CHAPTER

2

Digital embodiment and improving health outcomes: Healthy avatars make for healthy people

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One of the most fascinating aspects of new technologies is affording users the ability to modify the self and transform sensorial inputs. The ability to embody and control a digital self-representation (avatar, limb, etc.) that is situated within a synthetic environment has profound implications for health scholars and practitioners. For instance, people may change their health behaviors and attitudes after seeing their virtual self as healthy or sick, thin or obese, or old or young (Hershfield et al., 2011). Smokers may regain a sense of control after crushing cigarettes using haptic controllers in a virtual environment (Girard, Turcotte, Bouchard, & Girard, 2009). In addition, participants who played a video game and saw their future face in the game showing the physical consequences of smoking (e.g., wrinkles, spots, grayer skin) showed increased intention to quit smoking and more negative attitudes toward smoking in comparison to those who did not see their future smoker face (Song, Kim, Kwon, & Jung, 2013). In virtual reality (VR), people may learn how to operate a new limb (Won, Bailenson, Lee, & Lanier, 2015), practice pain management strategies (Li, Montaño, Chen, & Gold, 2011), and learn to manage post-traumatic stress disorder (Rothbaum et al., 1999).

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The present chapter focuses on the health outcomes of *digital self-representation* and theoretical mechanisms underlying its effects. We use this term broadly to describe the experience of creating, controlling, and interacting with real or synthetic people and objects while personified by a digital limb or a full digital body (i.e., an avatar). The chapter also discusses social processes involving real people interacting with *embodied agents* (e.g., game characters, digital personal assistant, virtual pets) designed to motivate individuals to increase health behaviors. The chapter describes trends, theoretical mechanisms, shortcomings, and future directions in research related to digital self-representation and interaction with embodied agents. Although this chapter is not a comprehensive metaanalysis, the topics covered are representative of current research in the field.

The chapter encompasses a range of options for the visual display of digital self-representations. In some contexts, users' digital bodies are fully visible as when users operate avatars in third-person view. If embodied in first-person view, people may be exposed to their digital appearance by seeing and controlling their digital limbs or when looking at one's avatar reflection in a digital mirror. In other contexts, users' digital bodies are implied as people can move and interact with synthetic objects but do not explicitly see their whole digital body (e.g., point-and-click interface). In this chapter, we reserve the term *avatar* to refer to human-controlled limbs, bodies, and characters that represent the user and allow interactions with real or synthetic partners and objects. In a recent review, Nowak and Fox (2018) define avatars as digital entities that represent users and allow them to interact with other avatars, objects, and characters in a virtual environment. While early forms of digital representations exist as usernames or graphical images and photos, avatars in VR and video games allow users to navigate and interact with digital objects. A key factor here is that the avatar is controlled by the user. Users provide inputs, which traditionally come from button presses in video games or motion detection in VR. Self-representations also experience consequences that come about as a result of the user's decisions and control input. For example, a user's avatar may receive health bonuses, penalties, and/or points as a consequence of user choices.

When a virtual representation is controlled not by the user but through a computer algorithm, it is known as an *agent*. Examples include artificial health assistants, virtual instructors, chatbots, and other characters depicted in anthropomorphic (e.g., human doctor) or non-anthropomorphic forms (e.g., pet or other animals). As such, the concept of human versus machine "agency" sets avatars theoretically apart from agents. Both agents and avatars have their place in health communication, and each contributes in unique ways. Avatars enable users to interact within a shared virtual environment with objects, other avatars, or agents.

Based on theories of social influence and identification, scholars have proposed that interactions with avatars are likely to be more effective than interactions with agents (Blascovich et al., 2002). People's motivations tend to be more easily influenced if they perceive they are in the presence of another individual. In support of this, a metaanalysis of 32 studies showed that avatars produced stronger persuasive responses among users as compared to agents (Fox et al., 2015). Hence, avatar-based manipulations may be ideal for digital health promotion interventions that aim to change attitudes and behavior. That being said, agents have multiple uses and advantages because they are algorithm-controlled and thus do not possess the basic needs of humans, making agents suitable for digital health interventions and services that require a 24/7 availability, such as a virtual health helpdesk. In addition, people engage in parasocial relationships with media characters and synthetic agents, implying that people may perceive agents and mediated characters as sentient anthropomorphic beings and thus build attachment, identification, etc.

