GAMES FOR HEALTH JOURNAL: Research, Development, and Clinical Applications
Volume 9, Number 2, 2020

DOI: 10.1089/g4h.2018.0134

Enhancing Healthy Behaviors Through Virtual Self: A Systematic Review of Health Interventions Using Avatars

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Abstract

Objective: A systematic review of health interventions using avatars ($N = 18$) was conducted to provide comprehensive knowledge of the effectiveness of using avatars to promote healthy behaviors, specifically in relationship to healthy eating and exercising.
Materials and Methods: Two researchers identified field or laboratory studies that had quantified study results, which were published in peer-reviewed journals in English from January 2000 to March 2019. Databases (PsychInfo, PubMed, and Web of Science), forward reference, and manual searches were used to identify the studies. Search terms included avatar, the Proteus effect, exercise, and diet, among others. Two field interventions and 16 laboratory studies were identified. Information on sample characteristics, technologies used, study design and conditions pertaining to avatars, outcome measures, results, and conclusion were extracted.
Results: Six different avatar characteristics used to elicit health outcomes were identified, which are the similarity with the user, avatar body size, self-domain (e.g., ideal-self), customizability, body transformation, and avatar's behaviors. Only a few studies had a no-avatar control group; thus, it was not possible to conclude whether employing avatars in health interventions increases the effectiveness of the interventions in comparison to not using an avatar.
Conclusion: The results indicate that using an avatar that is physically active, fit, and similar-looking (to the user) is effective in eliciting healthy behaviors.

Keywords: Systematic review, Avatars, Virtual self, Physical activity, Eating behaviors

Introduction

AVATARS, DEFINED AS graphical representations of users in mediated environments,[1] can be applied to a broad range of media technologies such as social media,[2] games,[3] and virtual reality.[4] Previous research has shown that avatar has great potential to generate positive psychological and behavioral outcomes in health domains.[5] For example, thanks to the graphic technologies creating highly realistic avatars, avatars can simulate the subject's past and current health status as well as future health consequences determined by current health choices (i.e., what-if scenarios).[5] Visually depicting future health consequences using an avatar can have a stronger persuasive impact on the users, than conventional textual or visual persuasion messages.[6,7] Moreover, avatars can facilitate subjects' engagement and enjoyment in health interventions through feelings of identification with or embodiment in avatars,[8,9] thereby improving retention rates.[10]

As avatars have the potential to facilitate success in health interventions, reviewing and synthesizing previous empirical research that utilized avatars is a timely task that will benefit future research by illuminating the ways in which users are psychologically connected to their avatars and processes through which an avatar's characteristics influence the users' health behaviors in real life. Practically, it can provide useful knowledge and guidelines in designing effective and enjoyable health interventions using avatars.

To our best knowledge, no systematic review of avatar use and effectiveness in health interventions is available thus far. Although a 2012 review examined avatar as one of the design features in e-health interventions,[11] it did not focus on the effectiveness of avatars. Moreover, the term avatar was not defined as a virtual representation of the user, but as an automatized system that simulates person-to-person interaction with the user, which is the definition of computer agents.[12] This study reviews the use of avatars and their effectiveness in health behavior change, particularly in physical activity and healthy eating. The specific objectives of this study are to (1) synthesize studies that used an avatar-based approach in health behavior change and the effectiveness of avatars

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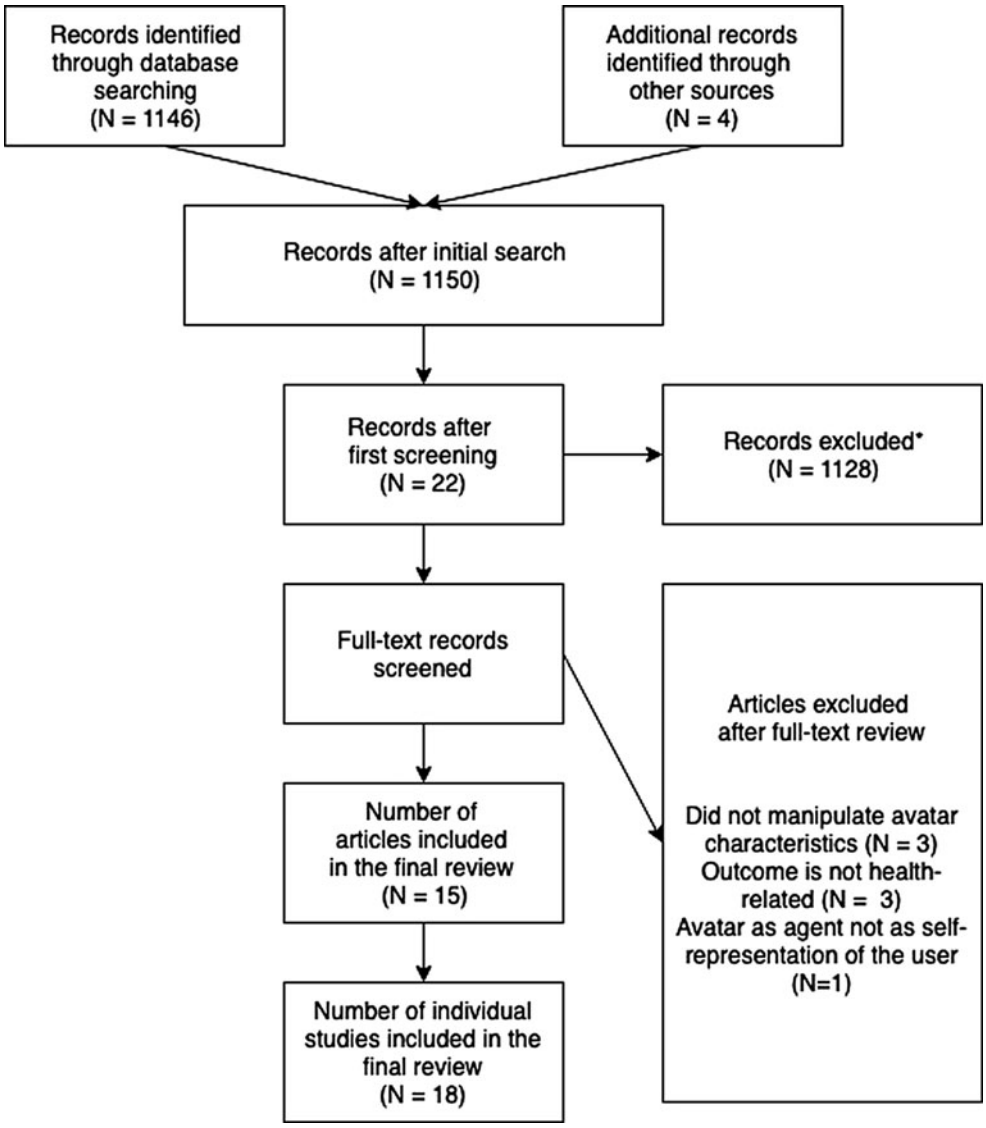

