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Designing Virtual Characters in Digital Health Technologies: A Self-presence Perspective

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Abstract:

Overweight and obesity represent major public health issues that affect more than 12.7 million children and adolescents. Health behavior change plays a critical role in self-managing obesity and overweight and can set the foundation for lifelong health for children and adolescents. Despite the potential of digital health technologies (DHTs) to help children and adolescents self-manage obesity and overweight, user engagement with DHTs, which plays a critical role in driving health behavior changes and improving health outcomes, remains low. One way to enhance user engagement with DHTs involves leveraging virtual characters through inducing self-presence among users. However, it is unclear how one can design virtual characters to achieve self-presence in DHTs to help children and adolescents self-manage obesity and overweight. The current study draws relevant data from a larger user-centered design science project to design a DHT that targets obese and overweight adolescents. We first derived relevant affordances pertinent to designing virtual characters through the self-presence perspective and then constructed design guidelines based on our findings. Further, we reviewed existing studies to determine potential support to further generalize our design guidelines. Based on our evidence, we propose design principles that can inform future efforts to design and assess virtual characters in DHTs. Developers and researchers who want to make DHTs more impactful in fostering healthier lifestyles among the youth should find our results useful.

Keywords: Self-presence, Virtual Characters, Digital Health, Design Principles, Affordances

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1 Introduction

Digital health technologies (DHTs) can drive health behavior-change processes that could lead to improved health behaviors and outcomes (Cole-Lewis et al., 2019). DHTs hold particular promise for adolescents managing health since adolescents who face health challenges mature to become more engaged in health management behaviors (Lozano & Houtrow, 2018; Sawyer & Aroni, 2005), tend adopt technology early on (Lee, 2014), and have the highest technology-use levels (Anderson & Jiang, 2018). In addition, studies indicate that adolescents generally have an interest in using DHT, such as to follow digital weight-management programs and self-manage obesity and overweight (Knoblock-Hahn & LeRouge, 2014; Knoblock-Hahn et al., 2016; LeRouge et al., 2016).

DHT shows promise for its ability to help adolescents manage their weight. Health behavior change plays a critical role in self-managing obesity and overweight and can set the foundation for lifelong health for children and adolescents (Utter et al., 2018). According to the World Health Organization (WHO),[1] obesity and overweight among children and adolescents have risen dramatically over the past decades. In 1975, the rate of obesity and overweight among children and adolescents was four percent in the world; in 2016, this percentage rose to over 18 percent. Obesity and overweight also place a substantial economic burden on the U.S. healthcare system and cost approximately US$173 billion annually (CDC, 2022).

Despite the potential for DHTs to help children and adolescents self-manage obesity and overweight, user engagement with DHTs, which plays a critical role in driving health behavior changes and improving health outcomes, remains low (Grady et al., 2018; Alkhaldi et al., 2016; Blandford, 2019; Christensen et al., 2009; Cugelman et al., 2011; Kelders et al., 2012; Neil et al., 2009). Low user engagement can prevent users from realizing the full benefits associated with DHTs. Therefore, we need to explore ways to address such a problem.

One way to improve user engagement with DHTs involves leveraging virtual characters (Golrang & Safari, 2021; Taylor, 2011). Virtual characters include avatars (i.e., user-created and -controlled characters) and agents (i.e., computer-controlled characters) (Bailenson et al., 2005; Nowak & Fox, 2018). Research suggests that integrating virtual characters into DHTs can enhance health outcomes. For example, virtual characters in DHTs for weight management can lead to greater weight loss compared to traditional in-person interventions (e.g., Horne et al., 2020). Some evidence also shows that virtual characters can increase user engagement through self-presence (Jung et al., 2022; Mitchell et al., 2022).

Self-presence, a form of virtual presence, is a salient affordance associated with user interaction with virtual characters (Shin, 2017). This affordance refers to “the extent to which some aspect of a person’s media [virtual characters] use is relevant to the user’s proto (body-schema) self, core (emotion-driven) self, and extended (identity-relevant) self” (Ratan & Hasler, 2009, p. 1). Studies also indicate that such a connection can lead to user engagement and, ultimately, behavior change (Ratan & Hasler, 2009; Yee & Bailenson, 2007). Even though self-presence is a critical affective affordance that can support user engagement with DHTs and further facilitate health behavior change, it remains unclear how one can design virtual characters to achieve self-presence in DHTs to help adolescents self-manage obesity and overweight.

Design principles, a main form of design knowledge in design science research (Chandra et al., 2015; Gregor, 2006; Gregor & Hevner, 2013; Jones & Gregor, 2007; Hevner et al., 2004), may offer the best methodological perspective to expand our current limits in knowledge and understanding about designing virtual characters in DHTs to help adolescents self-manage obesity and overweight. Design principles capture the knowledge about creating “instances of artifacts that belong to the same class” (Sein et al., 2011, p. 39). Design principles constitute prescriptive statements that explain how to do something to achieve a specific goal (Gregor et al., 2020).

Currently, little research has presented design guidelines, much less proposed design principles, to provide direction in the DHT and general IT design space to enhance self-presence through virtual characters. Existing studies on virtual character design either do not focus on design principles (Rheu et al., 2020) or focus on design principles that do not capture the self-presence concept and the health context (Blake & Moseley, 2010). A lack of understanding of how to design for self-presence can limit designers from realizing the full potential of virtual characters (Ratan & Hasler, 2009; Yee & Bailenson, 2007).

[1] https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight

Thus, in this study, we advance knowledge for the design of virtual characters in DHTs for self-management of obesity and overweight to induce self-presence. More specifically, we address the following research question (RQ):

> **RQ:** How should we design virtual characters in DHTs for children and adolescents' self-management of obesity and overweight to induce self-presence among users?

We draw design guidelines iterated from a user-centered design project and then seek insight from the literature for elevating these principles to propose more generalized design principles. Our findings contribute to the knowledge base on designing virtual characters in DHTs for self-management of obesity and overweight among children and adolescents. Such design knowledge contributes to a better understanding of the ways in which designers can induce self-presence through specific design choices. Furthermore, DHT developers who aim to create DHTs to foster user engagement over time and facilitate health behavior change among users can leverage and use our findings.

This paper proceeds as follows: In Section 2, we discuss the background of our study with a focus on DHTs, self-presence, and design principles for virtual characters. In Section 3, we discuss our methods, which involved leveraging data from prior studies and conducting a literature review to extend our findings to the broader use of virtual characters in DHTs. In Section 4, we report our study findings. In Section 5, we interpret our results, put them within a broader context, propose design principles, and acknowledge the limitations inherent in our research. Finally, in Section 6, we conclude the paper.

2 Background

DHTs provide new ways for people to manage chronic conditions (e.g., Hutton et al., 2011; McClure et al., 2013). This section delves into the importance of DHTs and their potential to facilitate lifestyle modifications and chronic disease management. Despite their potential, challenges such as low user engagement call for the need for more effective design strategies. The discussion in this section further explores the self-presence concept in virtual characters as a promising approach to enhance user engagement and the need to develop design principles for virtual characters in DHTs.

2.1 Digital Health Technologies

DHTs generally include mobile health apps, wearable devices, and platforms for remote health care (e.g., telehealth) (Mathews et al., 2019). DHTs have gained increasing attention in chronic disease self-management (Alkhaldi et al., 2016; Alkhaldi et al., 2017; Hutton et al., 2011; McClure et al., 2013). Specifically, these technologies can support individuals in making lifestyle changes that could lead to better health. For instance, DHTs can help individuals manage overweight and obesity by promoting dietary and physical activities that can lead to weight loss (Beleigoli et al., 2019). Further, DHTs can help individuals deal with chronic pain by tracking pain episodes, identifying triggers, and so on (Mann et al., 2013). In addition, DHTs can effectively improve medication adherence and blood pressure control among individuals with hypertension (Xiong et al., 2018).

Despite the potential of DHTs to help individuals self-manage their chronic condition, user engagement (a continuous user involvement with technology) remains low (Grady et al., 2018; Alkhaldi et al., 2016; Blandford, 2019; Christensen et al., 2009; Cugelman et al., 2011; Kelders et al., 2012; Neil et al., 2009). The industry market research also indicates that about 74 percent of users stop interacting with DHTs after 10 uses (Localytics, 2017).

The lack of user engagement is a problem as it undermines the potential of DHTs to deliver sustained health benefits. Recognizing the gap in the literature that addresses this issue, recent research has begun to explore innovative strategies to support user engagement (e.g., Grady et al., 2023; Winkler et al., 2023). Among these strategies, introducing virtual characters into DHT platforms has emerged as a promising solution (e.g., Winkler et al., 2023; Golrang & Safari, 2021; Taylor, 2011). Indeed, some evidence shows that virtual characters can increase user engagement through self-presence (Jung et al., 2022; Mitchell et al., 2022). Yet, how to design virtual characters to achieve self-presence in DHTs is not clear.