Several technologies allow users to control and interact with digital self-representations, including commercial video games, "serious games" meant to educate and raise awareness, apps or smartphone applications, and training simulations. Games, apps, and simulations are displayed in different modalities including traditional two-dimensional (2D) screens (e.g., monitors, smartphones), augmented reality (i.e., AR or sensory information overlaid on the physical world), and VR (experiences taking place within a three-dimensional (3D) computer-generated environment). In health contexts, studies find positive links between embodying avatars and interacting with agents on outcomes such as body image (Kim & Sundar, 2012), attitudes toward sugared beverages (Ahn, Fox, & Hahm, 2014), physical activity (Li & Lwin, 2016), and substance use (Hone-Blanchet, Wensing, & Fecteau, 2014).

In this chapter, we concentrate on the influence of avatar use and interaction with virtual characters on users' health behaviors and attitudes. Avatar and agent-based interactions are becoming increasingly common. For instance, people play video games on phones, consoles, and computer that depict digital characters on a screen and have access to AR apps that overlay such characters on the physical world avatars and agents (e.g., *Pokémon GO*). With the increased accessibility of VR systems, more individuals are equipped to access virtual environments. Research exploring the effects of one's avatar on health attitudes and behaviors helps practitioners and policymakers think about designing virtual worlds or tools that can lead to better health outcomes among the population.

Though using avatar and agent-based interactions to increase health outcomes may at first glance appear to be trivial and inconsequential, there is evidence that people experience virtual experiences as if it was a "real" experience. For example, media equation theorists maintain that people treat technology-mediated experiences and synthetic characters as if they were real places or people (Nass & Moon, 2000; Reeves & Nass, 1996). Individuals apply learned concepts and knowledge structures to their interaction with technology and so avatars and agents that display social cues implying health expertise may be automatically treated as health experts. In addition, new technologies that afford digital self-representation also allow users to experience a sense of presence (Biocca, 1997; Lee, 2004; Lombard, Ditton, & Weinstein, 2009). Games, apps, and simulations provide rich and realistic sensory information via visual, aural, and haptic cues. According to Lombard and Ditton (1997), this may enable users to feel as if they are transported from a physical to a synthetic environment (e.g., "I am there" or spatial presence), perceive conversations with human-controlled avatars or synthetic agents as sociable, warm, or intimate (i.e., "we are together" or social presence), or perceive that an object, avatar, or agent is within reach, as if brought from another place to a user's field of attention (e.g., "It is here," as in AR Pokémon games, in which a synthetic game character is superimposed over the physical world). In addition, self-presence refers to the influence of virtual experiences on perception of body image, physiological and emotional states, traits, and identity (Biocca, 1997; Ratan, 2012). Consider that a sense of presence is vital to conducting exposure therapy, which provides a guided and safe confrontation with the feared stimuli (Parsons & Rizzo, 2008). New technologies that allow users to control avatars, such as VR, facilitate activating learned fear structures for then to be modified through controlled exposure (Rothbaum et al., 1999).

The notion that people experience synthetic events as if it was "real" experience is supported by brain imaging methodologies, which have become popular in communication research (Weber, Mangus, & Huskey, 2015; Weber, Sherry, & Mathiak, 2008), especially to study digital experiences like video games (Klasen, Weber, Kircher, Mathiak, & Mathiak, 2012; Mathiak & Weber, 2006; Weber, Ritterfeld, & Mathiak, 2006). Such studies suggest that brain activity during virtual and physical (nonvirtual) experiences reflects similar neurological processes, such as those involved in spatial navigation (Spiers & Maguire, 2007b), though not necessarily equivalent in magnitude (Baumeister, Reinecke, Cordes, Lerch, & Weiss, 2010; Mikropoulos, 2001). For example, cortical activity associated with attention (frontal theta power) was stronger for participants swinging a physical golf putter than a virtual golf putter, possibly because participants were more familiar with physical putting and better able to attend to the relevant sensory information (Baumeister et al., 2010). Alternatively, in some cases, virtual experiences lead to stronger neurological activity and presence than nonvirtual experiences. For example, participants exhibited less clipping of EEG signals when navigating a simulated virtual environment compared to an equivalent physical space, suggesting that they were paying more attention in the virtual environment (Mikropoulos, 2001). This implies that design elements of virtual experiences may have neurological impact that is smaller, equal, and sometimes even greater in magnitude than real experiences.

