppelgänger vs. virtual other) and perceived personal relevance of the health message.

Furthermore, in order for participants to feel that a risk discussed in a health message is personally relevant, the negative consequence occurring to their virtual doppelgängers

would have to feel genuine. Perceived realism of virtual experiences, or the sense of "being there" in the mediated environment [22], has been shown to favorably influence a wide range of outcomes. Specifically, presence has been shown to maximize the effects of doppelgängers [19]. Particularly relevant in the current context of increasing the personal relevance of health messages through virtual doppelgängers is the concept of self presence, or the close mental mapping of the user's physical body to a virtual body [23]. Thus, we expect that:

H4: Self presence will serve as a mediator between experimental conditions (virtual doppelgänger vs. virtual other) and perceived personal relevance of the health message.

4 Methods

4.1 Sample and Procedure

The effect of three conditions on perceived personal relevance and risk of SSB consumption was assessed with a convenience sample of 47 participants (11 males, age M = 17.70, SD = 7.54) recruited from a large Southern university and offered course credit for participation. One week before the experiment, participants had their photograph taken for the creation of the virtual doppelgängers.

At the time of the experiment, all participants received the Pouring on the Pounds pamphlet and were instructed to read it carefully. After reading the pamphlet, participants were randomly assigned to one of three conditions: control (n = 16), virtual doppelgänger (n = 16), and virtual other (n = 15). Participants in the control condition completed survey measures after reading the pamphlet. Participants in the virtual doppelgänger and virtual other conditions were immersed in the IVE to vicariously experience the negative consequences of SSB consumption.

The IVE system used in the treatment conditions implemented a head-mounted display (HMD; VR2000 Ruggedized Pro) providing three-dimensional perception through stereoscopic views of the virtual world. The resolution was 1024 x 768 XGA with 45 degrees field of view. An orientation sensor with six degrees of freedom and an update rate of 125Hz was attached to the HMD to allow participants to control their field of view using naturalistic head movements. Finally, stereo audio information was delivered through the headphones of the HMD to present realistic sounds.

In the IVE, a virtual room was shown with either a virtual doppelgänger or a virtual other standing, consuming one soft drink a day for two years and consequently gaining weight. The virtual other was the representation of the participant preceding the current participant that matched in gender and ethnicity. As the virtual human consumed the soft drink, its body grew larger due to weight gain. The ten pounds a year in fat that the virtual human gained was also visually and aurally depicted as piles of fat splattering onto a digital scale. Figure 1 depicts the IVE treatment.

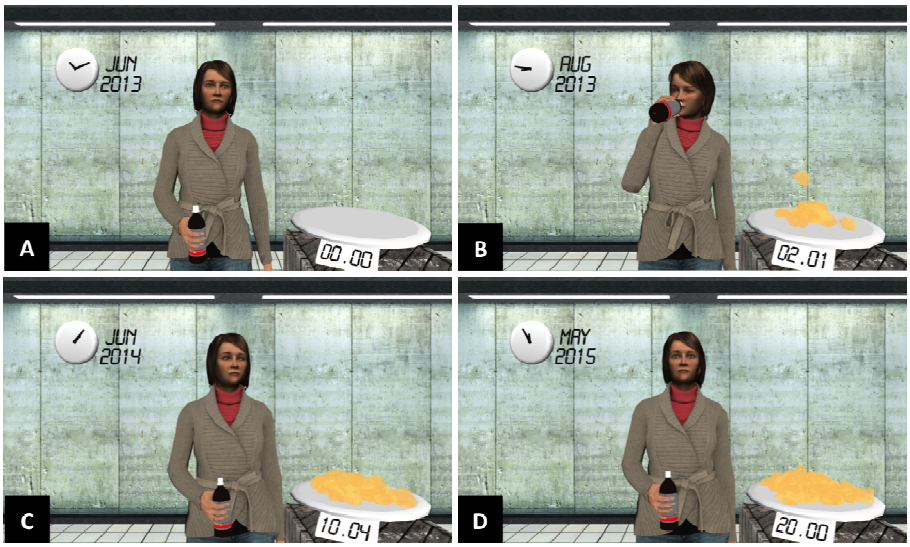

Fig. 1. Participants saw either a virtual doppelgänger or a virtual other standing in a room, holding a soft drink bottle (A). As the virtual human begins drinking from the bottle, the calendar and clock portray the rapid passing of time, and fat begins to fall on the digital scale (B). After one year of consuming soft drinks, the virtual human has gained ten pounds (C). At the end of two years, the virtual human has gained a total of 20 pounds as shown on the scale (D).

4.2 Dependent Measures

Risk Perception. Three 5-point interval scale items asked participants the extent to which they thought they and their friends were at risk of and concerned about gaining weight as a result of drinking SSBs. The three items were averaged to create a single index for risk perception (Cronbach's $\alpha = .72$).

Personal Relevance. A 5-point interval scale item asked participants how personally relevant the issue of gaining weight as a result of SSB consumption is to them.

