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How virtual avatar experience interplays with self-concepts: the use of anthropometric 3D body models in the visual stimulation process

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Abstract

We explored how viewing one's anthropometric virtual avatar would affect the viewer's self-body perception through the comparative evaluation of self-concepts—self-esteem and self-compassion, within the framework of allocentric lock theory. We recruited 18 female adults, aged 18–21, who identified themselves to have some level of body image concerns, and who had had no clinical treatment for their body image. Participants were randomly assigned either to the experimental or control group. The experimental group participated in both body positivity program and virtual avatar program, whereas the control group attended the body positivity program, only. The results affirmed that the body positivity program served as a psychological buffer prior to the virtual avatar stimulus. After the virtual avatar experience, the participants demonstrated self-acceptance by lowering their expectation on how they should look like. The findings from exit interviews enriched the quantitative results. This study verified the mechanism of the altered processing of the stored bodily memory by the egocentric sensory input of virtual avatars, and offered practical potential of the study outcomes to be applied in various emerging fields where novel applications of virtual 3D technology are sought, such as fashion e-commerce.

Keywords: Virtual avatar, 3D body scanning, Allocentric lock theory, Body perception, Self-esteem, Self-compassion

Introduction

The construct of body image involves an intricate composite of multiple attributes of the self as it is embedded in both the personal and sociocultural milieu (Cash & Pruzinsky, 1990). As we know, body image is not only associated with one's physical body size and shape, but also with one's self-perceptions in relation to the body (Cash, 2004). Further, it correlates with one's self-concepts such as self-esteem and self-compassion. Although they often are considered interchangeable (Leary et al. 2007; Neff & Vonk, 2009), self-esteem and self-compassion must be considered as distinct constructs. For instance, unlike self-compassion, self-esteem is linked to narcissism. And, in contrast

to self-esteem, self-compassion is correlated with stability in self-worth (Neff & Vonk, 2009). Importantly, self-esteem also has been shown to be readily impacted by adverse events, moving people to modify their views of themselves when negative events occur. Conversely, self-compassion appears to protect people from the impacts of these sorts of negative events (Neff & Vonk, 2009). Additionally, as compared to self-esteem, self-compassion has a stronger negative relationship with factors such as social comparison, anger, and self-consciousness (Leary et al. 2007; Neff & Vonk, 2009), thus it is less prone to be affected by such adverse psychosocial attributes.

In the virtual world, an avatar represents one's body. Although we know relatively well the factors that influence a person's body image in the real world, we are still discovering the mechanisms associated with the construct of body image in virtual space. In previous studies that investigated self-body perceptions and their associated behaviors in virtual space (e.g., Kuo et al. 2016; Serino et al. 2016), computer-generated imagery (CGI) has been used in creating virtual avatars. However, as we understand, the CGI-based virtual avatar is an artificially manipulated body form that mimics the visual imagery of a person's physical appearance. Hence, researchers (e.g., Park, 2018) have recognized critical limitations of the avatar creation process using the CGI, especially when using such avatars in body image research where an accurate representation of the body is necessary. Given this realization, there seems to be a recent trend in using a virtual avatar based on one's actual body dimensions collected from a digital anthropometric tool such as three-dimensional (3D) body scanning (Cornelissen et al. 2017; Mölbert et al. 2018; Park, 2017, 2018). Three-dimensional body scanning technology is an innovative anthropometric tool that creates a 3D body surface model based on highly accurate body measurement data using non-invasive depth sensors (Loker et al. 2004). The recent add-on of virtual reality to 3D body scanning allows the creation of virtual avatars based on one's own body anthropometric data that offers new possibilities for the technology. Despite 3D body scanning technology's practical benefits and its broad applications in the e-commerce and entertainment industries, the adoption of the 3D technology has been limited in the domain of clinical health research particularly associated with body image complications. Moreover, the impacts of using such anthropometrically-correct virtual avatars in clinical settings have been little investigated in current literature. Hereby, we claim that it is important to present virtual avatars in clinical experiments, reflecting the accurate representation of one's body, when these avatars are used as visual stimulus in studies particularly concerning body image and its associated health outcomes.

Given this context, this study aimed to explore how viewing one's virtual avatar that was simulated based on a person's actual body dimensional information (referred to as the "virtual avatar experience" in this study) would affect the viewer's self-body perception through the comparative evaluation of the two self-concept measures—self-esteem versus self-compassion. Particularly we examined the bodily experience phenomena within the frame of the allocentric lock theory by defining the virtual avatar experience as an egocentric sensory input (i.e., the first-person experience). We then assessed changes in the self-body perception and self-concepts to measure whether the viewer's allocentric representation of the body is unlocked. The theoretical perspective is further explained in the literature review of the paper. We performed this experimental study in young female adults, who are one of the most vulnerable populations to body-related

complications such as eating problems (Kotler et al. 2001) and body dissatisfaction (Bucchianeri et al. 2013).