Regardless of the differences in magnitude, virtual experiences provide a strong facsimile of real experiences, and thus, VR has been used to study many different neurological correlates of spatial navigation (Hartley, Maguire, Spiers, & Burgess, 2003; Iaria, Petrides, Dagher, Pike, & Bohbot, 2003; Maguire et al., 1998; Nowak, Resnick, Elkins, & Moffat, 2011; Spiers & Maguire, 2006, 2007a) and driving behavior (Calhoun et al., 2002; Carvalho, Pearlson, Astur, & Calhoun, 2006; Spiers & Maguire, 2007c; Walter et al., 2001). For example, skill in spatial navigation of a virtual environment was associated with right anterior/medial temporal engagement, which is consistent with suggestions from research outside of VR (Pine et al., 2002). Below, we review several strands of research investigating how digital self-representations can be leveraged to increase health-related outcomes, such as pain and recovery, physical activity, well-being, and food consumption and body image. We then offer integration, critique, and future directions for this literature.

Pain and recovery

The use of avatars in pain intervention can be broken down into two aspects: acute pain and chronic pain. Pain management of burn injury victims is an example of avatar use in acute pain. Patients embody an avatar in a video game and are tasked to throw snowballs at various targets (Hoffman et al., 2004; Jeffs et al., 2014; Schmitt et al., 2011). Results showed a decrease in perceived pain among participants after the intervention. Jeffs et al. (2014) suggested that the intervention was effective because the VR experience elicited engagement through distraction and enjoyment. The combination of these factors possibly led to the decrease in perceived pain experienced by the participant during the wound care that happened concurrently. Distressing medical procedures such as the insertion of needles is another aspect of acute pain that has received research attention. For instance, Gold et al. (2006) found that while a control group reported increased pain during a needle insertion procedure, participants who went through an embodied VR experience and undertook the needle insertion procedure halfway did not see a significant increase in pain. The authors attributed this to the effectiveness of VR as a tool to distract attention away from pain due to its immersive nature. Indeed, participants in the VR condition were twice as satisfied with their pain management experience as those in the control condition and reported interest in further embodied VR treatments.

Regarding chronic pain, individuals with complex regional pain syndrome were tasked to control virtual limbs to grasp objects in VR with varying levels of difficulty. Findings showed a reduction in pain intensity among participants (Sato et al., 2010). Studies have also examined the effects of translating movements in real life to either larger or smaller magnitudes in an embodied VR experience, with participants showing greater recovery and reduced pain during limb movement rehabilitation (Chen et al., 2017; Won et al., 2015). Several studies employed embodied VR interventions in helping cerebral palsy patients improve reaching kinematics (Chen, Garcia-Vergara, & Howard, 2015; Fluet et al., 2010; Huber et al., 2008). A study recently tasked patients recovering from brain injuries to walk in various embodied VR environments showed an improvement in patients' gross motor abilities, such as standing and walking (Biffi et al., 2017). While the mechanism for the effectiveness of the VR intervention remains unclear, these findings provide initial evidence that VR interventions can potentially help patients in recovery from chronic pain.