2.2 Self-presence

As one of the forms of virtual presence, self-presence is a salient affordance associated with user interaction with virtual characters (Shin, 2017). It functions by mapping users onto their virtual characters (Biocca,

1997) and converging the virtual with the physical through the interplay between users' offline and online identities (Behm-Morawitz, 2013). The biocultural theory of presence, which conceptualizes natural and technology-mediated presence in terms of proto, core, and extended presence (Riva et al., 2004), informs the self-presence concept. Proto presence refers to the physical awareness that arises when individuals coordinate their perceptions and movements and, therefore, differentiate themselves from the external world (Riva et al., 2004). Proto self-presence refers to the degree to which a virtual character serves as an extension to a user's physical body in the virtual environment (Marsh et al., 1999; Ratan, 2013). When proto self-presence occurs, a character's virtual body aligns with the various aspects of the user's physical body. For example, at the proto self-presence level, a character's virtual body can reflect the user's body shape (Ahuja et al., 2019; Piryankova et al., 2014; van Vugt et al., 2006).

Furthermore, core presence refers to an individual's emotional state that arises from encounters between the proto self and objects in the external environment (Riva et al., 2004). At the core level, self-presence refers to "the extent to which mediated interactions between self-presentation and mediated objects cause emotional responses" (Ratan, 2013, p. 326). For instance, at the core self-presence level, virtual characters can express specific emotions in reaction to the user's activities (Bernal & Maes, 2017).

Finally, extended presence refers to how individuals perceive their identity (Riva et al., 2004). At the extended level, self-presence refers to the extent to which some aspects of the virtual character reflect a user's identity (Ratan, 2013). For example, at the extended self-presence level, users can choose specific characteristics they identify with (Ratan, 2013; De Zwart & Lindsay, 2012).

Studies show that self-presence can lead to user engagement with technology and, ultimately, behavior change (Ratan & Hasler, 2009; Yee & Bailenson, 2007). For instance, when interacting with digital health agents who model healthy behaviors, users who actualize self-presence are more likely to engage with digital health agents and start practicing healthy behaviors in real life to conform to their agents' behaviors (Behm-Morawitz, 2013).

It remains unclear how virtual characters can be designed to induce self-presence, particularly with respect to the potential of DHTs to help adolescents and children self-manage obesity and overweight. One way to address the design gap is to develop principles to inform the design of virtual characters to induce self-presence.

2.3 Design Principles for Virtual Characters

Researchers recognize design principles as a well-known and accepted way to communicate nascent design knowledge in design science research (DSR) (Gregor, 2006; Gregor & Hevner, 2013; Jones & Gregor, 2007). DSR is a problem-solving approach that focuses on creating a novel artifact and knowledge about the artifact (Hevner et al., 2004) at different abstraction levels that range from concrete instantiations to design principles and design theories (Gregor & Hevner, 2013; Heinrich & Schwabe, 2014). In DSR, design principles constitute statements that guide or constrain actions, are prescriptive, and constitute the basis for action. Design principles are generally informed by the social context of key stakeholders and the overall purpose of the artifact (Wieringa, 2014). They can help practitioners (e.g., software developers) make effective design decisions by improving usability, influencing user perceptions, and increasing the appeal of technologies to users (Lidwell et al., 2010). Prior literature recognizes the value of design principles in various contexts: virtual environments with agents (Chaturvedi et al., 2011), information systems that support organizational sensemaking in environmental sustainability transformation (Seidel et al., 2018), wildlife management analytics systems (Pan et al., 2020), data literacy activities to support children's inquiries from complex data (Wolff et al., 2019), and so on.

Some existing studies have focused on developing design principles for virtual characters (e.g., Blake & Moseley, 2010; Nam & Park, 2009) but not in the context of healthcare and DHTs. For instance, Blake and Moseley (2010) discuss general design principles for virtual characters in educational technology. Design principles for educational technology might not be completely pertinent to the context of DHTs. The purpose of educational technology lies in facilitating learning (e.g., virtual characters providing users with links to relevant information sources) and supporting the cognitive efforts of users. Compared to the education context, the context of DHTs is more complex and multifaceted as it spans across various interconnected elements, such as the health condition, the patient, the health system, and so on (Nielsen & Sahay, 2022). Design principles associated with DHTs and associated components thereof (e.g., virtual characters) should, therefore, function with the healthcare context's unique elements in mind.

Moreover, while some research on virtual character design exists in the health context (e.g., LeRouge et al., 2016; Lisetti et al., 2015; Lisetti et al., 2013), researchers have not explored the DHT design concerning self-presence. We lack research that prescribes how to induce self-presence in DHTs. Some DHT studies focus on specific characteristics of virtual characters (e.g., similarity, body size) and the effectiveness of DHTs (Rheu et al., 2020). Other studies examined the relationship between self-presence and behavior change (Behm-Morawitz, 2013; Behm-Morawitz et al., 2016) or between behavior modification and behavior outcome (e.g., physical activity and eating behaviors) (Li et al., 2014; Peña et al., 2016; Peña & Kim, 2014; Ratan et al., 2020).

To address the above-mentioned gaps and propose design principles for virtual characters, we first derived design guidelines. Design guidelines sit at the boundary between theory and practice and facilitate knowledge transfer between researchers and practitioners (Gurzick & Lutters, 2009). Design guidelines are practical recommendations that are shaped through real-world testing and experience. They provide specific, actionable advice for practitioners (Hansen & Haj-bolouri, 2020). We leveraged design guidelines to inform design principles, which operate at a higher level of abstraction and contribute to design theory, thereby offering broader, foundational concepts that can be applied beyond a single instantiation of an artifact.

3 Methods

To address an absence of knowledge in the design of virtual characters that can induce self-presence, we first explored data from a comprehensive mixed-method study, providing the depth from which to derive design guidelines. Expressly, we referred to data from a larger user-centered DSR to design a DHT targeting obese and overweight adolescents (Knoblock-Hahn & LeRouge, 2014; Knoblock-Hahn et al., 2016; LeRouge et al., 2016; LeRouge et al., 2019). From this user-centered design science study, we derived desired affordances and features associated with user interaction with virtual characters. Prior studies indicate that identifying affordances can aid developers in designing IT artifacts (Adams et al., 2013; Karahanna et al., 2018; Norman, 1988, 1999, 2004; Norman et al., 2003). We used the affordances we identified as the basis for internal design guidelines for virtual characters in DHTs.

This section proceeds as follows: In Section 3.1, we introduce our data source, which originates from a larger user-centered design science project. In Section 3.2, we elaborate on our data-collection methods and two distinct phases in which we collected data. In Section 3.3, we explain the analytical methods that we applied in our data analysis. In Section 3.4, we describe the literature review we conducted to extend our findings to the broader context of the use of virtual characters in DHTs.

3.1 Data Source

We drew relevant data from a larger user-centered design (UCD) science project that employed multiple UCD techniques to design a DHT targeting obese and overweight adolescents (Knoblock-Hahn & LeRouge, 2014; Knoblock-Hahn et al., 2016; LeRouge et al., 2016; LeRouge et al., 2019). Particularly, the study used UCD techniques including user-driven focus groups, usability testing (questions and assessment scales), and prototyping. The Saint Louis University institutional review board approved the study design (IRB protocol numbers 24317 and 23081).

3.2 Data Collection

We collected the data used for the present study in two phases. Phase 1 included ten one-hour user-driven focus groups with adolescents participating in accredited weight self-management programs. The inclusion criteria included age (between 12 and 17 years old), computer use (experience with Internet and mobile phone technologies), and body mass index (85th–99th percentile range). Study participants included a diverse group of black, white, and Hispanic adolescents aged 12 to 17 from various socioeconomic backgrounds. Both males and females participated in the study. Adolescents and their parents provided their written consent before the adolescents participated in focus groups. Each focus group had three to seven participants (total = 48 participants: 15 male and 33 female). Focus groups with the adolescents included questions to elicit needs and contexts for their potential to use DHT and for the design and functional requirements for DHTs to assist them in self-managing their weight. Table 1 summarizes adolescents' demographic information. We used results from the first phase to inform the second phase.

Table 1. Phase 1 Adolescents' Demographics (N = 48)

Sex	
Male	32% (n = 15)
Female	68% (n = 33)
Age	
Between 12 and 14 years old	71% (n = 34)
Between 15 and 17 years old	29% (n = 14)
BMI	
95th BMI percentile or greater (obese)	79% (n = 38)
85th BMI percentile to less than the 95th BMI percentile (overweight)	21% (n = 10)

The second phase focused on usability testing of screen prototypes for a DHT and exploring the contexts of use. We recruited 70 adolescents attending the weight management camp sessions[2] to participate in usability sessions that lasted approximately one hour. Table 2 summarizes these adolescents' age and sex. Due to the sensitivity involved in collecting BMI data from participants or their parents/guardians and related reporting, Camp Jump Start leadership reviewed our recruitment list and verified (through camper records, which included a BMI measurement when the program began) that all participants met the BMI criteria: 1) inclusion criteria: BMI for age 85th percentile to less than 99th percentile, (2) exclusion criteria: severely obese (BMI for age 99th percentile or higher).