Literature review

Theoretical framework

Riva and colleagues (e.g., Riva, 2011, 2012; Riva & Gaudio, 2018) explained the function of virtual bodies within the frame of *allocentric lock theory*, which has its fundamental premises rooted in psychology and neuroscience. According to Riva (2012), our spatial experience, including the bodily one, is formed on the basis of the two different sensory inputs – egocentric and allocentric. *Egocentric* sensory input, described as a source for the first-person experience, provides primary information to configure representations of the present state of the body (including sensory tactile stimuli), whereas *allocentric* sensory input has its primary source in one's abstract knowledge, beliefs, and attitudes related to body as an object of the third-person experience. Both sensory inputs interact during the long- and short-term memory processing. However, at times, this process could be impaired either by internal (e.g., stress) or external causes (e.g., teasing or negative comments from others). In such cases, the stored allocentric representation of the body is locked because the egocentric inputs are no longer able to update the contents of one's body perception (Riva, 2011, 2012). Recently, several interesting studies have adopted this theoretical concept in empirical research in virtual contexts and confirmed its effect in modifying the enduring memory of the body (Beckmann et al. 2020; Lander et al. 2020; Riva & Gaudio, 2018; Serino et al. 2016). Specifically, Riva et al. (2018) affirmed that the virtual body approach can increase the contribution of new egocentric/internal somatosensory information directly to the existing allocentric memory, thus unlocking one's stored body memory.

Self-esteem and body image

Self-esteem has been conceptualized as one's overall appraisal or evaluation of the self (Rosenberg, 1965) as well as "...the degree to which the self is judged to be competent in life domains deemed important," (James, 1983; Neff & Vonk, 2009, p. 24). As Cooley (1902/1983) reminds us, self-esteem develops not only from one's own evaluations of the self, but also from perceptions of others' evaluations of the self. Self-esteem has been associated with women's body image; a number of studies have firmly established a relationship between women's body dissatisfaction and their self-esteem, such that higher dissatisfaction with the body is associated with lower self-esteem (e.g., Cash & Fleming, 2002; Cooley & Toray, 2001; Stice, 2002; Stice & Whitenton, 2002). Conversely, women with higher levels of self-esteem have been found to appraise their bodies more positively (e.g., Connors & Casey, 2006; Paxton et al. 2006; Swami et al. 2009; Tiggemann, 2005).

In addition to supporting positive body image, high self-esteem has been related to other positive personal attributes, such as happiness (Lucas et al. 1996), pleasant feelings, initiative, resilience, persistence, and willingness to experiment (Baumeister et al. 2003). High self-esteem also has been associated with negative personal outcomes—such as distortion in self-knowledge and heightened aggression—in part, because it is dependent on the realization of external standards and positive comparisons with others

(Neff, 2009). However, researchers have proposed that a “healthy perspective” on the self should not be reliant upon an evaluation of one’s self-worth relative to others (e.g., Aspinwall & Taylor, 1993; Neff, 2003a). In this vein, Neff and colleagues have argued that developing a positive sense of self-worth tied to the view that one is “better than others” is tenuous inasmuch as only a limited number of people can distinguish themselves or come to “feel good” about themselves by being “exceptional” (Neff, 2003a, 2011; Neff & Vonk, 2009). Leary (1999) has proposed that people often invoke self-esteem as a means by which to monitor others’ evaluations of them; if people perceive that they are failing to meet standards held by others/prescribed by society, self-esteem diminishes. If people perceive that standards are met, self-esteem is protected. According to Leary’s formulation, then, self-esteem—and an attendant sense of self-worth—are sometimes established by meeting external standards. Indeed, this reliance on evaluation of the self as a conduit to achieve a sense of self-worth may be a slippery slope for many women relative to issues of appearance and the body, especially in contemporary Western culture contexts, where women’s appearances are highly valued and where women may be motivated to evaluate the self in comparison to others or to an unrealistic, external beauty standard (Myers & Crowther, 2009; Wasylkiw et al. 2012).

Self-compassion and body image

Neff (2003a, 2003b) developed the concept of “self-compassion” as an alternative way to think about the possibility of adopting a healthy perspective on the self in which self-worth is not dependent upon comparisons of one’s performance in relation to others. Self-compassion is a psychological concept based on the ideology of showing oneself the same levels of compassion, empathy, and understanding shown to another (Neff, 2003a). Neff (2003a) identified three pillars of self-compassion: (a) showing the self kindness in lieu of judgment; (b) practicing mindfulness to balance negative self-feelings; and (c) understanding that everyone is human and judging one’s own lived experiences as part of the human condition. When people who are compassionate toward the self recognize that they are “falling short” on a target, they demonstrate self-acceptance rather than being critical of the self. Further, they are likely to be accepting of that which they cannot change in the self and try to change that which they can (Leary et al. 2007).

There is evidence to suggest that showing compassion toward the self may foster positive body-related experiences or buffer against poor body image (see Braun et al. 2016 for a review), with an inverse relationship between levels of self-compassion and feelings of body dissatisfaction (Braun et al. 2016; Kelly et al. 2014). Women who demonstrate compassion toward the self are more likely to accept their bodies in spite of misgivings, to hold positive attitudes toward their bodies, and to question narrow media ideals (Wood-Barcalow et al. 2010). Neff and Vonk (2009) also discovered that, in comparison to self-esteem, self-compassion predicted self-worth that was less tied to evaluations of physical appearance. Further in their exploration of the relationships among women’s self-compassion, motives to exercise, and exercise-related outcomes, Magnus et al. (2010) found that self-compassion accounted for differences in feelings of external judgment, a need to conform to body norms, and social anxiety in a way that self-esteem did not. The researchers also discovered that women with high levels of self-compassion were less likely to feel pressured to obtain a specific body ideal and to experience

physique anxiety, possibly owing to the fact that self-compassion provides a stable method for caring about the self that is not reliant on the opinions of others. As Magnus et al. (2010) observed, “what self-compassion potentially offers is a sense of self-worth not based on beauty standards or performance evaluations” (p. 375).