The use of embodied experiences for recovery has also been examined in mental health contexts (Freeman et al., 2017). In fear therapy, interventions that place individuals as an avatar in specific scenarios have found positive support in helping patients suffering from phobias such as heights (Emmelkamp, Bruynzeel, Drost, & van der Mast, 2001; Krijn et al., 2004), driving (Wald & Taylor, 2000; Walshe, Lewis, O'Sullivan, & Kim, 2005), insects (Hoffman, Garcia-Palacios, Carlin, Furness, & Botella-Arbona, 2003a), and social interaction (Harris, Kemmerling, & North, 2002; Klinger et al., 2004). Other aspects of mental health where embodied interventions have been developed for include anxiety disorders (Parsons & Rizzo, 2008; Powers & Emmelkamp, 2008) and posttraumatic stress disorder (Beck, Palyo, Winer, Schwagler, & Ang, 2007; Rothbaum, Hodges, Ready, Graap, & Alarcon, 2001). These studies employ embodied experiences to facilitate desensitization effects in which patients are exposed to virtual representations of objects, people, animals, or situations that trigger anxiety, fear, or phobia under controlled clinical conditions to achieve gradual habituation and decreased flight responses. A recent study found that avatars are able to reduce anxiety in individuals if they are asked to design one that represented anxiety and also if they destroyed these creations that represented anxiety (Pimentel, Halan, & Kalyanaraman, 2018). Tapping on self-discrepancy theory, the researchers propose that anxiety forms a part of one's identity as an "anxious self-concept." Individuals who customized avatars that represented their anxious self-concept reported lower anxiety compared to a control group, while those who pressed a button to disintegrate the customized anxiety avatar reported significant decrease in anxiety. Findings suggest that avatar-based health interventions may support anxiety reduction treatment by allowing individuals to project their anxious self-concepts onto avatars through customization and distancing themselves from anxiety through destroying these customized anxiety avatars (Pimentel et al., 2018).

Physical activity

Use of avatars and agents can also enhance attitudes toward physical activity and, more importantly, increase physical activity levels. For instance, playing an exergame with a photorealistic avatar increased physical activity among 12–14 year olds (Thompson et al., 2018). Avatars were constructed from a digital image of the player, and participants then played a pilot exergame. Teens reached vigorous levels of physical activity and kept it up for 74.9% of total game time. Playing with a self-resembling avatar was enjoyable although the exergame was difficult. Teens' perceived autonomy and competence showed small postgame increments relative to baseline (Thompson et al., 2018). In a study in which participants were set on a real treadmill while immersed in VR, participants were randomly assigned to three conditions (Fox & Bailenson, 2009). According to social cognitive theory (SCT), people learn vicariously through modeled behavior (Bandura, 1986). Participants in the vicarious reinforcement condition were assigned to an avatar that donned the participant's face image and gained or lost weight based on participants' concurrent treadmill activity. This was compared to an avatar donning the participant's face which did not change based on the participants' treadmill exercise and also to a control condition in which participants saw no avatar in VR. Participants were then told the study was over but they could stay in the lab and exercise some more if they wanted. Participants in the vicarious reinforcement condition performed more voluntary exercise in the lab as well as in the week following the experiment than those in other two conditions (Fox & Bailenson, 2009). This implies that people are more likely to perform physical activity after seeing an avatar that looks like themselves gain or lose weight, which is congruent with vicarious learning principles and imitation based on perceived similarity.

In addition, embodying avatars with stereotypical physical traits can also influence physical activity. Women were randomly assigned to an obese or thin avatar and then played a tennis exergame while wearing activity monitors with accelerometers (Peña & Kim, 2014). While using either a thin or obese avatar, participants played the game against an onscreen opponent agent that was either obese or thin. Based on accelerometer data, female participants showed increased physical activity when operating thin instead of obese avatars (Peña & Kim, 2014). Similar results were found when replicating these results with a sample of male participants who also showed lower physical activity in a tennis exergame while using obese instead of thin avatars (Peña, Khan, & Alexopoulos, 2016). These results are tied to the Proteus effect, which attempts to explain how avatar appearance (e.g., height, attractiveness, prosocial or antisocial connotations) may influence users' behavior and cognition in VR and video games. The Proteus effect relies on self-perception (i.e., deriving one's attitudes from observation and reflection upon one's own behavior, Yee & Bailenson, 2007) and priming mechanisms (i.e., acting upon subconscious heuristics and schemes initiated by an external influence, Peña, Hancock, & Merola, 2009). These mechanisms can be isolated as operating an avatar has stronger effects than seeing an avatar (Yee & Bailenson, 2009); at the same time, these self-perception and priming may operate simultaneously as controlling an avatar may change how users see themselves, and avatar appearance may also remind them of learned concepts, stereotypes, and behavioral scripts. For example, random assignment to thin or obese avatars activated social stereotypes associated to physical activity, such as thinness and agility, obesity and sluggishness, etc. (Peña et al., 2016). In addition, both men and women assigned to obese avatars playing against thin agents showed decreased physical activity. This points out to upward social comparison mechanisms in which people compare themselves to someone who is more skilled. In this case, men and women showed decreased physical activity while playing a tennis exergame against an agent that looked more in shape in comparison to their own avatar (Peña et al., 2016; Peña & Kim, 2014). Overall, this implies that physical activity can be influenced by common stereotypes related to exercising that are activated by avatar appearance. Social comparison processes may also influence physical activity as self versus opponent judgments help players assess whether they are at advantage or disadvantage (Peña et al., 2016; Peña & Kim, 2014).