Table 2. Phase 2 Adolescents' Demographics (N = 14)

Sex	
Male	29% (n = 4)
Female	71% (n = 10)
Age	
Between 9 and 11 years old	7% (n = 1)
Between 12 and 14 years old	65% (n = 9)
Between 15 and 17 years old	21% (n = 3)
Missing	7% (n = 1)

Adolescents and their parents provided their written consent before adolescents participated in usability testing sessions. Participants first answered general background questions (e.g., age, technology access) before performing a series of usability tasks related to the mockups that informed effort and performance expectancy (Venkatesh et al., 2003). Adolescents also listened to and assessed various audio voices that a professional actor recorded for the virtual characters that varied in their intonation and realism (the multiple voices had the following labels: dog-superhero, cat-surfer, farmer, and teen). The usability activities included having the adolescents interact with and provide qualitative feedback related to virtual characters. We analyzed qualitative data from the two phases using Dedoose.

In addition to qualitative feedback, 14 participants assessed different virtual character prototypes using binary and semantic differential scales (Salkind, 2007). Participants indicated their preferences for various emotions by responding to a binary scale. Also, participants used a semantic scale to evaluate different virtual character types. Finally, we assessed the prototypes to determine participants' aesthetic and emotional preferences.

3.3 Data Analysis

For data analysis, we leveraged the analytical approach (Matavire & Brown, 2013). We conducted the initial stage of our qualitative analysis with open coding to break the data down analytically and discern which transcript and note sections pertained to the design of virtual characters. The resulting code set included

2 Camp Jump Start (http://www.campjumpstart.com/) is a recognized adolescent weight loss and healthy living summer camp program grounded in evidence-based techniques and led by a professional medical provider.

features and affordances related to designing virtual characters. Second, we analyzed relevant coding structures by applying axial coding procedures to develop concepts to explicate self-presence layers (Corbin & Strauss, 1990). Specifically, we looked for meanings and concepts from the open code set that directly or tangentially pertained to proto, core, and extended self-presence. We mapped codes related to features and affordances (identified during open coding) to the proto, core, and extended self-presence dimensions. Such features and affordances formed the basis for internal, project-specific design guidelines for virtual characters. Appendix A contains supporting quotes, open codes (which informed features and affordances), and themes (self-presence layers).

During the coding process, we met regularly and used the constant comparative method to iteratively discuss initial coding relevant to the current study and reach a consensus regarding themes that we identified in selective coding (Saldaña, 2009). Only minor issues occurred, and they predominantly concerned agreeing on labels to use for identified codes. We completed the data analysis after we reached consensus that the resulting themes related to each self-presence layer were accurate and stable.

3.4 Literature Review

To move from guidelines from the study (see above) to proposing design principles, we reviewed the extent to which the guidelines derived from the data had empirical support and further elaborated on our knowledge outcomes. By exploring other projects and contexts, we focused on ensuring our guidelines applied to a broader context of use and proposing design principles for virtual characters.

Particularly, we conducted a focused narrative literature review (Stratton, 2019). Narrative literature reviews are unstructured reviews of literature that aim to describe and discuss specific topics and themes from a theoretical and contextual point of view, as well as provide justification for specific points raised by researchers (Stratton, 2019; Henry et al., 2018). Such reviews may be conducted using search words within standard databases but do not necessarily follow pre-defined protocols. In our case, we used various keywords (specifically, “virtual character,” “agent,” “avatar,” and “self-presence”) to search Google Scholar for relevant studies. We geared our search toward journals related to the human-computer interaction, health informatics, and psychology domains and on papers that focused on exploring the design, perceptions, and outcomes of user interactions with virtual characters. For each study that appeared relevant based on its abstract (specifically studies that delved into the design, perceptions, and outcomes of these interactions), we conducted a full-text review to ascertain whether they contained any evidence that supported the design guidelines that we propose. Consistent with the nature of narrative literature reviews, we focused on uncovering a diverse range of studies rather than on conducting an exhaustive review. Therefore, while we do not claim to have reviewed every publication on self-presence and virtual characters, our review highlights several studies that support our design guidelines.

In presenting our findings, we conform with general standards for academic writing (e.g., Hartley, 2008) that state that the results section should focus on the objective reporting of the study findings (i.e., findings from first and second phases) and that the discussion section should interpret these results and put them in a broader context (i.e., associate our findings with existing literature to derive more generalized design principles).

4 Results

Table 3 outlines various desired affordances associated with each self-presence layer, which form the basis for internal, project-specific design guidelines for virtual characters. Appendix A contains evidence trace tables with representative quotes. Our findings in the following subsections capture participants’ responses from usability testing of screen prototypes, quantitative assessments of different prototypes using binary and semantic differential scales, open-ended questions during usability testing, and focus groups.

Table 3. Design Guidelines for Virtual Characters in DHTs

Self-presence layer	Design guidelines
Proto	Selecting anthropometric measurements for virtual characters
	Using bubble/audio sound to communicate with virtual characters
	Selecting body movements for virtual characters
Core	Selecting facial expressions for virtual characters
	Receiving motivating messages and rewards from virtual characters
Extended	Selecting appearance for virtual characters
	Interacting with virtual characters functioning in dual roles as friends and coaches

4.1 Proto Self-presence

In alignment with proto self-presence, adolescents expressed that their virtual character could act as their proxy in the virtual environment. The adolescents identified specific body schema design elements that technology designers need to consider to facilitate proto self-presence in DHTs: anthropometric measurements, speech bubbles and/or audio sound, and body movements.

The adolescents discussed their character's physical body in relation to matching their anthropometric measurements, such as weight and height. Participants indicated they wanted to select the anthropometric measurements for their virtual characters. Choosing weight and height could let participants keep track of their physical appearance and feel connected to their virtual character. For example, one participant said:

> *Knowing that if I lose weight…. We weigh in on Fridays. So, on Fridays, if I get on, that's how much weight did I lose this week, then I would put in how much I weigh, and then it calculates for me, it's congratulations and shows my body like shrinking. And then, over time, I can just see. Then, I think that it would be cool as if you could have some…. It will show your success throughout the month, so like month one, and I will take a snapshot of your avatar, and then four months later, you can see four different, you know, and see how much.*

Furthermore, most adolescents expressed an interest in using a speech bubble, audio sound, or both while interacting with virtual characters. Particularly, adolescents mentioned that using such features would enable them to feel connected with their character through communication. For instance, one participant stated: "Maybe [virtual character] can communicate with you, it asks you something, it can playback, and you can have a conversation about it, kind of like Siri". We also presented adolescents with various audio voices. While they deviated in which voice types they preferred, all adolescents interested in the communication feature expressed preference in having the virtual character possess a voice that most aligned with a realistic teenage voice.

Finally, participants indicated the ability to select basic or complex body movements as relevant to their virtual character. Selecting various body movements could enable participants to feel supported through basic and complex body movements in the virtual environment and real life. Participants suggested moving the character's arms and legs to perform various basic actions: walking, running, jumping, shaking the head yes or no, clapping, and pointing. For instance, one participant said:

> *I want them to be able to eat food and, say hi and start jogging or walking in place. And, maybe, thumbs up. If they are confused about something that you are trying to do in the game, have them scratch their head….*

Participants also suggested more complex movement patterns to perform tasks, such as cooking, dancing, and eating. One participant, for example, said: "And that person [virtual character] is doing the cooking and the clean-up, so it shows you a little bit how to do this in a certain way that you're supposed to do it".

4.2 Core Self-presence

Participants discussed several virtual characters' features that align with core self-presence. They discussed features related to the virtual characters' facial expressions and the motivational content that could provide encouragement to users.

Participants indicated they would like to select facial expressions for their virtual characters. Figure 1 shows various facial expressions that adolescents could choose (the red circles indicate emotions with the highest "yes" percentages). Table 4 summarizes adolescents' preferences. The adolescents' most predominant preferences included the happy, confident, and sad facial expressions. They mentioned sadness (particularly disappointment on occasions when user behavior did not concur with the target behavior) as a desired facial expression. Regarding confidence, virtual characters that showed proud and optimistic expressions appealed to the adolescents. Almost all forms of happiness expressions seemed desirable. Participants did not generally select the angry facial expression option from the scale. However, they indicated (in response to other questions) that, in certain limited situations, such as when their food choices did not match their guidelines, anger would be an applicable expression (the enraged emotion in particular).