Virtual reality and body image

Body image disturbances are a result of the perceptual distortion of body and body dissatisfaction (Cash & Brown, 1987; Cash & Deagle, 1997). Body image distortion is often caused by visual size misestimation as compared to the body’s actual presence (over- or under-estimation), and body dissatisfaction is measured by the discrepancy between one’s perceived body and ideal-ought body usually based on questionnaires or figural ratings (Park, 2017, 2018). In their review on the use of virtual reality (VR) for psychological (phobia) treatment, Ferrer-García and Gutiérrez-Maldonado (2012) identified two key practical advantages of using VR in clinical research namely (a) that VR allows for the development and reproduction of 3D figures as desired and (b) that VR provides a secure, flexible, and controlled environment that offers real-live simulated situations related to psychological, clinical complications of concern. The authors asserted that although VR-based therapy is usually more effective than no treatment, the relative advantage of VR has not been confirmed yet as compared to that of cognitive behavioral therapy (CBT), suggesting a need for further research performed under controlled design with clinical samples.

Given that body image is a malleable rather than a fixed trait (Slade & Brodie, 1994), it can be affected by situational or emotional variables (Cash et al. 2002). As such, the adoption of VR has been explored in a limited number of previous clinical research as a stimulus tool for the treatment of body image disturbances. For example, Ferrer-García et al. (2010) explored the effect of VR as a means to influence the instability of body image disturbances in eating disorder patients. They used the virtual technology in their research, because unlike other conventional approaches it exposes subjects to interactive 3D environments that simulate real situations yet offering them a controllable maneuver, which likely induces emotional responses in virtual contexts, similar to the effects experienced in in vivo situations (Opriş et al. 2011; Powers & Emmelkamp, 2008). That is, body-image distortion and body-image dissatisfaction were assessed in eating disorder (ED) patients under the four experimental virtual environments: a kitchen with low-calorie food, a kitchen with high-calorie food, a restaurant with low-calorie food, and a restaurant with high-calorie food. Findings revealed that ED patients showed significantly higher levels of body-image distortion and body satisfaction after eating high-calorie food than after eating low-calorie food in virtual contexts, compared to the control group (i.e., non-ED patients) who exhibited no difference across all situations. Further, in his recent book, *Virtual Reality in Clinical Psychology*, Riva (2020) introduced VR as an embodied technology that facilitates the experience of the body by providing a new way to examine and analyze the body beyond real-world behaviors. Although VR has been widely adopted in clinical applications, the realistic presentation of VR avatars based on anthropometric data is almost non-existent, despite of its importance in understanding body image distortion and dissatisfaction. We speculate that this is primarily due to the current technical limitations of virtual 3D technology and the lack of previous attention

to technology in body image research, which lends a strong justification for the present work as a timely endeavor adopting and evaluating the clinical potential of the virtual 3D tool in the domain of body image.