FIG. 1. Inclusion and exclusion process.

compared to a nonavatar-based approach, (2) review theoretical explanations proposed or tested as underlying psychological mechanisms of effects of avatars, and (3) assess various types of avatar characteristics and their effectiveness.

Data Search

Data source

This study used three databases: PsychINFO, PubMED, and Web of Science. Research published between January 2000* to March 2019 were included. Search terms were combinations of the following two groups of keywords (1) ''avatar,'' ''character identification,'' ''virtual embodiment,'' ''self-presence,'' ''virtual representation,'' ''game character,'' ''mediated self,'' ''virtual self,'' ''exergame,'' and ''Proteus effect'' and (2) ''exercise,'' ''diet,'' ''eating,'' ''health intervention,'' ''health promotion,'' ''physical activity,'' ''nutrition,'' ''obese,'' ''obesity,'' ''weight loss,'' ''weight management,'' and ''well-being.'' Five hundred fifty-nine articles were found in Web of Science, 478 articles in PubMED, and 109 articles in PsychNFO. Four additional articles were identified by manually reviewing references in the reviewed articles (Fig. 1).

Data inclusion and exclusion criteria

An eligible study must have been published in English in peer-reviewed journals and examined the effect of avatars on health-related behavioral and/or psychological outcomes using quantitative methods. Research that used, but did not directly manipulate, avatar characteristics were excluded. In addition, studies that used the term avatar to indicate computer agent, not a representation of the user, were excluded. Finally, intervention studies with clinical populations were excluded because this research focuses on preventive health practices.

*The year 2000 was selected as the starting year because this was when avatar technology was mature enough to be used in health interventions and early avatar studies began to emerge.

Data extraction

The following information was extracted from the reviewed studies: (1) author(s), publication year, sample size, and characteristics; (2) technology used (hardware and software); (3) health domain and outcome measures; (4) manipulation of avatars; (5) underlying theories and/or concepts; and (6) study results (Tables 1 and 2). In addition, the risk of bias assessment was conducted by two researchers (Fig. 2).

Results

Summary of the data sample

Fifteen research articles were included in the review. Articles that had multiple studies were considered individually, which resulted in 18 studies in total. The total number of participants across all the studies was 1513 (male = 583 and female = 930). The sample size in the individual studies ranged from 23 to 156. All but three studies recruited college students as study subjects. The other three studies recruited overweight children,[13] overweight adults,[14] and overweight veterans.[15] Of the 18 studies reviewed, 2 studies were long-term field interventions, and 16 studies were laboratory experiments. Hardware used in the studies included 2D screen desktop computers, console games with a controller (i.e., Nintendo Wii), and 3D head-mounted gear. In terms of software, off-the-shelf games (e.g., *The Sims 4*), an online virtual world called *Second Life*, and an immersive virtual environment with 3D self-modeling were used.

Theoretical explanations

Regarding the theoretical bases, social cognitive theory[16] was the most frequently used.[15,17,18] Based on social cognitive theory, an avatar can be a behavioral model from which people learn healthy behaviors through observation and imitation. Eight studies mentioned the Proteus effect,[13,17,19–22] which explains the influence of avatars based on self-perception theory.[23] The Proteus effect argues that users behave in accordance with their avatar's perceived traits.[24] A similar theoretical explanation is the perception-behavior mechanism,[21] which posits a direct connection between perception and behavior.[25] According to this explanation, perceiving an avatar activates a certain self-concept, and subsequently, it induces the user to behave following the activated self-concept. Similarly, one study[20] argued that priming participants with a healthy self-concept using an avatar can lead to actual healthy behaviors.