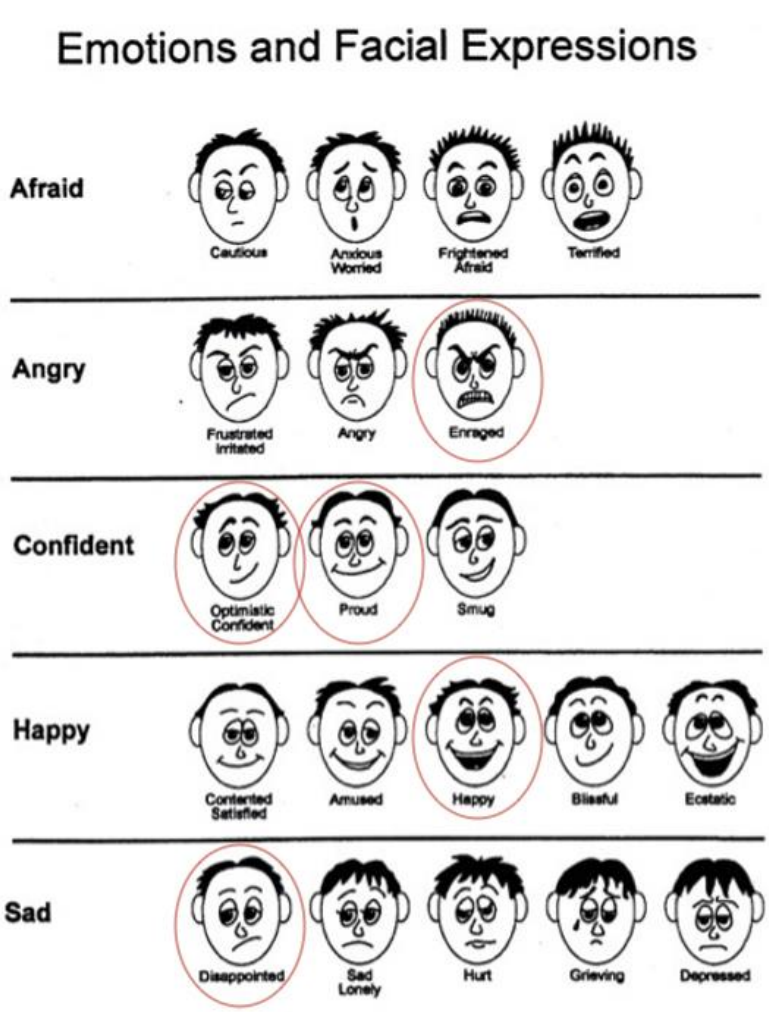

Figure 1. Emotion Chart

Selecting the facial expressions could enable participants to express their emotions towards their health behavior progress. For instance, one participant said: "According to your attitude, it [virtual character] could change its expression".

Moreover, participants shared that they would be interested in receiving motivating messages and rewards from their virtual characters. For example, some participants expressed an interest in the virtual character's instant encouragement (e.g., "Good job!"). In addition, they mentioned different reward system elements (e.g., badges and labels)—a common videogame feature—as motivational content that could encourage them to stay engaged with technology. Receiving motivating messages and rewards helped users feel motivated in their health journey: "If they [virtual characters] motivate you, then yeah, or you say if you have a goal, and then they say things to motivate you".

Table 4. Adolescents' Preferences for Virtual Characters' Facial Expressions (N = 14 from Usability Assessments)

Facial expressions	Yes (n (%))	No (n (%))	Missing (n (%))
Afraid			
Cautious	4 (28.6%)	9 (64.3%)	1 (7.1%)
Anxious	6 (42.9%)	7 (50%)	1 (7.1%)
Frightened	2 (14.3%)	11 (78.6%)	1 (7.1%)
Terrified	2 (14.3%)	11 (78.6%)	1 (7.1%)
Angry			
Frustrated/irritated	6 (42.9%)	7 (50%)	1 (7.1%)
Angry	5 (35.7%)	8 (57.1%)	1 (7.1%)
Enraged	**12 (85.7%)**	1 (7.1%)	1 (7.1%)
Confident			
Optimistic	**10 (71.4%)**	3 (21.4%)	1 (7.1%)
Proud	**9 (64.3%)**	4 (28.6%)	1 (7.1%)
Smug	7 (50%)	6 (42.9%)	1 (7.1%)
Happy			
Contented/satisfied	4 (28.6%)	9 (64.3%)	1 (7.1%)
Amused	3 (21.4%)	10 (71.4%)	1 (7.1%)
Happy	**11 (78.6%)**	2 (14.3%)	1 (7.1%)
Blissful	6 (42.9%)	7 (50%)	1 (7.1%)
Ecstatic	6 (42.9%)	7 (50%)	1 (7.1%)
Sad			
Disappointed	**10 (71.4%)**	3 (21.4%)	1 (7.1%)
Lonely	5 (35.7%)	8 (57.1%)	1 (7.1%)
Hurt	6 (42.9%)	7 (50%)	1 (7.1%)
Grieving	3 (21.4%)	10 (71.4%)	1 (7.1%)
Depressed	3 (21.4%)	10 (71.4%)	1 (7.1%)

4.3 Extended Self-presence

Participants identified various virtual characters' features contributing to the ongoing construction of an individual self and aligning with extended self-presence. These features include selecting character appearance (e.g., clothes) and using a virtual character as a friend and coach.

Participants generally indicated that they would be interested in selecting appearances for their virtual characters. However, they varied with respect to how much they preferred virtual characters to resemble them. Some adolescents said they want to photograph themselves and create their virtual characters based on their actual appearance. Other participants emphasized that they wanted a virtual character that resembled themselves more loosely. Further, participants wanted to have the option to customize their character by choosing clothing, accessories, facial hair, eye color, skin tone, hairstyle, facial structure, and body size. For example, one participant said:

> *You can make it [virtual character] look like you if you like. So I think that if you could actually get clothing to put on your guy, and accessories and all of that, I think it would also make it more interesting to people.*

In addition, participants discussed their interest in choosing a visual representation for their characters. Participants' preferences for virtual characters varied in realism: "cartoon-me" (see Figure 2) and "semi-professional" (see Figure 3) received the highest ratings on the semantic differential scale on the likeability criterion. Appendix B provides additional descriptive statistics (e.g., including frequency distributions and standard deviations) associated with the data in Figure 2 and Figure 3.

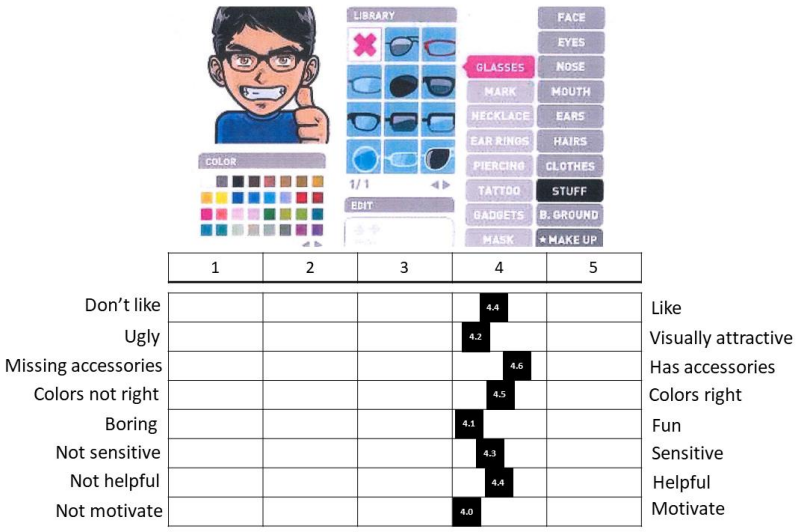

Figure 2. Cartoon-Me

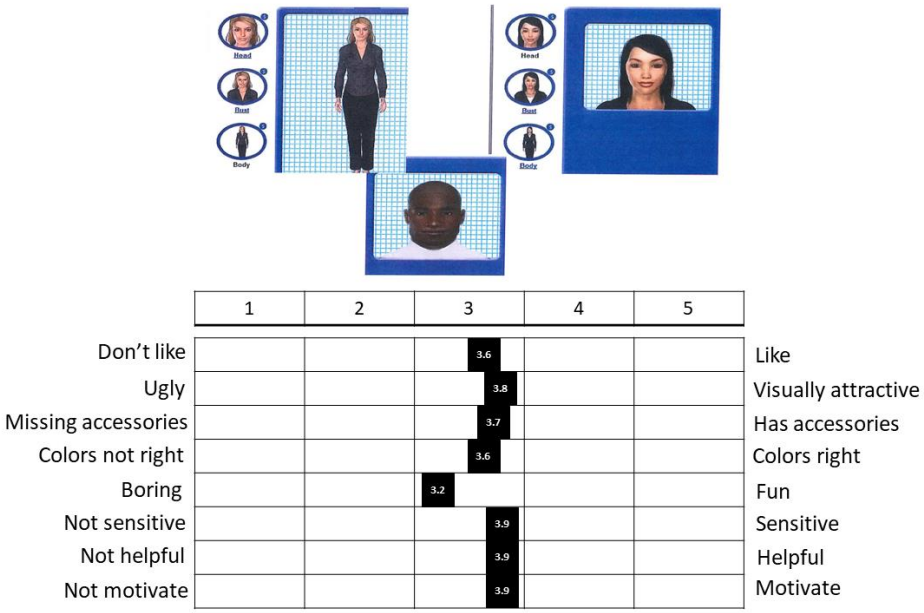

Figure 3. Semi-real Professional

Selecting their characters' appearance (from style to visual representation) would enable users to express themselves in virtual environments. For instance, one participant stated: "I'd like [virtual character] to be a representation of the person that's using it".