Li, Lwin, and Jung (2014) tested the separate effects of embodying an overweight avatar and exposure to stereotype threat. Overweight students were assigned to either overweight or normal weight avatars in a running exergame. Half of the participants were also exposed to a stereotype threat, where they were told that overweight participants tend to perform poorer in the exergame. Participants who were assigned overweight avatars performed poorer than those assigned normal weight avatars, whereas those exposed to the stereotype threat performed poorer than those who did not receive the stereotype threat information. These results lend support to the influence of both the Proteus effect and stereotype threat and show that visual and stereotype salience can influence individuals' physical activity motivations and behavior when they embody a character in virtual environments. A follow-up study (Li & Lwin, 2016) examined the influence of the self-avatar through the lens of SCT (Bandura, 1986). A key factor that influences the impact of learned behavior is similarity between the model and the self. Exergames therefore can offer an enactive learning experience when a player controls his avatar. According to Li and Lwin (2016), there were significant links between presence of a user's avatar and avatar identification, which subsequently increased enjoyment and exercise motivations.

One crucial aspect of digital experiences in general is that people are expected to integrate and match mental models from previous experiences to interactive environments, and vice versa. This may affect their experience with such technology and their willingness to continue using it. In a recent study, participants were assigned to ride the *Expresso HD* bicycle, which features a traditional upright exercise bike with handlebars to steer an onscreen graphical bicycle, while the resistance of the pedals vary depending on the terrain (McGloin & Embacher, 2018). The *Expresso HD* exergame was seen as a more natural experience by participants with higher gaming experience, but real-world road cycling experience was not related to perceiving the exergame riding experience as more natural. Participants who experienced increased immersion also enjoyed the exergame more, and increased enjoyment was associated with more desire to ride the exergame bike again (McGloin & Embacher, 2018). Overall, riding a physical bicycle that displays motion across a virtual landscape may have different effects on people who play video games or bike in the real world more frequently, as people with direct experience may have different mental models when operating exergames with one's own body.

Interacting with synthetic agents playing the role of "pets" may also help promote physical activity (Ahn et al., 2015). This harkens back to handheld digital pets or *Tamagotchi*, which asked users to interact with as small device that presented users with a simulated pet to interact and take care of. Capitalizing on the Youth Physical Activity Promotion (YPAP) model, a study implemented the use of virtual pets to increase children's perceptions of self-efficacy and expected outcomes (e.g., "Am I able to exercise?" "Is it worth it?") to engage in physical activity (Ahn et al., 2015). YPAP describes enabling, predisposing, and reinforcing factors that influence the practice of physical activity. Based on YPAP, Ahn et al. (2015) propose that virtual pets that set activity goals for children and also provide feedback encouraging further exercise may boost physical activity self-efficacy and expected outcomes. Children in a summer camp met a virtual pet dog at kiosks located in the camp. Kiosks were equipped with a screen to render the virtual pet and a Kinect device to detect user voice and gestures. The virtual dog asked children to set physical activity goals and then the child would leave the kiosk and return later. Children wore activity monitors with embedded accelerometers so that they would be congratulated by the virtual dog and allowed to play with it if they had met their physical activity goal. If they had not met their physical activity goal, then the virtual dog would tell the child that the goal was unmet and to continue exercising. Physical activity in the virtual pet group was compared to children in a summer camp with no virtual pets during a 3-day observation period. Children in the virtual pet group engaged in an average 1.09 more hours per day (156% more activity) and had increased intentions to continue engaging in physical activity in the future relative to children in the control group (Ahn et al., 2015). In addition, increased physical activity self-efficacy led to both increased intention for future physical activity and more positive expected outcomes. More positive physical activity expected outcomes were also linked to increased physical activity future intentions (Ahn et al., 2015).