Two studies[26,27] used self-discrepancy theory[28] as a theoretical framework. According to the theory, there are three basic domains of the self: the actual self, the ideal self, and the ought self. These studies had participants create an avatar that reflect a particular domain of self and examined whether changing one's view of the self through the avatar leads to a change in health behaviors. Finally, the General Learning Model (GLM) was used in two studies.[29,30] The GLM assumes that personal and environmental factors influence an individual's internal state, and thereby elicit specific behaviors. These studies viewed avatar as a personal or environmental factor, which could activate an internal state that leads to health behaviors.

Effects of avatars

The first objective of the study was to synthesize previous studies and examine whether the use of an avatar leads to better health intervention outcomes. Three studies directly compared an avatar treatment condition to a no-avatar control condition. Among them, one study[14] found that the avatar condition was more effective for exercise efficacy. Another study found that the participants in the condition where their avatar's body size changed as a result of their behavior showed a significant difference in the users' level of physical activity, while there was no difference between the no-change avatar and control groups.[17] The last study did not find any difference among all conditions for calorie expenditure during physical activity and self-efficacy for physical activeness.[15]

Effects of avatar characteristics

The second objective was to review and assess the effect of different avatar characteristics. Various avatar characteristics were implemented, including similarity (avatar similar vs. dissimilar to the user), body size (obese vs. normal avatar), customizability of avatar (customizable vs. non-customizable), avatar body transformation (change vs. no change), self-domain (ideal self vs. actual self vs. ought self avatar), and avatar's behavior (healthy vs. unhealthy). Some studies employed more than one avatar characteristics.

Similarity. Five studies implemented similar versus dissimilar avatars.[15,17,30] Similarity manipulation included actual physical resemblance and perception of similarity. Four studies found the effectiveness of a similar avatar. Three studies showed that the participants had a higher level of motivation for an actual engagement in physical activity when they observed the similar avatar exercising or when they exercised using an avatar that looks or is perceived to be similar to them, compared to a dissimilar avatar.[17,30] Another study did not find a significantly larger effect of using a similar avatar on enhancing the participants physical activity levels, as compared to a non-similar avatar or not using an avatar at all.[17]

Avatar body size. Five studies[13,18,19,21,22] focused on how an avatar's body size influenced users' health-related behaviors. Four studies[13,18,19,21] found the main or interaction effects, and one study found no effect.[22] Peña et al.[19,21] found that a normal-sized avatar increased physical activity during exergame play. In addition, participants who used an obese avatar showed decreased physical activity when they perceived the body size difference to be significant between their own avatar and the opponent player's avatar. Moreover, those who were in the normal-sized avatar condition showed more vigorous physical activity when playing against a normal-sized avatar than an obese avatar. These interaction effects indicate that in a competitive exergame setting, an opponent avatar should be active and fit to motivate users, but the gap between the users' own avatar and the competitor avatar should not be too large.

Another exergame study[13] found that participants who used a normal-sized avatar showed better exercise attitude and motivation after playing the game as well as better game performance than obese avatar users. The last study[18] found that the normal-sized avatar elicited healthy behaviors from