Method

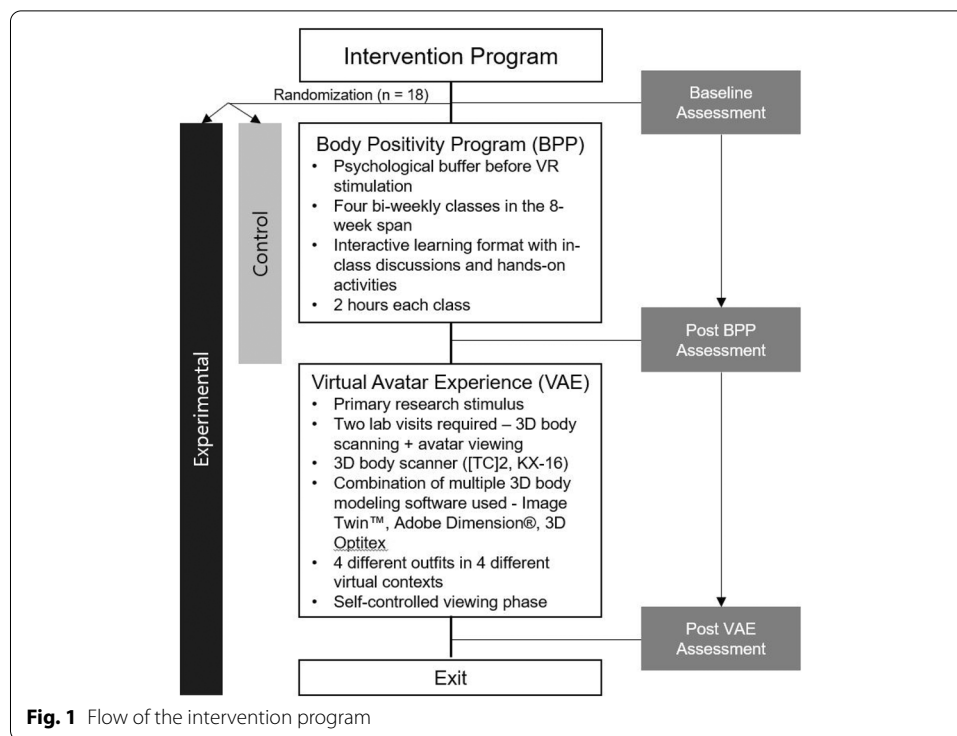
Procedures

Using the massive emailing system of a participating public 4-year university in the United States, we recruited eighteen female adults ($N=18$) who were in the age range of 18–21 (representing those in the transition stage from late adolescence to young adulthood), who identified themselves to have some level of body image concerns, and who had had no clinical treatment for their body image disturbance and its associated medical complications. The intervention program that we developed for this experimental study consisted of the two main components, including the body positivity program and the virtual avatar experience program. We developed the body positivity program as a psychological buffer prior to the virtual avatar experience, in response to Wood-Barcalow et al. (2010) who suggested researchers and clinicians offer a foundation for positive body image before exposing study participants to interventive stimulus.

Each participant was randomly assigned to one of the study groups (control vs. experiment). The experimental group ($N=9$) participated in both body positivity program and virtual avatar program, whereas the control group ($N=9$) attended the body positivity program, only. However, participants were not informed which group they were assigned to. Before participating in the intervention program, all participants were informed of the research procedures and the voluntary nature of the study participation. Once they agreed and signed the consent, they were invited to join the program (IRB No. 17-7412H). The program and related data collection took place in the spring of 2018. The overview of the research procedures is illustrated in Fig. 1.

The body positivity program was designed to help the participants (a) appreciate an inclusive conceptualization of beauty, (b) develop media literacy skills, (c) develop self-esteem and skills to proactively cope with or filter negative body image information, and (d) create messages of body acceptance and self-compassion. We delivered the body positivity program through the four bi-weekly classes and utilized in-class discussions and hands-on activities in an interactive learning environment. Therefore, the body positivity program was operated for the span of 8 weeks. Each class took approximately 2 h, and at least two researchers were present during a class period to facilitate active engagement of the participants and answer to any questions that the participants might have during the interactive activities. Further details of the body positivity program are described in Ogle et al. (2019).

Once the body positivity program was complete, participants who were assigned to the experimental group were scheduled to visit the research lab where a 3D body scanner ([TC]2, KX-16) was located. Each participant in the experimental group visited the lab twice. During the first lab visit, we collected each participant's anthropometric data using 3D body scanning. During the second lab visit, we created each participant's own virtual avatar based on the 3D body scan data collected from the first visit. In creating virtual avatars, we adopted a combination of multiple 3D body modeling software,

**Table 1** Virtual outfit and context combinations for virtual avatar stimulus

Avatar	Virtual outfit	Virtual context
1	Casual top and jeans	University campus
2	Round neck top and basic skirt	Office
3	Black cocktail dress	Boutique
4	One-piece swimsuit	Beach

including Image Twin™ and Adobe Dimension®. We then used 3D Optitex to virtually engineer 3D garment patterns to clothe the avatar body models in four different outfits.

We then developed the stimulus materials for the virtual avatar experience program by situating the clothed avatars in four representative contextual backgrounds, which included the university campus, the office, the retail boutique, and the beach (Table 1). Previous researchers (e.g., Shafran et al. 2007) have asserted that during body checking, people, especially those with unhealthy body image, tend to examine their body with a particular focus on the problem areas of concern, which can further evoke adverse feelings about their body (Park, 2017). Therefore, to lessen the participants' personal attachment to the virtual avatars as much as possible, we developed the virtual stimulus materials with a neutral face, as Fig. 2 illustrates. We hoped that this approach would facilitate the participants' holistic examination of their virtual avatars without focusing on their faces or other particular body areas.

For the virtual avatar experience, the participants were shown the maneuver techniques of avatar viewing tools (e.g., 360-degree rotation, zoom-in, and zoom-out) and were allowed to examine their own virtual avatars on a 17-inch laptop screen in an