Furthermore, responses from some participants supported their intention to bring parts of the real world into the virtual environment—specifically, answers related to using a virtual character as a coach and a friend. As a friend, a virtual character can be a supporting figure. As a coach, it can provide advice about healthy food choices and exercise, demonstrate the cooking process step by step, and provide healthy alternatives to food options. In such roles (e.g., as friends and coaches), virtual characters would help participants feel supported in their engagement with technology and ongoing health management efforts. For instance, one participant stated:

> *[The virtual character] can be like, "How are you doing today?" and then on the score from 1 to 10, it can be like, "Are you doing fine?" I'm doing bad. "Why are you doing bad? What are you feeling?" And then it could just, again, be kind of motivational and just keep you going.*

5 Discussion

In this study, we derive design guidelines based on in-depth, mixed-method data from a user-centered design science project to design a DHT that targets obese and overweight adolescents. To move from guidelines from one study to proposing design principles, we reviewed prior studies to further elaborate on our knowledge outcomes. While the studies that we consulted did not expressly provide agreeing or disputing design guidelines or mention design principles related to self-presence in health-related virtual characters, they did indicate the importance of incorporating features and affordances, which informed our guidelines for user experience (e.g., user satisfaction (Bickmore & Ring, 2010)) and outcomes from users' interacting with virtual characters that possess such features and affordances (e.g., user engagement (Frost et al., 2012; Tielman et al., 2017) and intention to use (Lisetti et al., 2013)). Further, not all studies cited in this section point to the healthcare context or specifically reference the self-presence levels (or even the self-presence construct itself).

At the proto level, our findings revealed that it is important for adolescents to have the freedom to select anthropometric measurements for their virtual characters. The user's conceptualization of the virtual character's role (namely, a coach and/or friend) may affect the user's choice of anthropometric measurements. Prior studies indicate that by emphasizing that it is important for users to align avatars' looks to users' looks (Fox & Bailenson, 2009; Kastenmüller, 2013; Malhorta et al., 2016; Robertson et al., 2015). Indeed, research has found that the user's ability to align an avatar's look to a user's look and user interaction with transformational avatars (whose characteristics change along with user changes in body shape) support health behavior change (Fox, 2009; van Vugt et al., 2006). Prior studies, however, also indicate that aligning avatars' look to users' look may lead to anxiety due to increased awareness of users' body image, particularly among adults dealing with overweight, obesity, or general dissatisfaction with their physical appearance (e.g., Navarro et al., 2020; Song, et al., 2014). Although these insights primarily pertain to the adult demographic, whether DHTs should allow users to select virtual characters' anthropometric measurements that mirror their real body size remains ambiguous. In addition, we lack literature on specifying the virtual character's anthropometric measures for virtual characters designed to serve as a coach or friend. Future research should more thoroughly investigate the impact that virtual characters with varying anthropometric dimensions (that either reflect or diverge from users' actual body size) have on users' self-presence. Our study's conclusions with respect to selecting virtual characters' anthropometric measures resonate with, yet do not contradict, earlier findings. Specifically, our results point to the need to grant users the freedom to select the anthropometric measures that their virtual characters exhibit. The decision on whether these measures should closely match users' actual physical dimensions or a conceived friend's or coach's physical dimensions offers a rich avenue for future investigation.

Furthermore, our findings emphasize that it is important for adolescents to be able to use a speech bubble and/or audio sound and select basic and/or complex body movements. Researchers have previously linked virtual characters' interactivity (e.g., moving body parts or interacting with users via text messages) to users' enhanced motivation to engage with a particular health technology (Frost et al., 2012; Tielman et al., 2017). Such findings support our design guidelines at the proto level (see Table 3).

Overall, we propose the following design principles (DP) on the proto self-presence level:

DP1: To allow users to achieve proto self-presence, users should be able to select anthropometric measurements for their virtual characters.

DP2: To allow users to achieve proto self-presence, users should be able to use a speech bubble and/or audio sound when interacting with their virtual characters.

DP3: To allow users to achieve proto self-presence, users should be able to select basic and/or complex movements for their virtual characters.

Moreover, our findings capture design aspects at the core level, such as selecting facial expressions and receiving motivating messages and rewards. Prior research indicates that virtual characters that show emotions lead to higher engagement with health technology (Creed & Beale, 2012). For example, research found that characters that express empathy towards users motivated users to engage with technology (Bickmore et al., 2005). Moreover, controlling virtual characters' facial expressions led to higher user satisfaction and a better user experience (Bickmore & Ring, 2010, Lisetti et al., 2013). Research also found that virtual characters that express empathy verbally and adapt their facial expressions to the users' perceived facial expressions in real time led to higher perceived enjoyment and sociability, higher social presence, higher trust, and higher intention to use a counseling health intervention (Lisetti, 2013). In

addition, prior studies have indicated that gamification features (particularly rewards) can promote users' motivation and engagement with technology (Alsawaier, 2017). In alignment with the prior studies and our design guidelines at the proto level (see Table 3), we propose the following design principles:

DP4: To allow users to achieve core self-presence, users should be able to select facial expressions for their virtual characters.

DP5: To allow users to achieve core self-presence, users should be able to receive motivating messages and rewards from their virtual characters.

Finally, at the extended level, our findings included selecting the appearance of virtual characters and using them in the roles of a coach and friend. Indeed, prior studies indicate that users' ability to customize their virtual characters can increase their intention to maintain their health (Kim & Sunder, 2012). Furthermore, our results reveal that users want to interact with virtual characters in the roles of friends and/or coaches. Even though the literature lacks evidence about outcomes from using a virtual character that acts as a friend, some findings share benefits of such virtual characters for users (e.g., virtual characters guiding and instructing users) (Andrews, 2014; Easton et al., 2018). Based on prior studies that support our design guidelines, we propose the following design principles:

DP6: To allow users to achieve extended self-presence, users should be able to select the appearance of their virtual characters.

DP7: To allow users to achieve extended self-presence, users should be able to interact with virtual characters who act as a friend and a coach.

Overall, our design principles enrich the knowledge base on designing virtual characters in DHTs to help children and adolescents manage obesity and overweight and provide guidance for DHT developers. As we mention in Section 1, despite the potential of DHTs to assist children and adolescents in self-managing obesity and overweight, user engagement remains low, which suggests a critical need for better design strategies (Grady et al., 2018; Alkhaldi et al., 2016; Blandford, 2019; Christensen et al., 2009; Cugelman et al., 2011; Kelders et al., 2012; Neil et al., 2009). Additionally, while researchers understand self-presence to be a fundamental affective affordance that could boost user engagement with DHTs and catalyze health behavior change, the specific ways to design virtual characters to achieve this effect in the obesity-management context among adolescents remain elusive.

Until now, we had no clear design principles in the DHT and broader IT landscape that focus on enhancing self-presence via virtual characters. We address this gap in this study by providing insights based on examining the three self-presence layers: proto (related to the physical body), core (connected to one's psychological aspect), and extended (associated with one's identity). Such insights pave the way for DHT developers to create tools that foster sustained user engagement and effectively drive health behavior change.

5.1 Limitations

Despite the study's contributions, we recognize that this study has multiple limitations. While the study included adolescents from diverse backgrounds as participants, the sample included only adolescents between 12 and 17 years old. Our findings may not apply to children younger than 12 or older than 17. Moreover, participants self-selected to participate in the weight-management programs, which indicates that they may have had higher motivation and intention than average. Thus, our results might skew toward highly motivated adolescents willing to use digital tools. Also, we acknowledge that we constrained the scope of the proposed design principles given that we derived the guidelines from a user-centered design project. Future research should investigate potential additional design principles associated with self-presence that we may not have identified in this study.

We also recognize that we focused on deriving design principles with an implied emphasis on early use and adoption. There is a need for longitudinal studies that implement our design principles in DHTs. Interestingly, studies on virtual characters in the education domain indicate that customizing virtual characters' appearance (which aligns with DP6 in this study) can lead to low user engagement over time (e.g., Gamage & Ennis, 2018). Yet, it remains unclear whether such findings apply to the healthcare domain. Therefore, future work should explore the extent to which our proposed design principles contribute to user engagement and health behavior change over time.

6 Conclusion

Virtual characters can be leveraged to address low engagement with DHTs by inducing self-presence among users. Yet, until now, it has not been evident how to design virtual characters from the self-presence perspective. Our study provides insight into this issue by leveraging data from a user-centered DSR project that focused on helping children and adolescents self-manage obesity and overweight. By deriving design guidelines and extending their applicability using existing studies, we proposed seven design principles to guide the design of virtual characters in DHTs.

We encourage future work to test, adapt, and extend our general findings into contexts beyond DHTs that help adolescents self-manage obesity and overweight. Notably, researchers may be able to adapt our findings to other chronic care contexts (e.g., hypertension, chronic pain, among others) that require health behavior change, to general wellbeing contexts (wherein individuals engage in healthy behaviors for disease preventive purposes), and to other age groups. In addition, we encourage future efforts that extend our self-presence findings and design principles to situations outside healthcare.

Overall, virtual characters hold significant potential as a technology tool that can promote user engagement. It is, therefore, crucial for researchers to enhance our understanding of the design of virtual characters.