Table 1. Data Extraction Results

	Sample			*Technology*		
Authors	*N*	*Age*	*Recruitment criteria*	*Hardware*	*Software*	*Duration*
Li et al.[13]	140 (M = 83, F = 57)	9 to 12, SD = N/A	O Children	Console game with a controller	Exergame (Nintendo Wii)	One-time exposure (30 minutes)
Behm-Morawitz et al.[14]	90 (M = 0, F = 90)	M = 25, SD = 9.92	O Adults	2D screen Desktop computer	Online Virtual World (Second Life)	1 month (at least 2 hours per every week)
Ruiz et al.[15]	28 (M = 27, F = 1)	62 ± 6, SD = N/A	O Veterans	2D screen Desktop computer	3D self-modeling	8 weeks (45 minutes per intervention, three time per week)
Fox and Bailenson[17]	63 (M = 32, F = 31)	M = 20.28, SD = 1.70	C	3D head-mounted gear	3D self-modeling	One-time exposure (NDI)
	53 (M = 32, F = 21)	M = 20.54, SD = 5.81	C	3D head-mounted gear	3D self-modeling	One-time exposure (NDI)
	73 (M = 23, F = 50)	M = 20.61, SD = 2.50	C	3D head-mounted gear	3D self-modeling	One-time exposure (5 minutes 20 seconds)
Joo and Kim[18]	124 (M = 45, F = 79)	M = 23.15, SD = 2.02	C	2D screen Desktop computer	The Sims 4	One-time exposure (30 minutes)
Peña et al.[19]	96 (M = 96, F = 0)	M = 21.25, SD = 2.35	C	Console game with a controller	Exergame (Nintendo Wii)	One-time exposure (35–40 minutes)
Sah et al.[20]	133 (M = 0, F = 133)	M = 20.26, SD = 1.34	C	2D screen Desktop computer	A web-based health game	One-time exposure (15 minutes)
Peña and Kim[21]	94 (M = 0, F = 94)	M = 21.07, SD = 1.24	C	Console game with a controller	Exergame (Nintendo Wii)	One-time exposure (10–15 minutes)
Verhulst et al.[22]	23 (M = 21, F = 2)	M: M = 22.52, SD = 0.87 F: M = 22.5, SD = 0.71	C	3D head-mounted gear	Virtual reality (virtual store)	One-time exposure (4 minutes)
Kim and Sundar[26]	95 (M = 26, F = 69)	N/A	C	2D screen Desktop computer	Online Virtual World (Second Life)	One-time exposure (10 minutes)
Jin[27]	156 (M = 53, F = 103)	M = 19.89, SD = 1.12	C	Console game with a controller	Exergame (Nintendo Wii)	One-time exposure (NDI)
Kastenmüller et al.[30]	27 (M = 13, F = 14)	M = 21.37, SD = 1.82	C	Console game with a controller	Exergame (Nintendo Wii)	One-time exposure (15 minutes)
	41 (M = 24, F = 17)	M = 20.88, SD = 2.05	C	Console game with a controller	Exergame (Nintendo Wii)	One-time exposure (15 minutes)
Kuo et al.[31]	76 (M = 28, F = 48)	M = 21.2, SD = N/A	C	3D head-mounted gear	3D self-modeling	One-time exposure (40 seconds)
Waddell et al.[32]	132 (M = 48, F = 84)	M = 20.42, SD = N/A	C	2D screen Desktop computer	Online Virtual World (Second Life)	One-time exposure (NDI)
Fox et al.[33]	69 (M = 32, F = 37)	M = 20.2, SD = N/A	C	3D head-mounted gear	3D self-modeling	One-time exposure (6 minutes)

C, college students; F, number of female participants; M, number of male participants; *N*, sample size, N/A, not available; NDI, no detailed information; O, overweight.

the users only when the avatars practiced healthy behavior, while the normal-sized avatar performing unhealthy behaviors did not. In comparison, obese avatars were not effective in changing the participants' behaviors regardless of behavior types.

Self-domain. Four studies[20,26,27,31] utilized avatars reflecting different domains of self (e.g., ideal, actual/present, or ought self), and two studies[26,31] found the main effect of an avatar reflecting ideal self. The first study[31] found that participants who used ideal-self avatars showed lower discounting rates (i.e., tendency to disregard the value of future gains relative to immediate rewards), which resulted in healthier eating behaviors than those who used present-self avatars. The second study[26] found that participants who created a desired-self avatar that represented their ideal body showed a clearer visualization of the ideal body shape than those who created an actual-self avatar. On the other hand, the actual-self avatar creators displayed a higher level of health risk perception. The visualization and health risk perception were positively related to the tendency for prevention-focused self-preservation (i.e., not engaging in unhealthy behaviors).

The other two studies[20,27] found interaction effects with other variables. One study[27] found a three-way interaction between activated self-concept, regulatory focus, and efficacy appeals. When the actual self was activated by creating an avatar in a health game, a fit between regulatory focus and efficacy appeal (i.e., priming promotion focus and using self-efficacy appeal or prevention focus and using response efficacy appeal) resulted in greater healthy dieting intention. However, when the ideal self was activated, the opposite was true. The other study found that the effect of activation of ought self on the healthy eating behavior was moderated by health consciousness; those who were highly health conscious were more likely to show healthier behavior than those who are not when ought self was activated.[20]

Customizability. Two studies examined the effect of avatar customization.[26,32] One[26] showed that participants who customized their own avatar showed greater intention to spend the time to maintain their health. However, unlike their response about the intention, those who customized their avatar actually engaged in more unhealthy behaviors than those who were randomly assigned an avatar. Another study[32] found an interaction effect between the avatar's gender and internalization of health ideals. Specifically, those who internalized health as a part of their ideal self showed greater intention for exercise and healthier eating when they customized an avatar whose sex is the opposite to their own than those who did not internalize healthy ideal self.

Body transformation. Two studies utilized change versus no-change conditions.[17,33] One study[17] found that participants in changing avatar conditions (i.e., gaining weight when participants were inactive and losing weight when participants were exercising) showed greater physical activity after the use of avatars than participants in no-avatar or no-transformation conditions. The second study[33] found that the participant's sex moderated the avatar effect. The study hypothesized that body transformation would increase participants' feeling of presence and lead to healthier eating behaviors. For female participants, the increased presence resulted in healthier behaviors than those who felt a low presence, whereas male participants showed the opposite pattern.

Behavior. Three studies utilized the avatar's health behaviors.[17,18,30] One study[30] found the main effect of physical activity level on participant's feelings of exhaustion in exergames. The other two studies found interaction effects between the avatar's behavior and similarity[17] and body size[18], which are mentioned in the Similarity and Avatar body size sections.

Discussion

Implementation of avatars in health interventions

Among the 18 studies, 3 studies had a no-avatar control condition. Due to the small number of studies, it is hard to conclude whether adding an avatar to health intervention is likely to result in better intervention outcomes. However, study results suggest that using an avatar with a particular characteristic can enhance health outcomes.