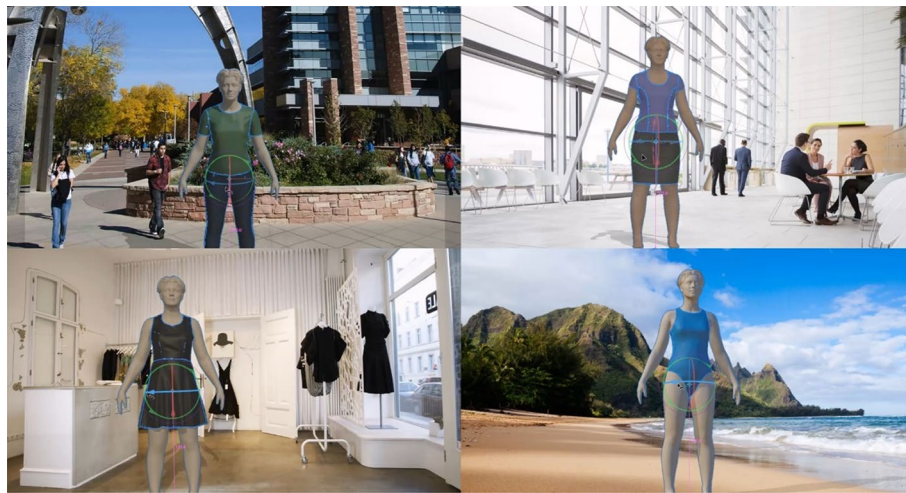


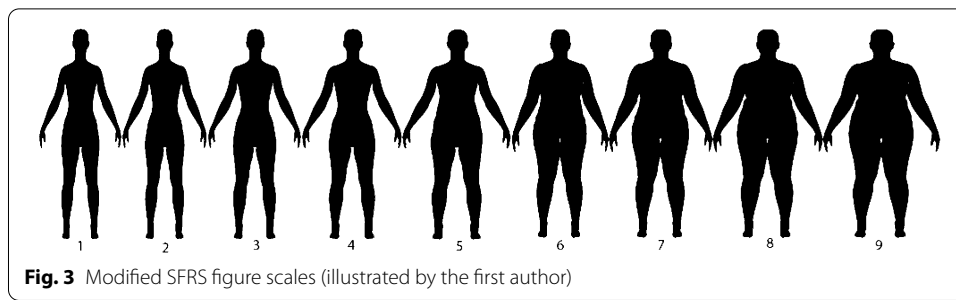
Fig. 2 Visual stimuli of virtual avatars

undisrupted, private setting. When each participant entered the room, a researcher offered her a bottle of water, demonstrated the avatar viewing tools for her, and allowed her to practice until she felt comfortable. When the participant was ready, the researcher exited the room and invited the participant to examine the virtual avatar stimulus materials as long as she desired. When the participant was ready to end the session, she signaled this to the researcher who was waiting outside the room. The total duration of completing the virtual avatar experience ranged from 4 to 13 min.

Measurement instrument

To measure the effect of the intervention program on self-concepts, we assessed the following three attributes—self-body perception, self-esteem, and self-compassion—three times throughout the program. Specifically, the assessments occurred at the baseline, at the completion of the body positivity program, and at the completion of the virtual avatar experience program (refer to Fig. 1). A measurement instrument was developed on the basis of the following three standard metrics, which included Stunkard's Figure Rating Scale (SFRS) (Stunkard et al. 1983), Rosenberg's Self-Esteem (SE) Scale (Rosenburg, 1965) and the Self-Compassion (SC) Scale (Raes et al. 2011). A total of 28 items were asked in the measurement instrument consisting of three items of the SFRS scale, 10 items of the SE scale, and 12 items of the SC scale, as well as three demographic questions inquiring the participants' age, height, and weight.

The SFRS scale was adopted and modified to assess the participants' self-body images that best represented their actual, ideal, and ought body, on the nine body figure scale from 1 (thinnest) to 9 (fattest) (Fig. 3). According to Stunkard et al. (1983), the *actual body* refers to the body that one feels is the actual appearance of one's own body; the *ideal body* refers to the body that one wishes to have; and the *ought body* refers to the body that one feels it is one's duty or obligation to obtain. The 10-item Rosenberg's SE scale was included in the measurement instrument to assess global self-worth (i.e., self-esteem) by measuring both positive and negative feeling about the self on a 4-point



Likert scale format ranging from strongly agree (1) to strongly disagree (4). Lastly, the 12-item SC scale was used to measure self-kindness, self-judgment, common humanity, isolation, mindfulness, and over identification and computed subscale scores on a 5-point Likert scale ranging from almost never (1) to almost always (5), to generate a total score of self-compassion.

Data analysis

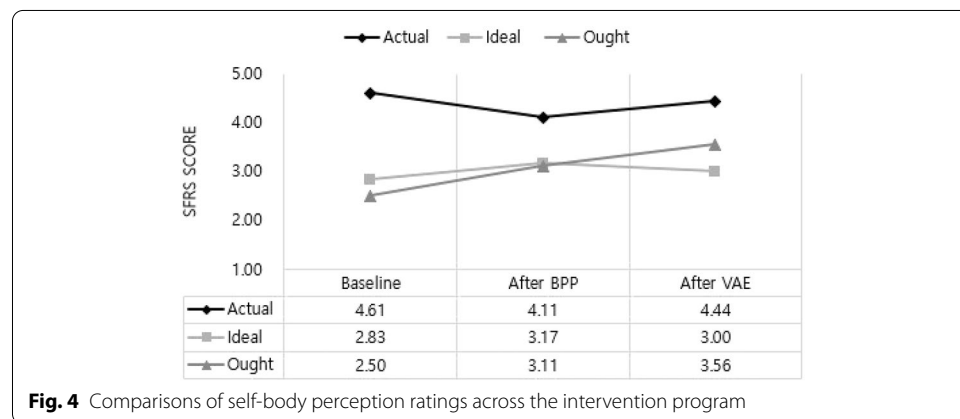
The data sets analyzed in this study included the rating scores of the three measuring attributes (i.e., SFRS, SE and SC), as well as demographic information of the study participants. Descriptive and inferential data were analyzed using IBM SPSS 26.0, and significance was determined at $p < 0.05$. Independent samples t-tests were used to verify the homogeneity of the two sample groups (control and experimental) on the measuring attributes at the baseline. Repeated measures ANOVA (Greenhouse–Geisser) tests compared mean differences in the three attributes across the data collection points, and Bonferroni post hoc tests examined mean differences of the attributes between the data sets. Graphs and charts were also utilized to visualize the results of the statistical analyses.