Self-referent thoughts. Cognitive responses to the experimental stimuli were assessed using the thought-listing procedure [24]. Immediately following experimental treatments, participants were asked to freely write down as many thoughts as they had. The total number of self-referent thoughts (e.g., "I need to stop drinking Coke," "I should cut down on my soda consumption," "I hope I don't look like that") were counted and divided by the total number of thoughts ($Min = 1$, $Max = 12$, $M = 6.05$, $SD = 2.67$) in order to account for the individual differences in cognitive processes. This measure was only collected in the virtual doppelgänger and virtual other conditions.

Self Presence. Five 5-point interval scale items adapted from prior studies [19, 25] asked participants the extent to which they felt that if something happened to the virtual human it was happening to them; the virtual human was their own body; they were in the virtual human's body; the virtual human was an extension of them; and

the virtual human was them. The five items had high reliability, with Cronbach's α = .90, and were averaged to create a single index of self presence. This measure was only collected in the virtual doppelgänger and virtual other conditions.

Game Play (Covariate). A single open-ended item asked participants the average number of hours a week they spend playing video, computer, mobile, and arcade games, and was controlled for in the ensuing analyses.

5 Results

H1A and H1B were tested with an ANCOVA with experimental condition as the independent variable, risk perception as the dependent variable, and game play as the covariate. Results revealed a significant main effect of condition, $F(1, 43) = 5.38$, $p = .008$, $\eta^2 = .20$. A post hoc analysis using Fisher's Least Significant Difference (LSD) revealed that both virtual doppelgängers ($M = 2.80$, $SD = .84$) and virtual others ($M = 3.02$, $SD = .90$) were equally influential in increasing perceived risk compared to the control group ($M = 2.18$, $SD = .49$). H1A was supported; H1B was not.

H2A and H2B were tested with an ANCOVA with experimental condition as the independent variable, personal relevance as the dependent variable, and game play as the covariate. Results revealed a significant main effect of experimental condition, $F(1, 43) = 3.56$, $p = .04$, $\eta^2 = .14$. A post hoc analysis using Fisher's LSD revealed that virtual doppelgängers ($M = 3.24$, $SD = 1.28$) promoted a significantly higher level of personal relevance to the health message compared to the control ($M = 2.20$, $SD = .83$) and the virtual other ($M = 2.47$, $SD = 1.24$) conditions, which did not significantly differ. Thus, H2A and H2B were both supported.

The PROCESS path-analysis macro for SPSS [26] was used to test the mediation models for H3 and H4. To test H3, experimental conditions were coded (*virtual others* = 0, *virtual doppelgängers* = 1) and entered as the independent variable; self-referent thought was entered as the mediator; personal relevance as the dependent variable; and game play as the control variable. Bootstrapping methods were used and results of the direct and indirect effects are reported in Table 1. Results indicated that self-referent thought has a strong relationship with relevance; thinking about the negative consequences in terms of the self encouraged participants to consider the health message to be personally relevant. Further, self-referent thought mediated the relationship between experimental condition and personal relevance. Seeing the virtual doppelgänger led to more self-referent thinking about negative consequences than seeing the virtual other, and thinking more about the self led to greater perceived relevance to the message. Thus, H3 was supported.

The PROCESS path-analysis macro was used again to test H4. Experimental condition was entered as the independent variable; self presence was entered as the mediator; personal relevance as the dependent variable; and game play as the control variable. Bootstrapping methods were used and results of the direct and indirect effects are reported in Table 2. Results indicated that self presence has a strong

Table 1. Regression Weights, Indirect Effects Showing Mediation, Bootstrap 95% Confidence Interval, Lower and Upper Bounds

			Bootstrap 95% CI	
Regression Weights	Coefficient	*SE*	Lower	Upper
Direct Effects				
Condition → Self Thoughts^{+}	.22	.12	-.022	.468
Condition → Relevance	.37	.46	-.586	1.320
Self Thoughts → Relevance*	1.75	.69	.330	3.171
Indirect Effects	Effect Size	*Bootstrap SE*		
Condition → Self Thoughts → Relevance*	.39	.23	.085	1.111

Note. SE = standard error; CI = confidence interval.
Bootstrap resampling = 1000. ** $p < .01$, * $p < .05$, $^{+}$ $p = .06$.

relationship with relevance; perceiving that the negative consequences occurring to the virtual human is real encouraged participants to consider the health message to be personally relevant. Self presence mediated the relationship between experimental condition and personal relevance. Therefore, experiencing presence while experiencing the negative consequence occurring to the virtual doppelgänger was more effective in heightening personal relevance compared to the virtual other. Thus, H4 was supported.

Table 2. Regression Weights, Indirect Effects Showing Mediation, Bootstrap 95% Confidence Interval, Lower and Upper Bounds

			Bootstrap 95% CI	
Regression Weights	Coefficient	*SE*	Lower	Upper
Direct Effects				
Condition → Self Presence^{+}	.55	.28	-.028	1.128
Condition → Relevance	.24	.43	-.646	1.130
Self Presence → Relevance**	.94	.27	.380	1.497
Indirect Effects	Effect Size	*Bootstrap SE*		
Condition → Self Presence → Relevance*	.52	.32	.060	1.470

Note. SE = standard error; CI = confidence interval.
Bootstrap resampling = 1000. ** $p < .01$, * $p < .05$, $^{+}$ $p = .06$.