Utilizing diverse avatar features in health interventions

Six different strategies have been employed by previous studies: similarity, avatar body sizes, self-domain, customizability, body change, and avatar's behavior. Although this review does not provide a quantitative analysis of their effectiveness, over 60% of studies that employed similarity or body size as avatar manipulation found the main effect of the strategy.

Regarding similarity, the results suggest that when the users perceive the avatar to be similar to themselves, it amplifies the impact of the avatar's behavior on the user's subsequent behavior. This implies that the psychological connection between the user and the avatar, induced by the perception of similarity, plays a vital role in engendering health behaviors. This psychological connection can be conceptualized as identification,[34] embodiment,[1,35] or self-presence.[36] Although these concepts commonly aim to explain the connection between the user and the avatar, they capture different types of experiences.[37,38] Future research should test a mediating or moderating role of these concepts to further illuminate the underlying process of similarity effect.

Another noticeable result was the effect of the body size of avatars. Three out of four studies found that a fit avatar was effective in eliciting health-related outcomes. This result is consistent with self-perception theory,[23] which argues that people behave in accordance with their own observation of themselves. In a similar vein, when using an avatar, people align their behaviors to what they perceive their proxy (i.e., avatar) to be like.

Studies that utilized customization, self-domain, body change, and avatar's behavior found significant interaction effects between each other or with user trait variables (Table 2). Therefore, the avatar characteristics reviewed in this study may be more effective when they are combined to promote behavioral changes,[17,18] or when user characteristics (e.g., personality traits, and attitude toward or involvement in healthy lifestyle) are taken account of.[20,29]

Theoretical and practical implications

The theoretical frameworks mentioned in the studies can be categorized into three groups: social cognitive approach, perception-behavior consistency approach, and self-discrepancy approach.

Table 2. Data Synthesis Results

	Experimental conditions				*Key results*		
Authors	*Type*	*Details*	*Outcome measures*	*Theoretical frames*	*Main effect*	*Moderator*	*Mediator*
Li et al.[13]	DA	Avatar body size (obese vs. normal)	PA (exercise attitude, exercise motivation, and game performance)	Stereotype threat, The Proteus effect	Normal avatar participants had better exercise attitude, exercise motivation, motivation to use the Nintendo Wii to exercise, and game performance compared to obese avatar group	N/A	N/A
Behm-Morawitz et al.[14]	AN	Existence of Avatar (avatar vs. no avatar)	PA (frequency of exercising, exercise efficacy, and weight loss), E (nutrition efficacy)	Health self-efficacy, avatar-efficacy, and self-presence	Avatar group showed increased exercise efficacy and weight loss than the no-avatar group	N/A	N/A
Ruiz et al.[15]	AN, DA	Similarity (similar vs. dissimilar vs. no avatar control)	PA (kcal/day expenditure gain during physical activity, self-efficacy to be physically active)	Social cognitive theory	No main effect of similarity.		N/A
Fox and Bailenson[17]	AN, DA	Body transformation (change vs. no change vs. no avatar control)	PA (exercise repetition)	Social cognitive theory, The Proteus effect	Changing avatar group showed greater level of physical activity than no-changing avatar and no avatar control groups (the other two groups showed no significant difference)	N/A	N/A
Fox and and Bailenson[17]	DA	Similarity (similar vs. dissimilar)	PA (exercise repetition)	Social cognitive theory, The Proteus effect	Similar-avatar group showed greater physical activity than dissimilar-avatar groups	N/A	N/A
Fox and Bailenson[17]	DA	Similarity, behavior (similar/running vs. similar/loitering vs. dissimilar/running)	PA (physical activity in daily lives for 24 hours after the experiment)	Social cognitive theory, The Proteus effect	Similar-running avatar group showed greater level of physical activity in the exercise than dissimilar-running and similar loitering avatar groups	N/A	N/A
Joo and Kim[18]	DA	Avatar body size, behavior (body size: obese vs. normal avatar; Behaviors: healthy behaviors (exercising and consuming vegetables) vs. unhealthy behaviors (stay sedentary and eat unhealthy foods)	PA (the number of steps on stepper), E (number of high-sugar cookies consumed)	Social cognitive theory	No main effect of avatar behaviors and body size. Interaction effect of avatar body size and behavior.	Avatar behavior	
Peña et al.[19]	DA	Avatar body size (obese vs. normal)	PA (wrist and waist activity)	Social comparison, The Proteus effect	Normal avatar group showed greater wrist activity than obese avatar groups	Perceived body size difference between the user's avatar and opponent agent	N/A
Sah et al.[20]	DA	Self-domain (ideal vs. ought vs. actual self-avatar)	E (in-game food choice, after-game food choice)	The Proteus effect, goal priming, self-discrepancy theory	No main effect of self-domain	Health consciousness	N/A
Peña and Kim[21]	DA	Avatar body size (obese vs. normal)	PA (wrist, waist activity)	Social comparison, perception-behavior mechanism, The Proteus effect	Normal avatar participants showed more waist activity compared to obese avatar participants.	Body size of opponent agent	N/A

(*continued*)