Finally, AR games may also enable users to engage in increased physical activity by leveraging interactions with virtual agents, even if players simply intend to play the game. For example, *Pokémo*n *GO* is an AR game in which users go to different locations to hunt creatures or Pokémon (i.e., agents) to add to their collection. In doing so, players may inadvertently exert themselves more than they would otherwise. To test for this hypothesis, a study combined data from search engine queries ("*Pokémo*n *GO*") with physical activity measurements from wearable devices (Althoff, White, & Horvitz, 2016). Users that made multiple search queries for details about the game increased their activity by an average of 1473 steps a day, which represented an increase of over 25% relative to their baseline physical activity level (Althoff et al., 2016). With over 800 million downloads and counting, this study estimate that *Pokémon GO* added 144 billion steps to physical activity in the United States across a number of inactive populations (Althoff et al., 2016). There is also evidence for *Pokémon GO* increasing self-reported walking and moderate physical activity (Broom & Flint, 2018). These effects lasted after 3 months for those who remained playing (Broom & Flint, 2018). Though it appears that AR games such as *Pokémon GO* are effective health interventions, other studies show no effects and very low rates of continued play over time (Wattanapisit, Saengow, Ng, Thanamee, & Kaewruang, 2018). More research is needed to establish whether AR games are an effective method for increasing physical activity (Wattanapisit et al., 2018).

Psychological well-being

Under specific conditions, embodying avatars and interacting with agents may also boost individuals' subjective well-being. Subjective well-being involves a focus on global well-being factors such as happiness and life satisfaction but also a focus on specific domains, such as job, family, relationships, health, etc (Andrews & Robinson, 1991). Subjective well-being reflects a sum of an individual's life in society, and thus several constructs directly and indirectly tap into subjective well-being. Directly related factors include happiness and satisfaction, whereas indirectly related factors include self-esteem, depression, locus of control, and alienation (Andrews & Robinson, 1991).

Embodying avatars and interacting with other users and agents may influence psychosocial well-being (Slater & Sanchez-Vives, 2016), especially to the degree that users feel immersed in a virtual context (Behm-Morawitz, 2013). For instance, users may psychologically experience self, social, and spatial presence when playing games or using interactive technologies, and these different presence experiences may indirectly influence well-being and health and appearance satisfaction. As noted above, spatial presence is the feeling of being "there" in a mediated environment; social presence refers to perceiving social actors (e.g., avatars, agents) in a game or mediated setting as if it was real human-to-human communication, and self-presence refers to how virtual experiences influence perception of body image, physiological and emotional states, traits, and identity. In particular, self-presence was predicted to be more closely associated with the effects of embodying avatars on individual's identity and well-being as this factor is more linked to individual users than spatial and social presence (Behm-Morawitz, 2013). Confirming this expectation, individuals experiencing more self-presence in *Second Life* reported increased influence of their avatar on their real self in terms of well-being, body management (e.g., dieting and exercise), and satisfactory virtual relationships. One explanation was that heightened presence with one's virtual self may influence users to take more pride in their appearance and increase health consciousness, which in turn may have positive effects on individuals' real self (Behm-Morawitz, 2013). This implies that avatar use can serve as a mirror in which individuals can try on different styles and identities that are impermanent and risk-free (Behm-Morawitz, 2013). Individuals may observe these new identities and stylistic changes applied to one's avatar, and positive changes may be mimicked in real life as inspired by one's virtual self. Avatar use could serve as a source of motivation to take care of one's real body as survey respondents who perceived their avatar to be more attractive than their real self and yet still representative of their ideal appearance were more likely to report avatar influence on their well-being and appearance (Behm-Morawitz, 2013).

In addition, the way in which people customize their avatars may reflect underlying levels of well-being. Participants were asked to choose the features of their avatar for six different game scenarios (Trepte & Reinecke, 2010). Participants with higher life satisfaction created avatars that resembled the users' actual personality factors, whereas users with lower life satisfaction created more dissimilar avatar (Trepte & Reinecke, 2010). Similarly, a sample of World of Warcraft players rated their avatar as possessing more desirable traits compared with their actual self, especially among players with lower psychological well-being (Bessière, Seay, & Kiesler, 2007). These studies imply that avatar customization choices correlate with players' well-being and imply that the ability to create avatars who embody players' ideal selves may have repercussions for psychological well-being (Bessière et al., 2007).