Semi-structured, face-to-face interviews were conducted with participants at three points: at baseline, midpoint (after the body positivity program), and exit (after the virtual avatar experience). Interviews were conducted by research personnel and lasted between 13 and 45 min (mean = 26.4 min). Based on 10 open-ended questions, each interview focused upon participants' body image and perceptions/experiences of the given program/experience. For instance, exit interviews focused upon the following general areas: reflections on the virtual avatar program (e.g., "How did you feel about your virtual avatars?"), changes in self-body perceptions prompted by the virtual avatar program (e.g., "Can you tell us about how the virtual avatar experience helped you or did not help you to change your perspective of your body?"), and changes in real life prompted by the virtual avatar program (e.g., "Have you noticed any changes in your life, including your exercise routines, nutritional diet and/or social relationships with others?"). Interviews were transcribed, and data were analyzed using the constant comparison process associated with the constructionist grounded theory approach (Charmaz, 2000). "Open coding" was adopted to identify key meanings within the data (Charmaz, 2000; Strauss & Corbin, 1994). Next, we compared these key meanings to one another and grouped similar meanings together into categories and subcategories that were developed into a coding guide. We applied the coding guide to the data, looking for all occurrences of each category/subcategory, thus affording a more in-depth analysis. During the final

Table 2 Self-body perception ratings across the intervention program

	Mean (σ)			ANOVA		
	Baseline	After BPP	After VAE	F	df	p
Actual	4.61 (.92)	4.11 (.90)	4.44 (.88)*	4.203	1.709	.043*
Ideal	2.83 (.72)	3.17 (.86)	3.00 (.87)	1.191	1.933	.329
Ought	2.50 (1.10)	3.11 (1.02)	3.56 (1.51)*	6.595	1.651	.013*
Actual–Ideal	1.78 (.65)	.94 (.64)	1.44 (.88)	4.000	1.716	.048*
Actual–Ought	2.11 (.96)	1.00 (.91)	.89 (.78)	6.562	1.858	.010*

* < .05; ** < .01

**Fig. 4** Comparisons of self-body perception ratings across the intervention program

stage of analysis, we developed the categories and subcategories into key themes that aptly captured the essence of participants' experiences (Charmaz, 2000; Strauss & Corbin, 1994). Because this paper focuses upon the virtual avatar experience, we limit our focus to the analysis of the exit interviews; analyses of the baseline and midpoint interviews are reported elsewhere (Ogle et al. 2019).

Results

Participant profiles

The average age of all participants was 18.69 years old (SD 0.59; range 18–20), with fifteen non-Hispanic Whites (83.3%), two Hispanics (11.1%), and one African American (5.6%). The average body dimensions of the participants were 65.44 inches (SD 3.33; 166.22 cm) in height and 155.93 lbs. (SD 32.13; 70.73 kg) in weight. The average Body Mass Index (BMI), calculated based on the height and weight, was 25.62 kg/m² (SD 5.43), which characterized the participant group as slightly overweight (> 25 kg/m²).

The effect on self-body perceptions

The SFRS scores indicated the participants' self-body disparities among their actual, ideal, and ought body across the intervention program (Table 2). At the baseline, the mean scores that the participants rated on their actual, ideal, and ought body were 4.61 (SD = 0.92), 2.83 (SD = 0.71), and 2.50 (SD = 1.10), out of the nine figure rating scale (refer to Fig. 4), respectively. To explain, the participants perceived the size of

their actual body the largest on the relative scale of SFRS, followed by the ideal and ought body. The results of independent-samples *t*-tests showed no significant difference between the experimental and control group in their self-reported scores on the actual, ideal and ought body at $p < 0.05$, which signified that the participants, whether they were assigned in the experimental or control group, perceived their self-body (in the three aspects) in a similar way. After the body positivity program, the mean score of the actual body, rated by all participants, decreased by 0.50, from 4.61 to 4.11 ($SD = 0.90$), while that of the ideal body increased by 0.034 from 2.83 to 3.17 ($SD = 0.86$), and that of the ought body increased by 0.61 from 2.50 to 3.11 ($SD = 1.02$). *P*-values of the mean comparisons between the baseline and after the body positivity program were < 0.05 in all three self-body image scales, signifying that after the body positivity program, the participants perceived their actual body thinner than they originally thought, whereas they became more tolerant and relaxed with their perceived ideal body and ought body, which indicated positive directions in their self-body perceptions after receiving positive information helping them have healthier body image.

Further, after participating in the virtual avatar experience program, the mean score of the actual body increased by 0.33 (mean = 4.44, $SD = 0.29$), while that of the ideal body decreased by 0.17 (mean = 3.00, $SD = 0.29$), as compared to the scores after the body positivity program. Additionally, the mean score of the ought body increased as much as 0.45 from 3.11 ($SD = 1.02$) to 3.56 ($SD = 0.50$) after the virtual avatar experience (refer to Fig. 4). That is, after the virtual avatar experience, the mean rating of the actual body that decreased noticeably after the body positivity program bounced back almost to the baseline stage, and that of the ideal body became lower than after the body positivity program, which indicates a generally negative trend for body image. However, despite of the concerning results with regard to the actual and ideal body, it should be noted that the participants still demonstrated the positive change in their perceived ought body even after the virtual avatar experience.