Table 2. (Continued)

Authors	Experimental conditions: Type	Experimental conditions: Details	Outcome measures	Theoretical frames	Key results: Main effect	Key results: Moderator	Key results: Mediator
Verhulst et al.[22]	DA	Avatar body size (obese vs. normal)	E (the number of healthy and unhealthy food products bought, food perception)	The Proteus effect	No main effect for different avatar body size.	N/A	N/A
Kim and Sundar[26]	DA	Customizability, self-domains (customized and ideal avatar vs. customized and actual avatar vs. assigned attractive avatar vs. assigned unattractive avatar)	PA (intention to spend time for exercise), E (healthy food choice)	Self-discrepancy theory, self-perception theory, social learning theory, and regulatory focus theory	Customized avatar group showed higher intention to spend their time to maintain good health (i.e., a general tendency for self-preservation) than noncustomized group Customized avatar group showed more unhealthy behavior, that is, they chose a higher number of coupons for unhealthy foods or health-related services (e.g., tanning and fast food). Those who created an ideal avatar showed higher visualization of their ideal body. Higher visualization of body was associated with prevention-focused self-preservation. Those who created an actual avatar showed higher perception of risk to general physical body. Perception of the health risk was associated with general tendency for self-preservation.	N/A	N/A
Jin[27]	DA	Self-domain (ideal vs. actual self-avatar)	E (low calorie dieting intention)	Self-discrepancy theory, regulatory focus theory, and self-efficacy, response-efficacy	No main effect of self-domain	Regulatory focus, efficacy appeals	N/A
Kastenmüller et al.[30]	DA	Similarity (similar vs. dissimilar)	PA (motivation to play sports)	General leaning model, identification	Similar group showed increased motivation to play sports than dissimilar group	N/A	N/A
Kastenmüller et al.[30]	DA	Similarity, behavior (similar/high-level physical activity vs. dissimilar/high-level physical activity vs. dissimilar/low-level physical activity)	PA (motivation to perform the sports, exhaustion, and physical activity after a week)	General leaning model, identification	Similar avatar participants in high-level activity (Jogging) showed greater motivation to play sports and greater amount of exercise a week after than the dissimilar groups Participants in low-level physical activity condition (Bowling) showed less exhaustion	N/A	Motivation to play sports
Kuo et al.[31]	DA	Self-domains (ideal vs. present self)	E (amount of ice cream eaten, amount of sugar chosen for the reward drink)	Multiple-self models	Ideal-self avatar participants showed lower discounting rates. Ideal-self avatar participants ate less ice cream and chose smaller amounts of sugar for their drink compared to present-self avatar participants	N/A	Discounting rates
Waddell et al.[32]	DA	Customizability (customization type: same sex vs. opposite sex; customization levels: high vs. low)	PA (exercise intention), E (coupon choice for food- and health-related services)	Object self-awareness theory	No main effect of customization type, customization level Interaction between customization type and internalization of health ideals was found.	Internalization of health ideals	N/A
Fox et al.[33]	DA	Body transformation (avatar body change vs. no change)	E (number of candies eaten)	Social cognitive theory, presence	No main effect of body transformation Interaction between gender and presence—body transformation increased feeling of presence, but effects of presence were different depending on the participant gender.	Gender of the participant	N/A

AN, avatar versus no-avatar condition; DA, different avatar condition; E, eating behaviors; N/A, not applicable; PA, physical activity.

	Random sequence generation (Selection bias)	Allocation concealment (Selection bias)	Selective reporting (Reporting bias)	Blinding participants and personnel (Performance bias)	Blinding outcome assessment (Detection bias)	Incomplete outcome data (Attrition bias)	Other sources of bias (Other bias)
Li et al.[13] (2014)	U	U	L	U	U	U	U
Behm-Morawitz et al.[14] (2016)	U	U	U	U	U	L	U
Ruiz et al.[15] (2012)	U	U	L	U	U	H	U
Fox and Bailenson [17] (2009) S1	U	U	L	U	U	L	U
Fox and Bailenson [17] (2009) S2	U	U	L	U	U	U	U
Fox and Bailenson [17] (2009) S3	U	U	L	U	L	L	U
Joo et al.[18] (2017)	U	U	L	U	U	L	H
Peña et al.[19] (2016)	U	U	U	L	L	L	U
Sah et al.[20] (2016)	U	U	L	U	U	U	U
Peña et al.[21] (2014)	U	U	L	L	L	L	U
Verhulst et al.[22] (2018)	U	U	L	U	U	L	U
Kim et al.[26] (2012)	U	U	L	U	U	U	U
Jin[27] (2012)	U	U	L	U	U	U	U
Kastenmüller et al.[30] (2013) S2	U	U	L	U	U	U	U
Kastenmüller et al.[30] (2013) S3	U	U	U	U	U	L	H
Kuo et al.[31] (2016)	L	L	L	L	L	L	U
Waddell et al.[32] (2015)	U	U	L	U	U	U	U
Fox et al.[33] (2009)	U	U	L	U	U	L	U

FIG. 2. Risk of bias assessment. H, high risk of bias; L, low risk of bias; U, unclear risk of bias.