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References

Adams, M. A., Sallis, J. F., Norman, G. J., Hovell, M. F., Hekler, E. B., & Perata, E. (2013). An adaptive physical activity intervention for overweight adults: A randomized controlled trial. *PLoS ONE*, *8*(12), 1-11.

Ahuja, C., Ma, S., Morency, L. P., & Sheikh, Y. (2019). To react or not to react: End-to-end visual pose forecasting for personalized avatar during dyadic conversations. In *Proceedings of the International Conference on Multimodal Interaction*.

Alkhaldi, G., Hamilton, F. L., Lau, R., Webster, R., Michie, S., & Murray, E. (2016). The effectiveness of prompts to promote engagement with digital interventions: A systematic review. *Journal of Medical Internet Research*, *18*(1), 1-14.

Alkhaldi, G., Modrow, K., Hamilton, F., Pal, K., Ross, J., & Murray, E. (2017). Promoting engagement with a digital health intervention (HeLP-Diabetes) using email and text message prompts: Mixed-methods study. *Interactive Journal of Medical Research*, *6*(2), 1-14.

Alsawaier, R. S. (2017). The effect of gamification on motivation and engagement. *International Journal of Information and Learning Technology*, *35*(1), 56-79.

Anderson, M., & Jiang, J. (2018*).* Teens, social media & technology 2018. *Pew Research Center*. Retrieved from https://www.pewresearch.org/internet/2018/05/31/teens-social-media-technology-2018/

Andrews, A. R. (2014). *Avatar coaching: A case study on the perceptions of virtual reality coaching interventions with an avatar coach* (doctoral dissertation). Capella University.

Bailenson, J. N., Swinth, K., Hoyt, C., Persky, S., Dimov, A., & Blascovich, J. (2005). The independent and interactive effects of embodied-agent appearance and behavior on self-report, cognitive, and behavioral markers of copresence in immersive virtual environments. *Presence: Teleoperators & Virtual Environments*, *14*(4), 379-393.

Behm-Morawitz, E. (2013). Mirrored selves: The influence of self-presence in a virtual world on health, appearance, and well-being. *Computers in Human Behavior*, *29*(1), 119-128.

Behm-Morawitz, E., Lewallen, J., & Choi, G. (2016). A second chance at health: How a 3D virtual world can improve health self-efficacy for weight loss management among Adults. *Cyberpsychology, Behavior and Social Networking*, *19*(2), 74-79.

Beleigoli, A. M., Andrade, A. Q., Cançado, A. G., Paulo, M. N., Maria De Fátima, H. D., & Ribeiro, A. L. (2019). Web-based digital health interventions for weight loss and lifestyle habit changes in overweight and obese adults: Systematic review and meta-analysis. *Journal of Medical Internet Research*, *21*(1), 1-10.

Bernal, G., & Maes, P. (2017). Emotional beasts: Visually expressing emotions through avatars in VR. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*.

Bickmore, T., Gruber, A., & Picard, R. (2005). Establishing the computer-patient working alliance in automated health behavior change interventions. *Patient Education and Counseling*, *59*(1), 1-10.

Bickmore, T., & Ring, L. (2010). Making it personal: end-user authoring of health narratives delivered by virtual agents. In Proceedings of the *10th International Conference on Intelligent Virtual Agents.*

Biocca, F. (1997). The cyborg's dilemma: Progressive embodiment in virtual environments. *Journal of Computer-Mediated Communication*, *3*(2).

Blake, A., M., & Moseley, J., L. (2010). The emerging technology of avatars: Some educational considerations. *Educational Technology*, *50*(2), 13-20.

Blandford, A. (2019). HCI for health and wellbeing: Challenges and opportunities. *International Journal of Human-Computer Studies*, *131*, 41-51.

CDC. (2022). *Overweight & Obesity*. Retrieved from https://www.cdc.gov/obesity/basics/consequences.html

Chandra, L., Seidel, S., & Gregor, S. (2015). Prescriptive knowledge in IS research: Conceptualizing design principles in terms of materiality, action, and boundary conditions. In *Proceedings of the 48th Hawaii International Conference on System Sciences*.

Chaturvedi, A. R., Dolk, D. R., & Drnevich, P. L. (2011). Design principles for virtual worlds. *MIS Quarterly*, *35*(3), 673-684.

Cole-Lewis, H., Ezeanochie, N., & Turgiss, J. (2019). Understanding health behavior technology engagement: Pathway to measuring digital behavior change interventions. *JMIR Formative Research*, *3*(4), 1-10.

Corbin, J., & Strauss, A. (1990). Grounded theory research: Procedures, canons, and evaluative criteria. *Qualitative Sociology*, *13*, 3-21.

Creed, C., & Beale, R. (2012). User interactions with an affective nutritional coach. *Interacting with Computers*, *24*(5), 339-350.

Christensen, H., Griffiths, K. M., & Farrer, L. (2009). Adherence in internet interventions for anxiety and depression: systematic review. *Journal of Medical Internet Research*, *11*(2), 1-16.

Cugelman, B., Thelwall, M., & Dawes, P. (2011). Online interventions for social marketing health behavior change campaigns: a meta-analysis of psychological architectures and adherence factors. *Journal of Medical Internet Research*, *13*(1).

Easton, C. J., Berbary, C. M., & Crane, C. A. (2018). Avatar and technology assisted platforms in the treatment of co-occurring addiction and IPV among male offenders. *Advances in Dual Diagnosis*, *11*, 126-134.

Fox, J., & Bailenson, J. N. (2009). Virtual self-modeling: The effects of vicarious reinforcement and identification on exercise behaviors. *Media Psychology*, *12*(1), 1-25.

Frost, J., Boukris, N., & Roelofsma, P. (2012). We like to move it move it! motivation and parasocial interaction. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems.*

Gamage, V., & Ennis, C. (2018). Examining the effects of a virtual character on learning and engagement in serious games. In *Proceedings of the 11th ACM SIGGRAPH Conference on Motion, Interaction and Games*.

Golrang, H., & Safari, E. (2021). Applying gamification design to a donation-based crowdfunding platform for improving user engagement. *Entertainment Computing*, *38*, 1-8.

Grady, A., Pearson, N., Lamont, H., Leigh, L., Wolfenden, L., Barnes, C., Wyse, R., Finch, M., Mclaughlin, M., Delaney, T., Sutherland, R., Hodder, R., & Yoong, S. L. (2023). The effectiveness of strategies to improve user engagement with digital health interventions targeting nutrition, physical activity, and overweight and obesity: Systematic review and meta-analysis. *Journal of Medical Internet Research*, *25*.

Grady, A., Yoong, S., Sutherland, R., Lee, H., Nathan, N., & Wolfenden, L. (2018). Improving the public health impact of eHealth and mHealth interventions. *Australian and New Zealand Journal of Public Health*, *42*(2), 119-119.

Gregor, S. (2006). The nature of theory in information systems. *MIS Quarterly*, *30*(3), 611-642.

Gregor, S., Chandra Kruse, L., & Seidel, S. (2020). The anatomy of a design principle. *Journal of Association for Information Systems*, *21*(6), 1622-1652.

Gregor, S., & Hevner, A. R. (2013). Positioning and presenting design science research for maximum impact. *MIS Quarterly*, *37*(2), 337-355.

Jones, D., & Gregor, S. (2007). The anatomy of a design theory. *Journal of the Association for Information Systems*, *8*(5), 313-335.

Gurzick, D., & Lutters, W. G. (2009). Towards a design theory for online communities. In *Proceedings of the 4th International Conference on Design Science Research in Information Systems and Technology*.

Heinrich, P., & Schwabe, G. (2014). Communicating nascent design theories on innovative information systems through multi-grounded design principles. *In Proceedings of the 9th International Conference on Design Science Research in Information Systems and Technology.*

Hansen, M. R. P., & Haj-Bolouri, A. (2020). Design principles exposition: A framework for problematizing knowledge and practice in DSR. In *Proceedings of the 15th International Conference on Design Science Research in Information Systems and Technology.*

Henry, B. M., Skinningsrud, B., Vikse, J., Pękala, P. A., Walocha, J. A., Loukas, M., Tubbs, R. S., & Tomaszewski, K. A. (2018). Systematic reviews versus narrative reviews in clinical anatomy: Methodological approaches in the era of evidence-based anatomy. *Clinical Anatomy*, *31*(3), 364-367.

Hevner, A. R., March, S. T., Park, J., & Ram, S. (2004). Design science in information systems research. *MIS Quarterly*, *28*(1), 75-105.

Horne, M., Hill, A., Murells, T., Ugail, H., Chinnadorai, R., & Hardy, M. (2020). Using avatars in weight management settings: A systematic review. *Internet Interventions*, *19*, 1-17.

Hutton, H. E., Wilson, L. M., Apelberg, B. J., Tang, E. A., Odelola, O., Bass, E. B., & Chander, G. (2011). A systematic review of randomized controlled trials: Web-based interventions for smoking cessation among adolescents, college students, and adults. *Nicotine & Tobacco Research*, *13*(4), 227-238.