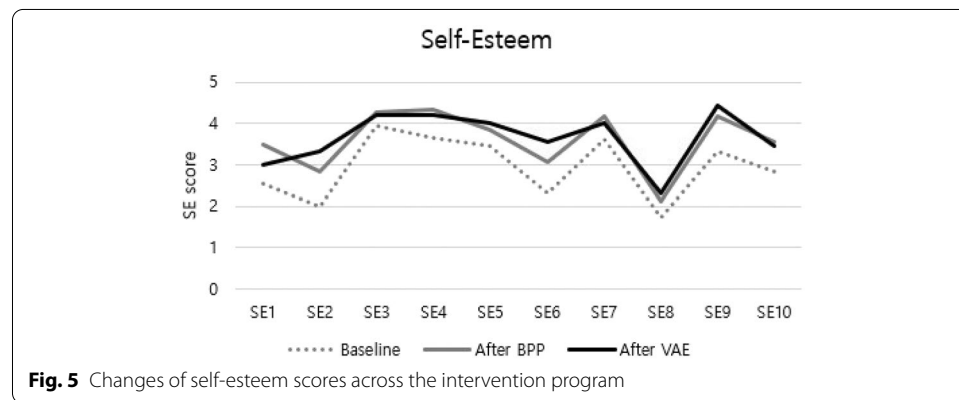
If we look at the results from a slightly different angle, we may notice interesting perspectives on the data. That is, after the virtual avatar experience program, the mean score of the ideal body, which once increased as much as 0.34 from the baseline, had almost returned to its original state. The result may be interpreted in that one's perception on the ideal body (i.e., one's perceived beauty ideal) was relatively harder to change as it was evinced in its returning trend to the baseline, after receiving the extra experimental stimulus (i.e., having a virtual avatar experience), even if it had turned in a positive direction after the body positivity program. On the other hand, after exposure to the virtual avatar stimulus, the mean score of the actual body did not change much, as compared to the score collected right after the body positivity program. The result may indicate that the perception on the actual body was stabilized through the intervention program and the trend remained truthful even after the virtual avatar stimulus.

The most interesting point here is on the score changes of the ought body. To wit, the scores of the ought body continually increased from the baseline through the body positivity program, further to after the virtual avatar experience program. The result could indicate that the intervention program of this study, particularly when

Table 3 Self-esteem scores across the intervention program

	Scale item	Baseline Mean (σ)	After BPP Mean (σ)	After VAE Mean (σ)
1	On the whole, I am satisfied with myself	2.56 (.86)	3.50 (.79)	3.00 (.71)
2	At times I think I am no good at all†	2.00 (.69)	2.83 (.86)	3.33 (1.00)
3	I feel that I have a number of good qualities	3.94 (.73)	4.28 (.83)	4.22 (.83)
4	I am able to do things as well as most other people	3.67 (1.03)	4.33 (.77)	4.22 (.67)
5	I feel I do not have much to be proud of†	3.44 (.78)	3.83 (.99)	4.00 (.50)
6	I certainly feel useless at times†	2.33 (.84)	3.06 (.80)	3.56 (.88)
7	I feel I'm a person of worth, at least on an equal plane with others	3.61 (.78)	4.17 (.71)	4.00 (.87)
8	I wish I could have more respect for myself	1.72 (.96)	2.11 (.96)	2.33 (1.12)
9	All in all, I am inclined to feel that I am a failure†	3.33 (1.08)	4.17 (.71)	4.44 (.73)
10	I take a positive attitude toward myself	2.83 (1.04)	3.56 (.71)	3.44 (.53)
	Total mean (σ)	2.94 (.59)	3.58 (.53)	3.65 (.43)

† Reversed items

**Fig. 5** Changes of self-esteem scores across the intervention program

it was combined with the virtual avatar experience program, was most effective in the study participants' ought body perception—how they perceived they should look like (ought body) versus how they wished to look like to meet the society's standards (ideal body).

The effect on self-esteem

The score changes of Rosenberg's SE scale (Rosenburg, 1965) displayed a consistent positive trend throughout the intervention program. On the 5-point Rosenberg's SE scale, the mean score at the baseline was 2.94 ($SD=0.59$), and then it increased to 3.58 ($SD=0.53$) after the body positivity program and further to 3.66 ($SD=0.43$) after the virtual avatar experience program (Table 3). That is, the participants' SE scores increased by 0.64 from the baseline to after the body positivity program, and they increased further from 3.58 to 3.66 after the virtual avatar experience (Fig. 5).