The social cognitive approach focuses on modeling after the avatar. Study results pertaining to similarity, body transformation, and avatar behaviors demonstrate that avatars can be a powerful model for vicarious or enacted learning.[39,40] By practicing healthy behaviors through an avatar, users can learn the behaviors, and the learning could be facilitated by an increased similarity between the avatar and the user. Furthermore, given that body transformation was found to be effective, visualizing positive health consequences through the transformation of an avatar seems to increase the user's positive outcome expectancy,[41] which motivates them to adopt healthy behaviors. State-of-the-art graphic technology allows a high level of similarity between an avatar and the user, as well as a realistic simulation of health behaviors and their consequences. Future health interventions can benefit from these technological advancements to maximize effectiveness.

The perception-behavior consistency approach is based on the premise that people automatically behave in a way consistent with their perception of self or others.[23,42] Since avatars are a virtual representation of the users, an avatar being perceived healthy and active can be carried over to the user' own self-conception, consequently engendering corresponding behaviors. Although the theoretical proposition of this approach has been well established, the underlying process has not been rigorously tested. Future research should test whether the user's self-concept is actually changed in line with the avatar's characteristics.

Finally, the self-discrepancy approach is based on a discrepancy between different self-domains. Different self-domains made salient to users through an avatar direct the users' attention to the gap between what they ideally want to be or what they should be and what they are now. This discrepancy, in turn, motivates individuals to narrow the gap. Self-discrepancy should not be too large as it can be demotivating.

Limitation

First, this study only included research participants who are from a nonclinical population. Fifteen out of 18 studies used a college student sample, which hinders generalization of the study results. For clinical populations, researchers might need to consider other dispositional or contextual

variables unique to the population. Most of the included studies used short-term exposure, although oftentimes health-related behavioral change requires the long-term efforts. Therefore, investigating long-term effects of avatar use will be beneficial. Finally, this study focuses more on reviewing and synthesizing diverse avatar strategies that have been used in existing research and illuminating their theoretical mechanisms. It does not report a statistical analysis of the results due to the small number of studies in each category of the independent variables. Future research can provide a more concrete conclusion about the effectiveness of different avatar strategies using the meta-analytic approach.

Conclusion

This review found that employing an avatar in health interventions could be effective when the avatar is similar to the user, fit, customizable, and demonstrating health consequences. Users could be motivated by an avatar that reflects their ideal or ought self. When these strategies are used, relevant user traits should be taken into consideration, including gender and health consciousness. Social cognitive theory, self-perception theory, and self-discrepancy theory can best explain the underlying processes of the effects of avatar use on health behavior.

Author Disclosure Statement

No competing financial interests exist.