Jung, S., Lee, D., You, S., Biocca, F., & Kum-Biocca, H. (2022). The role of the self-presence for interactive large digital displays: Gesture interactivity and mirrored-selfimage for advertising content. *International Journal of Human-Computer Interaction*, *38*(16), 1576-1588.

Karahanna, E., Xu, S. X., Xu, Y., Andy, & Harbin. (2018). The needs-affordances-features perspective for the use of social media. *MIS Quarterly*, *42*(3), 737-756.

Kastenmüller, A., Greitemeyer, T., Fairclough, S., Waite, D., & Fischer, P. (2013). Playing exergames and sporting activity: The impact of identification with one's game character. *Social Psychology*, *44*(4), 264-270.

Kelders, S. M., Kok, R. N., Ossebaard, H. C., & Van Gemert-Pijnen, J. E. (2012). Persuasive system design does matter: a systematic review of adherence to web-based interventions. *Journal of Medical Internet Research*, *14*(6), 1-24.

Kim, Y., & Sunder, S. (2012). Visualizing ideal self vs. actual self through avatars: Impact on preventive health outcomes. *Computers in Human Behavior*, *28*(4), 1356-1364.

Knoblock-Hahn, A. L., & LeRouge, C. M. (2014). A qualitative, exploratory study of predominantly female parental perceptions of consumer health technology use by their overweight and/or obese female adolescent participating in a fee-based 4-week weight-management intervention. *Journal of the Academy of Nutrition and Dietetics*, *114*(4), 570-577.

Knoblock-Hahn, A. L., Wray, R., & LeRouge, C. M. (2016). Perceptions of adolescents with overweight and obesity for the development of user-centered design self-management tools within the context of the chronic care model: a qualitative study. *Journal of the Academy of Nutrition and Dietetics*, *116*(6), 957-967.

Lee, S. Y. (2014). Examining the factors that influence early adopters' smartphone adoption: The case of college students. *Telematics and Informatics*, *31*, 308-318.

LeRouge, C., Dickhut, K., Lisetti, C., Sangameswaran, S., & Malasanos, T. (2016). Engaging adolescents in a computer-based weight management program: Avatars and virtual coaches could help. *Journal of the American Medical Informatics Association*, *23*(1), 19-28.

LeRouge, C., Durneva, P., Sangameswaran, S., & Gloster, A. M. (2019). Design guidelines for a technology-enabled nutrition education program to support overweight and obese adolescents: Qualitative user-centered design study. *Journal of Medical Internet Research*, *21*(7), 1-18.

Li, B. J., Lwin, M. O., & Jung, Y. (2014). Wii, myself, and size: The influence of proteus effect and stereotype threat on overweight children's exercise motivation and behavior in exergames. *Games for Health Journal*, *3*(1), 40-48.

Lidwell, W., Holden, K., & Butler, J. (2010). *Universal principles of design, revised and updated: 125 ways to enhance usability, influence perception, increase appeal, make better design decisions, and teach through design*. Rockport Pub.

Lisetti, C., Amini, R., & Yasavur, U. (2015). Now all together: Overview of virtual health assistants emulating face-to-face health interview experience. *Künstliche Intelligenz*, *29*(2), 161-172.

Lisetti, C., Amini, R., Yasavur, U., & Rishe, N. (2013). I can help you change! An empathic virtual agent delivers behavior change health interventions. *ACM Transactions on Management Information Systems, 4*(4), 1-28.

Localytics. (2017). *24% of users abandon an app after one use*. Retrieved from http://info.localytics.com/blog/24-of-users-abandon-an-app-after-one-use

Lozano, P., & Houtrow, A. (2018). Supporting self-management in children and adolescents with complex chronic conditions. *Pediatrics*, *141*(S3), S233-S241.

Malhotra, A., Hoey, J., König, A., & van Vuuren, S. (2016). A study of elderly people's emotional understanding of prompts given by virtual humans. In *Proceedings of the 10th EAI International Conference on Pervasive Computing Technologies for Healthcare*.

Mann, E. G., LeFort, S., & VanDenKerkhof, E. G. (2013). Self-management interventions for chronic pain. *Pain Management*, *3*(3), 211-222.

Marsh, J. P., Gorayska, B., & Mey, J. L. (Eds.). (1999). *Humane interfaces: Questions of method and practice in cognitive technology*. Elsevier.

Matavire, R., & Brown, I. (2013). Profiling grounded theory approaches in information systems research. *European Journal of Information Systems*, *22*(1), 119-129.

Mathews, S. C., McShea, M. J., Hanley, C. L., Ravitz, A., Labrique, A. B., & Cohen, A. B. (2019). Digital health: A path to validation. *npj digital Medicine*, *2*, 1-9.

McClure, J. B., Shortreed, S. M., Bogart, A., Derry, H., Riggs, K., St John, J., Nair, V., & An, L. (2013). The effect of program design on engagement with an Internet-based smoking intervention: Randomized factorial trial. *Journal of Medical Internet Research*, *15*(3), 88-100.

Mitchell, S., Bragg, A., Gardiner, P., De La Cruz, B., & Laird, L. (2022). Patient engagement and presence in a virtual world world diabetes self-management education intervention for minority women. *Patient Education and Counseling*, *105*(4), 797-804.

Nam, Y. H., & Park, J. Y. (2009). The understanding of avatar design: Various types and styles of avatars and the design. *Journal of The Korea Society of Illustration*, *18*(2009), 91-102.

Navarro, J., Cebolla, A., Llorens, R., Borrego, A., & Baños, R. M. (2020). Manipulating self-avatar body dimensions in virtual worlds to complement an internet-delivered intervention to increase physical activity in overweight women. *International Journal of Environmental Research and Public Health*, *17*(11).

Neil, A., Batterham, P., Christensen, H., Bennett, K., & Griffiths, K. (2009). Predictors of adherence by adolescents to a cognitive behavior therapy website in school and community-based settings. *Journal of Medical Internet Research*, *11*(1).

Nielsen, P., & Sahay, S. (2022). A critical review of the role of technology and context in digital health research. *Digital Health*, 8, 1-10.

Norman, D. A. (1988). *The psychology of everyday things.* Basic Books.

Norman, D. A. (1999). Affordance, conventions, and design. *Interactions*, *6*(3), 38-42.

Norman, D. A. (2004). *Emotional design: Why we love (or hate) everyday things*. Basic Books.

Norman, D. A., Ortony, A., & Russell, D. M. (2003). Affect and machine design: Lessons for the development of autonomous machines. *IBM Systems Journal*, *42*(1), 38-44.

Nowak, K. L., & Fox, J. (2018). Avatars and computer-mediated communication: A review of the definitions, uses, and effects of digital representations. *Review of Communication Research*, *6*, 30-53.

Pan, S. L., Li, M., Pee, L. G., & Sandeep, M. S. (2021). Sustainability design principles for a wildlife management analytics system: An action design research. *European Journal of Information Systems*, *30*(4), 452-473.

Peña, J., Khan, S., & Alexopoulos, C. (2016). I am what I see: How avatar and opponent agent body size affects physical activity among men playing exergames. *Journal of Computer-Mediated Communication*, *21*(3), 195-209.

Peña, J., & Kim, E. (2014). Increasing exergame physical activity through self and opponent avatar appearance. *Computers in Human Behavior*, *41*, 262-267.

Piryankova, I. V., Stefanucci, J. K., Romero, J., De La Rosa, S., Black, M. J., & Mohler, B. J. (2014). Can I recognize my body's weight? The influence of shape and texture on the perception of self. *ACM Transactions on Applied Perception*, *11*(3), 1-18.

Ratan, R. (2013). Self-presence, explicated: Body, emotion, and identity extension into the virtual self. In R. Luppicini (Ed.), *Handbook of research on technoself: Identity in a technological society* (pp. 322-336). IGI Global.

Ratan, R., Beyea, D., Li, B. J., & Graciano, L. (2020). Avatar characteristics induce users' behavioral conformity with small-to-medium effect sizes: A meta-analysis of the proteus effect. *Media Psychology*, *23*(5), 651-675.

Ratan, R. A., & Hasler, B. (2009). Self-presence standardized: Introducing the self-presence questionnaire (SPQ). In *Proceedings of the 12th Annual International Workshop on Presence*.

Rheu, M., Jang, Y., & Peng, W. (2020). Enhancing healthy behaviors through virtual self: A systematic review of health interventions using avatars. *Games for Health Journal*, *9*(2), 85-94.

Riva, G., Waterworth, J. A., & Waterworth, E. L. (2004). The layers of presence: A bio-cultural approach to understanding presence in natural and mediated environments. *CyberPsychology & Behavior*, *7*(4), 402-416.

Robertson, S., Solomon, R., Riedl, M., Gillespie, T. W., Chociemski, T., Master, V., & Mohan, A. (2015). The visual design and implementation of an embodied conversational agent in a shared decision-making context (eCoach). In *Proceedings of the Second International Conference on Learning and Collaboration Technologies.*

Saldaña, J. (2009). *The coding manual for qualitative researchers*. Sage.

Salkind, N. (2007). *Encyclopedia of measurement and statistics*. Sage.