Food consumption and body image

Virtual experiences have been used to examine issues related to health and food consumption. A review of 17 studies suggests that VR-based interventions provide effective treatment for eating disorders and obesity and are particularly well-suited for reducing body image dissatisfaction and increasing self-esteem and self-efficacy (Ferrer-Garcia, Gutiérrez-Maldonado, & Riva, 2013). The success of such approaches derives from the ability for VR technologies to induce similar emotional and behavioral responses as in traditional exposure therapies. However, compared to traditional therapies, VR treatment can be more effective in improving psychological hindrances to healthy eating, increasing motivation for change, and reducing problematic eating behaviors, given the higher level of control and safety afforded by VR (Riva, Bacchetta, Baruffi, & Molinari, 2001).

Supporting the notion that virtual food leads to physiological effects that resemble those of real food, one study found that participants reacted more quickly during interactions with virtual foods compared to virtual ball objects (Schroeder, Lohmann, Butz, & Plewnia, 2016), thus confirming a behavioral bias for food. In another study, obese participants found virtual food presented through an AR interface to be as palatable and arousing as real food (Pallavicini et al., 2016). These studies support the verisimilitude of virtual foods and thus the validity of using virtual experiences to address issues of health and food consumption.

However, the extent of this verisimilitude is dependent of the immersiveness of the technologies being utilized. For example, participants who smelled or touched a physical donut while interacting with a donut in VR ate fewer donuts and felt more satiated compared to participants who only interacted with the virtual donut without smell or touch (Li & Bailenson, 2018). The authors attribute the effects to embodied cognition (Barsalou, 1999). The embodied cognition framework suggests that past experiences can create perceptual symbols of sensory modalities. During a virtual experience of the food item, the individual accesses symbols that are linked to the smell, taste, and touch of the donut. These symbols then allow the individual to experience a simulated food consumption experience, leading to a decrease in the craving for and subsequent consumption of donuts.

Another approach to this research focuses on manipulating avatar features to influence perceptions of and associations with the self in experimental settings (Peña et al., 2009; Yee & Bailenson, 2007, 2009). Multiple studies have found that viewing reduced-weight virtual selves leads to healthier eating behaviors after exposure (Fox, Bailenson, & Binney, 2009; Kuo, Lee, & Chiou, 2016). These studies (Fox et al., 2009; Kuo et al., 2016) suggest that perceiving the self in a virtual environment leads to changes in self-perception that influence subsequent behavior. Another study of college-age students found that health consciousness was correlated with choosing to eat more vegetables at the end of the study for participants who used an avatar to design to reflect the ought self (how others think you ought to be) or the ideal self (how you would ideally like to be; marginally significant), but not for people who designed and used an actual-self avatar (Sah, Ratan, Sandy Tsai, Peng, & Sarinopoulos, 2016). This suggests that the aspects of self-concept made salient during avatar design (see example from this study

FIGURE 2.1 Avatar customization screen from Yoobot vs YooNot (British Health Foundation), used to illustrate self-concept effects on food choices (Sah et al., 2016).

in Fig. 2.1) influence the users' subsequent behaviors. Another study found that participants who participated in an intervention within a 3D avatar in a virtual world compared to those who used a 2D social networking site (no avatar) exhibited greater nutrition and exercise self-efficacy (Behm-Morawitz, Lewallen, & Choi, 2016). Also, children requested larger portions of fruits and vegetables after interacting with a virtual dog whose health improved or deteriorated depending on the user's actual consumption of fruits and vegetables (Ahn et al., 2015). In line with SCT, this finding suggests that self-efficacy with respect to eating fruits and vegetables is an individual-level factor that is influenced by the embodied social (vicarious) experience with the virtual dog within the environmental incentive structure. Altogether, these studies support the notion that self-concept and self-efficacy are malleable and can be influenced by cues embedded within virtual experiences (Wheeler, Demarree, & Petty, 2007).