Funding Information

References

1. Biocca F. The cyborg's dilemma: Progressive embodiment in virtual environments. J Comput Mediat Commun 1997; 3:JCMC324.
2. Kim Y, Sundar SS. Me, myself, and my avatar. In: Wood TN, Solomon MR, eds. *Virtual Social Identity and Consumer Behavior.* Armonk, NY: M.E. Sharpe; 2009: pp. 141–156.
3. Jin SA. Avatars mirroring the actual self versus projecting the ideal self: The effects of self-priming on interactivity and immersion in an exergame, Wii Fit. Cyber Psychol Behav 2009; 12:761–765.
4. Fox JA, Bailenson JN. Virtual self-modeling: The effects of vicarious reinforcement and identification on exercise behaviors. Media Psychol 2009; 12:1–25.
5. Fox JA. Avatars for health behavior change. In: Noar SM, Harrington NG, eds. *eHealth Applications: Promising Strategies for Behavior Change*. New York, NY: Routledge; 2011: pp. 96–109.
6. Ahn SJ. Incorporating immersive virtual environments in health promotion campaigns: A construal level theory approach. Health Commun 2015; 30:545–556.
7. Song H, Kim J, Kwon RJ, et al. Anti-smoking educational game using avatars as visualized possible selves. Comput Human Behav 2013; 29:2029–2036.
8. Kiesler S, Powers A, Fussell SR, et al. Anthropomorphic interactions with a robot and robot-like agent. Soc Cogn 2008; 26:169–181.
9. Reeves B, Nass CI. *The Media Equation: How People Treat Computers, Television, and New Media like Real People and Places*. Calif, NY: Cambridge University Press; 1996.
10. Lisetti C. *Proceeding from IHI 2012: 10 Advantages of Using Avatars in Patient-Centered Computer-based Interventions for Behavior Change.* Miami, FL: ACM SIGHIT; 2012.
11. Morrison LG, Yardley L, Powell J, et al. What design features are used in effective e-health interventions? A review using techniques from critical interpretive synthesis. Telemed J E Health 2012; 18:137–144.
12. Brave S, Nass C, Hutchinson K. Computers that care: Investigating the effects of orientation of emotion exhibited by an embodied computer agent. Int J Hum Comput Stud 2005; 62:161–178.
13. Li BJ, Lwin MO, Jung Y. Wii, myself, and size: The influence of Proteus effect and stereotype threat on overweight children's exercise motivation and behavior in exergames. Games Health J 2014; 3:40–48.
14. Behm-Morawitz E, Lewallen J, Choi G. A second chance at health: How a 3D virtual world can improve health self-efficacy for weight loss management among adults. Cyberpsychol Behav Soc Netw 2016; 19:74–79.
15. Ruiz JG, Andrade AD, Anam R, et al. Using anthropomorphic avatars resembling sedentary older individuals as models to enhance self-efficacy and adherence to physical activity: Psychophysiological correlates. Stud Health Technol Inform 2012; 173:405–411.
16. Bandura A. Social cognitive theory. In: Vasta R, ed. *Annals of Child Development: Six Theories of Child Development.* Greenwich, CT: JAI Press; 1989: pp. 1–60.
17. Fox J, Bailenson JN. Virtual self-modeling: The effects of vicarious reinforcement and identification on exercise behaviors. Media Psychol 2009; 12:1–25.
18. Joo YK, Kim K. When you exercise your avatar in a virtual game: The role of avatars' body shape and behavior in users' health behavior. Interact Comput 2017; 29:455–466.
19. Peña J, Khan S, Alexopoulos C. I am what I see: How avatar and opponent agent body size affects physical activity among men playing exergames: Physical activity in exergames. J Comput Mediat Commun 2016; 21:195–209.
20. Sah YJ, Ratan R, Sandy Tsai HY, et al. Are you what your avatar eats? health-behavior effects of avatar-manifested self-concept. Media Psychol 2016; 1–26.
21. Peña J, Kim E. Increasing exergame physical activity through self and opponent avatar appearance. Comput Hum Behav 2014; 41:262–267.
22. Verhulst A, Normand J, Lombart C, et al. Influence of being embodied in an obese virtual body on shopping behavior and products perception in VR. J Front Robot AI 2018; 5:113.
23. Bem DJ. Self-perception theory. Adv Exp Soc Psychol 1972; 6:1–62.
24. Yee N, Bailenson JN, Ducheneaut N. The Proteus effect implications of transformed digital self-representation on online. Commun Res 2009; 36:285–312.
25. Bargh JA, Chartrand TL. The unbearable automaticity of being. Am Psychol 1999; 54:462–479.
26. Kim Y, Sundar SS. Visualizing ideal self vs. actual self through avatars: Impact on preventive health outcomes. Comput Hum Behav 2012; 28:1356–1364.
27. Jin SA. Self-discrepancy and regulatory fit in avatar-based exergames. Psychol Rep 2012; 111:697–710.
28. Higgins ET. Self-discrepancy theory. Psychol Rev 1987; 94:120–121.
29. Buckley KE, Anderson CA. A theoretical model of the effects and consequences of playing video games. In: Vorderer P, Bryant J, eds. *Playing Video Games: Motives,*

responses, and Consequences. Mahwah, NJ: Lawrence Erlbaum Associates; 2006: pp. 363–378.
30. Kastenmüller A, Greitemeyer T, Fairclough S, et al. Playing exergames and sporting activity: The impact of identification with one's game character. Soc Psychol 2013; 44: 264–270.
31. Kuo HC, Lee CC, Chiou WB. The power of the virtual ideal self in weight control: Weight-reduced avatars can enhance the tendency to delay gratification and regulate dietary practices. Cyberpsychol Behav Soc Netw 2016; 19: 80–85.
32. Waddell TF, Sundar SS, Auriemma J. Can customizing an avatar motivate exercise intentions and health behaviors among those with low health ideals? Cyberpsychol Behav Soc Netw 2015; 18:687–690.
33. Fox J, Bailenson J, Binney J. Virtual experiences, physical behaviors: The effect of presence on imitation of an eating avatar. Presence: Teleoperators and Virtual Environments 2009; 18:294–303.
34. Van Looy J, Courtois C, De Vocht M, et al. Player identification in online games: Validation of a scale for measuring identification in MMOGs. Media Psychol 2012; 15: 197–221.
35. Fox JA, Bailenson JN, Tricase L. The embodiment of sexualized virtual selves: The Proteus effect and experiences of self-objectification via avatars. Comput Hum Behav 2013; 29:930–938.
36. Ratan R. Self-presence, explicated: Body, emotion, and identity extension into the virtual self. In: Lupicini R, ed. *Handbook of Research on Technoself: Identity in a Technological Society.* Hershey, PA: IGI Global; 2012: pp. 322–336.
37. Schultze U. Embodiment and presence in virtual worlds: A review. J Inform Technol 2019; 25:434–449.
38. Jung Y. Moderating effects of social presence on behavioral conformation in virtual reality environments: A comparison between social presence and identification. International Workshop on Presence (PRESENCE). 2009.
39. Bandura A. Health promotion from the perspective of social cognitive theory. Psychol Health 1998; 13:623–649.
40. Peng W. The mediational role of identification in the relationship between experience mode and self-efficacy: Enactive role-playing versus passive observation. Cyberpsychol Behav 2008; 11:649–652.
41. Williams DM, Anderson ES, Winet RA. A review of the outcome expectancy construct in physical activity research. Ann Behav Med 2005; 29:70–79.
42. Chartrand TL, Bargh KA. The chameleon effect: The perception–behavior link and social interaction. J Pers Soc Psychol 1999; 76:893–910.

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