6 Discussion

Using virtual humans within IVEs in addition to a traditional health pamphlet was more effective in heightening perceptions of personal relevance and risk than a

non-tailored pamphlet developed for the general population. Furthermore, virtual doppelgängers were more influential than virtual others in increasing perceived personal relevance of the risk of SSB consumption as described in the pamphlet. Two underlying mechanisms seem to be driving the increase in perceived relevance—self-referent thoughts and self presence.

The findings suggested that using virtual humans, in general, to deliver vicarious experiences of future negative consequences augments the effects of traditional health messages by heightening perceived risk perceptions and is more effective than the baseline of using traditional media alone. As heightened risk perception has been considered as one of the main motivators of behavior change [27], these results imply that IVEs may be valuable contributors to public health campaigns.

Furthermore, the results yielded insight into the perception of personal relevance, which has been shown to encourage attention [6] and elaborated processing of information [3]. Although virtual humans in general were effective in increasing risk perception, virtual doppelgängers were significantly more effective in increasing the perception of personal relevance compared to virtual others. Because virtual doppelgängers display a photorealistic similarity with the individual, it may have been difficult to ignore or underestimate the self's vulnerability to the risk discussed in the message. Conversely, it may have been easier to discount the risk when the negative consequence occurred to an unfamiliar other, as is often the case with non-tailored health messages [5]. As perceived personal relevance is thought to be the main driver of tailoring effects [7], these results suggest that optimal tailoring effects may be reaped by photorealistically tailoring each virtual human to each individual.

The virtual doppelgängers' influence on perceived personal relevance was driven by both self-referent thoughts and self presence. Perceived realism of a mediated experience leading to heightened perceptions of personal relevance and risk in the context of health communication has also been demonstrated with traditional media [4]. Current results extend these earlier findings by indicating that it is not only the realism of the vicarious experience, but also the extent to which the experience brings forth self-referent thoughts that lead to increase in personal relevance. As Bandura [18] noted, it seems to be a combination of environmental stimuli and cognitive processing of the stimuli that leads to potential behavioral modification. This suggests that regardless of the realism of the material delivered by advanced digital media, the message may be ineffective if it fails to elicit self-referent thoughts in relation to the health issue discussed in the message.

The incorporation of virtual doppelgängers within traditional health promotion campaigns seems to be a timely endeavor. As only two digital photographs were used to create the virtual doppelgängers, and as social media users inundate the virtual space with photos of themselves, the implementation of virtual doppelgängers within the social media space is particularly feasible. The simplicity of the design of these virtual agents and simulations yields promising practical implications outside the virtual space as well. This is particularly true as participants in the current study were given only limited interactivity with the virtual simulation. The current findings suggest that virtual health agents may serve as effective change agents by having individuals merely view the negative health consequences of their virtual doppelgängers and

may be easily applicable to a wide range of health contexts. For instance, these agents may be a simple, yet effective, health intervention technique to be used in doctor's offices along with traditional health pamphlets. By presenting patients with a brief simulation featuring a virtual agent that looks photorealistically like the patient in addition to the pamphlets typically offered during office visits, doctors might be able to effectively encourage the patients to think more seriously about the risk and how relevant it is to themselves. Furthermore, with the increasing popularity of gaming technology such as the Microsoft Kinect and the Oculus Rift, IVE systems are increasingly becoming accessible, affordable, and ubiquitous. Moreover, virtual doppelgängers offer high scalability and may be used across different media platforms ranging from mobile devices to desktop computers; applied in health messages dealing with a variety of topics; and sent to existing IVE systems at home en masse so that individuals may be exposed to valuable health messages in the comforts of their own homes.

One limitation is that the current study used a relative small sample comprised of college students. The relatively young sample of research participants is highly relevant for studying SSB consumption [28], and the partial eta-squared values suggest sufficient level of power despite the small sample size. However, future studies should investigate the effects of virtual doppelgängers across a wider range of populations and with a larger sample for greater accuracy and generalizability of results. This study also only included a single treatment. Longitudinal research should be pursued to examine the effects over time. Finally, in this study, we did not measure users' reactions to doppelgängers. In some cases, realistic virtual agents can fall into the uncanny valley, and users have aversive reactions [29], which would likely negate the effects of a health message.

In sum, virtual doppelgängers present a promising novel approach that fuses traditional tailoring strategies with advanced digital technology. Within the timely context of reducing SSB consumption, virtual doppelgängers offer a unique yet feasible and translatable solution in a world inundated with advertising and promotions. With the continuing advancement of digital media technologies, the capacity of virtual doppelgängers to serve as powerful amplifiers of message effects seems limitless.

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