Sawyer, S. M., & Aroni, R. A. (2005). Self-management in adolescents with chronic illness. What does it mean and how can it be achieved? *Medical Journal of Australia*, *183*(8), 405-409.

Seidel, S., Chandra Kruse, L., Székely, N., Gau, M., & Stieger, D. (2018). Design principles for sensemaking support systems in environmental sustainability transformations. *European Journal of Information Systems*, *27*(2), 221-247.

Sein, M. K., Henfridsson, O., Purao, S., Rossi, M., & Lindgren, R. (2011). Action design research. *MIS Quarterly*,35(1), 37-56.

Song, H., Kim, J., & Lee, K. M. (2014). Virtual vs. real body in exergames: Reducing social physique anxiety in exercise experiences. *Computers in Human Behavior*, *36*, 282-285.

Shin, D. H. (2017). The role of affordance in the experience of virtual reality learning: Technological and affective affordances in virtual reality. *Telematics and Informatics*, *34*(8), 1826-1836.

Stratton, S. J. (2019). Literature reviews: methods and applications. *Prehospital and Disaster Medicine*, *34*(4), 347-349.

Taylor, L. D. (2011). Avatars and emotional engagement in asynchronous online communication. *Cyberpsychology, Behavior, and Social Networking*, *14*(4), 207-212.

Tielman, M., Neerincx, M., van Meggelen, M., Franken, I., & Brinkman, W. (2017). How should a virtual agent present psychoeducation? Influence of verbal and textual presentation on adherence. *Technology and Health Care*, *25*(6), 1081-1096.

Utter, J., Larson, N., Laska, M. N., Winkler, M., & Neumark-Sztainer, D. (2018). Self-perceived cooking skills in emerging adulthood predict better dietary behaviors and intake 10 years later: A longitudinal study. *Journal of Nutrition Education & Behavior*, *50*(5), 494-500.

van Vugt, H. C., Konijn, E. A., Hoorn, J. F., & Veldhuis, J. (2006). Why fat interface characters are better e-health advisors. In *Proceedings of the 6th International Conference on Intelligent Virtual Agents,*

Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. *MIS Quarterly*, *27*(3), 425-478.

Wieringa, R. J. (2014). *Design science methodology for information systems and software engineering*. Springer.

Winkler, A., Kutschar, P., Pitzer, S., van der Zee-Neuen, A., Kerner, S., Osterbrink, J., & Krutter, S. (2023). Avatar and virtual agent-assisted telecare for patients in their homes: A scoping review. *Journal of Telemedicine and Telecare*.

Wolff, A., Wermelinger, M., & Petre, M. (2019). Exploring design principles for data literacy activities to support children's inquiries from complex data. *International Journal of Human-Computer Studies*, *129*, 41-54.

Xiong, S., Berkhouse, H., Schooler, M., Pu, W., Sun, A., Gong, E., & Yan, L. L. (2018). Effectiveness of mHealth interventions in improving medication adherence among people with hypertension: A systematic review. *Current Hypertension Reports*, *20*, 1-15.

Yee, N., & Bailenson, J. (2007). The Proteus effect: The effect of transformed self-representation on behavior. *Human Communication Research*, *33*(3), 271-290.

De Zwart, M., & Lindsay, D. (2012). My self, my avatar, my rights? Avatar identity in social virtual worlds. In D. Riha (Ed.), *Frontiers of cyberspace* (pp. 81-100). Rodopi.

Appendix A: Evidence Trace Table

Table A1. Evidence Trace Table

Example quotes →	Open codes →	Theme
"I do like it, so it can show you what you like, with the measurement goals to show you how big your hips are or how tall you are." *"If you weighed 250 this day, and then a week or a month later you weigh 220, and you see your progress, the avatar responds to your progress by getting skinnier as you do."*	Anthropometric measurements	Proto self-presence
"It [virtual character] could read to you so you can talk to it, and it can read out loud to you." *"Maybe it [virtual character] can communicate with you, it asks you something, it can playback, and you can have a conversation about it."*	Communication	
"Maybe you could have a couple of games available or something for them to play or maybe with the whole avatar. If you exercise, then you could make the avatar exercise." *"And that person [virtual character] is doing the cooking and the clean-up, so it shows you a little bit how to do this in a certain way that you're supposed to do it."*	Body movements	
"Happy, never really angry, but it [virtual character] can become mad a little bit, you know? If you're not doing it for more than a week, it could become angry?" *"Anxious and worry, if you are not stepping it up on the game, have them [virtual characters] be like, oh no, you are losing or something like that."*	Facial expressions	Core self-presence
"It [virtual character] would encourage you to eat better things." *"If they [virtual characters] motivate you, then yeah, or you say, if you have a goal and then they say things to motivate you, then yes."*	Motivational content	
"Maybe you can put facial hair, and you can kind of like the Wii." *"You can make it [virtual character] look like you if you like. So, I think that if you could actually get clothing to put on your guy, and accessories and all of that, I think it would also make it more interesting to people."*	Appearance	Extended self-presence
"I like a buddy alongside - with you as you go, it feels like it changes with you, it's sort of a buddy and then is also a teacher […]." *"[The virtual character] can be like, 'How are you doing today?' and then on the score from 1 to 10, it can be like, 'Are you doing fine?' I'm doing bad. 'Why are you doing bad? What are you feeling?' And then it could just, again, be kind of motivational and just keep you going."*	Friend and coach	

Appendix B: Descriptive Statistics for Figure 2 and Figure 3

Table B1. Descriptive Statistics for Figure 2 (Cartoon-Me) (N = 14)

Category/response	1 (n, %)	2 (n, %)	3 (n, %)	4 (n, %)	5 (n, %)	Mean	Standard deviation
Don't Like/like	0 (0%)	0 (0%)	2 (14.3%)	5 (35.7%)	7 (50%)	4.36	0.75
Ugly/visually attractive	0 (0%)	1 (7.1%)	1 (7.1%)	6 (42.9%)	6 (42.9%)	4.21	0.89
Missing accessories/has accessories	0 (0%)	0 (0%)	0 (0%)	5 (35.7%)	9 (64.3%)	4.64	0.5
Colors not right/colors right	0 (0%)	1 (7.1%)	0 (0%)	4 (28.6%)	9 (64.3%)	4.50	0.86
Boring/fun	0 (0%)	1 (7.1%)	2 (14.3%)	5 (35.7%)	6 (42.9%)	4.14	0.95
Not sensitive/sensitive	0 (0%)	1 (7.1%)	1 (7.1%)	5 (35.7%)	7 (50%)	4.29	0.91
Not helpful/helpful	0 (0%)	0 (0%)	1 (7.1%)	6 (42.9%)	7 (50%)	4.43	0.65
Not motivate/motivate	0 (0%)	1 (7.1%)	3 (21.4%)	4 (28.6%)	6 (42.9%)	4.07	1

Table B2. Descriptive Statistics for Figure 3 (Semi-real Professional) (N = 14)

Category/response	1 (n, %)	2 (n, %)	3 (n, %)	4 (n, %)	5 (n, %)	Mean	Standard deviation
Don't like/like	1 (7.1%)	3 (21.4%)	2 (14.3%)	2 (14.3%)	6 (42.9%)	3.64	1.45
Ugly/visually attractive	1 (7.1%)	0 (0%)	5 (35.7%)	3 (21.4%)	5 (35.7%)	3.79	1.89
Missing accessories/has accessories	3 (21.4%)	0 (0%)	2 (14.3%)	2 (14.3%)	7 (50%)	3.71	1.64
Colors not right/colors right	2 (14.3%)	1 (7.1%)	3 (21.4%)	3 (21.4%)	5 (35.7%)	3.57	1.45
Boring/fun	3 (21.4%)	2 (14.3%)	3 (21.4%)	1 (7.1%)	5 (35.7%)	3.21	1.63
Not sensitive/sensitive	1 (7.1%)	1 (7.1%)	3 (21.4%)	3 (21.4%)	6 (42.9%)	3.86	1.29
Not helpful/helpful	1 (7.1%)	1 (7.1%)	3 (21.4%)	2 (14.3%)	7 (50%)	3.93	1.33
Not motivate/motivate	1 (7.1%)	1 (7.1%)	2 (14.3%)	4 (28.6%)	6 (42.9%)	3.93	1.27

About the Authors

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Cynthia LeRouge is an Affiliate Professor in the Schools of Medicine and Public Health at the University of Washington. She recently retired as professor and Ryder Eminent Scholar Chair in MIS at the School of Business at Florida International University. Cynthia LeRouge has specialized in the study of health information systems/health informatics for over 23 years, particularly in the areas of telemedicine, consumer health informatics, and public health informatics. Projects she pursues explore the design, implementation, and evaluation of information technology artifacts and process models in healthcare practice. Cynthia LeRouge has authored over 125 peer-reviewed publications. She served as the first public health informatics visiting scholar at the Centers for Disease Control. She has held multiple leadership roles in industry prior to her academic career and positions of leadership with the American Telemedicine Association Business and Finance SIG and served as founding Co-editor-in-chief of Health Systems Journal.

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