Discussion and conclusions

Researchers and practitioners have leveraged the ability to embody avatars and interact with embodied agents to foster healthier behaviors and attitudes through games and simulated experiences delivered through tethered or mobile platforms. Simulated experiences can aid in fostering health behaviors as they are perceived as real, and users can experience various facets of presence (e.g., "I am there," "we are together," "it is here"). Simulated experiences and agents may trigger brain activity that is weaker than its real counterpart, but they may also start physiological reactions of an equal or even stronger magnitude. In addition to task familiarity, attention, and task-user mental model matching, more research is needed to clarify which factors predict when a weaker, equal, or stronger physiological reaction is expected.

Virtual experiences have shown promising results for treating acute and chronic pain and pain rehabilitation. Manipulating users' avatar appearance can influence concurrent and subsequent physical activity in exergame and VR contexts. Avatars can bring to mind stereotypes that may influence the performance of physical activity. Interacting with agents embodied as pets or collectible characters may also incentivize physical activity. Avatar selves may allow users to try on different selves and increase control and well-being. VR interventions also show promising results in increasing self-esteem and self-efficacy for individual experiencing food disorders. There is also initial evidence that virtual experiences involving different aspects of the self can influence subsequent food choices.

The studies reviewed rely on various psychological theories (e.g., presence, desensitization, vicarious learning, self-efficacy, modeling, identification, self-perception, priming, self-concept) that are implemented in the design and measurement of virtual experiences. In this sense, the field is translational in nature as it does not generate its own theories as much as it imports tested approaches from related domains, particularly psychology. This has advantages as researchers may implement proven assumptions and methods to test for the effects of avatar and agent-related interventions, but it also limits the field as it does not generate its own specific assumptions and methods. Also, some of the studies reviewed above do not have a strong theoretical grounding and, instead, were more interested in testing whether a given manipulation or intervention effectively influenced a specific health outcome. These trends may be related to the applied nature of investigating how virtual experiences can influence health behaviors and attitudes, and it may change as the field matures and becomes more specialized.

Another noticeable trend is the lack of repeated measures or longitudinal study designs. With a few exceptions, the majority of the studies discussed above are single-exposure laboratory experiments instead of randomized control trials with repeated measures. Establishing lasting health improvements as a result of experimental manipulations of avatar and agents may require more stringent tests that include preregistered studies, randomized controlled trials, use of baseline scales, and longitudinal designs, along with more diverse samples that do not only include college students.

There is also a relative dearth of research utilizing psychophysiological or brain-scanning based techniques. There are huge potential knowledge gains to be developed by connecting health outcomes to the underlying neurological processes involved in using avatars. Such measurement technologies are becoming more accessible to researchers, both financially and technologically. For example, researchers have implemented special VR displays (wide field of view, high resolution, stereographic) within the extremely loud and magnetized environment of fMRI machines that do not interfere with brain scanning and allow participants to experience a sense of presence within the media environment (Hoffman, Richards, Coda, Richards, & Sharar, 2003b; Hoffman, Richards, Magula, et al., 2003c; Ku et al., 2003).

Furthermore, in order to track and render virtual environments, VR systems collect huge amounts of data related to the user. This includes location, voices, product preferences, and physical behavior such as eye gaze, facial expressions, interpersonal distance, gait, and posture. In fact, commercial systems in 2018 are able to collect 18 different kinds of movement. In a typical setup, around 20 million unique data points on nonverbal behavior are collected for a 20 minute VR experience

(Bailenson, 2018). Data derived from these VR setups can be used to optimize the effect of virtual experiences. A VR health intervention that seeks to get people to engage in more physical activity can detect and track user's facial expressions and bodily movements from the base stations and head-mounted displays. Furthermore, patients in clinical settings are often required to put on monitoring devices such as heart rate trackers, physical activity monitors, and pedometers. Data collected from these sources can be analyzed to build predictive models. For example, a recent study showed relationships between head movements in VR experiences and affective responses (Li, Bailenson, Pines, Greenleaf, & Williams, 2017). It is not difficult to see how predictive models built from millions of data points can allow researchers and practitioners to build more effective virtual interventions, not only on an aggregate level but also in tailoring experiences to suit specific individual's preferences and motivations.

Though more research is needed, initial evidence indicates that virtual manipulations and interventions are an effective and engaging tool to instill healthier behaviors and attitudes as these technologies allow for the implementation, manipulation, and expression of basic psychological processes.

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