ANOVA test results of within-subjects effects (Greenhouse–Geisser) demonstrated statistical significance of the changing trends across the intervention program ($p=0.001$), which determined notable differences in the SE scores collected at the three different data collection points. Bonferroni post hoc tests were performed to identify

which particular differences between pairs of means were significant, while controlling the experiment-wise error rate at $p < 0.05$. The results showed all three pairs—baseline vs after the body positivity program, baseline vs. after the virtual avatar experience program, and after the body positivity program vs. after the virtual avatar experience program—with p values of 0.000, 0.000, and 0.049, respectively. Hence, the increase of the participants' SE scores was statically meaningful at each of the comparisons through the intervention program. That is, there was a positive effect of both body positivity program and virtual avatar experience program on the self-esteem.

The effect on self-compassion

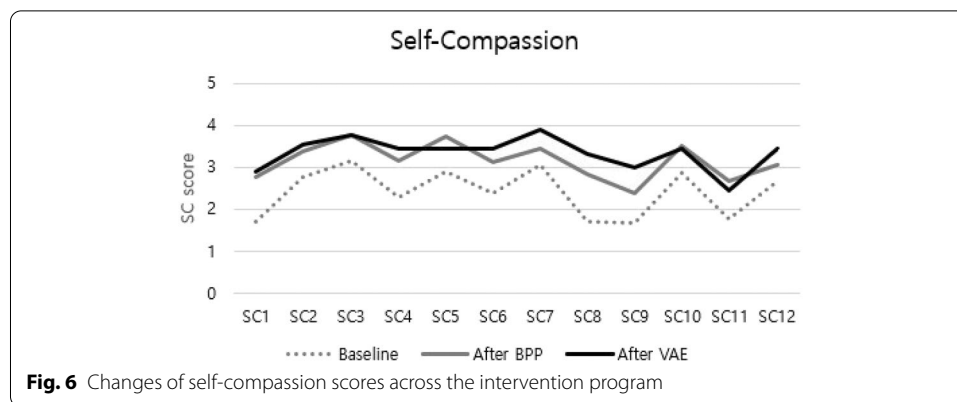
At the baseline, the mean score of the SC scale was 2.42 ($SD = 0.32$), out of 5, and the score became 3.15 ($SD = 0.19$) after the body positivity program and the direction furthered to 3.34 ($SD = 0.16$) after the virtual avatar experience program (Table 4). The descriptive data showed the overall positive increasing trend in the SC scores throughout the intervention program (Fig. 6).

The repeated-measures ANOVA compared the mean SC scores at the three data collection points at the 95% confidence level. The results demonstrated the multivariate effect of SC on the participants' self-concept and confirmed that the mean scores at the varying data collection points significantly differed from one another ($p = 0.001$). More specifically, the post hoc tests analyzed pair-wise comparisons between the datasets, and showed that all three pairs of the datasets collected at the baseline vs. after the body positivity program, the baseline vs. after the virtual avatar experience, and after the body

Table 4 Self-compassion scores across the intervention program

Scale item		Baseline Mean (σ)	After BPP Mean (σ)	After VAE Mean (σ)
1	When I fail at something important to me, I become consumed by feelings of inadequacy [†]	1.72 (.67)	2.78 (.88)	2.89 (.93)
2	I try to be understanding and patient toward those aspects of my personality I don't like	2.78 (.81)	3.39 (.70)	3.56 (.73)
3	When something painful happens I try to take a balanced view of the situation	3.17 (.99)	3.78 (.88)	3.78 (.67)
4	When I'm feeling down, I tend to feel like most other people are probably happier than I am [†]	2.28 (.96)	3.17 (.92)	3.44 (.88)
5	I try to see my failings as part of the human condition	2.89 (.96)	3.72 (.75)	3.44 (1.13)
6	When I'm going through a very hard time, I give myself the caring and tenderness I need	2.39 (.85)	3.11 (.83)	3.44 (1.01)
7	When something upsets me I try to keep my emotions in balance	3.06 (1.00)	3.44 (1.15)	3.89 (.60)
8	When I fail at something that's important to me I tend to feel alone in my failure [†]	1.72 (.89)	2.83 (.99)	3.33 (1.00)
9	When I'm feeling down I tend to obsess and fixate on everything that's wrong [†]	1.67 (.69)	2.39 (1.09)	3.00 (1.12)
10	When I feel inadequate in some way, I try to remind myself that feelings of inadequacy are shared by most people	2.88 (1.32)	3.50 (.79)	3.44 (1.24)
11	I'm disapproving and judgmental about my own flaws and inadequacies [†]	1.78 (.94)	2.67 (.84)	2.44 (1.01)
12	I'm intolerant and impatient towards those aspects of my personality I don't like [†]	2.67 (1.03)	3.06 (.73)	3.44 (1.01)
Total mean (σ)		2.42 (.32)	3.15 (.19)	3.34 (.16)

[†] Reversed items



positivity program vs. after the virtual avatar experience, were significantly different each other at $p=0.000$, 0.000 , and 0.041 , respectively.

Exit narratives

Here, we report the analysis of exit interviews with the experimental group who had gone through the entire intervention program including the body positivity program and the virtual avatar experience program. Our discussion explores three key themes that emerged in the data: experiencing my virtual avatar, changes in self-body perceptions, and self-concepts in real life.

Experiencing my virtual avatar

Overall, the participants shared diverse responses to the experience of engaging with their clothed virtual avatars, characterizing the experience as “weird,” “cool,” and “pleasantly surprising” and suggesting that the experience prompted a range of emotions, including comfort, nervousness, and self-consciousness. All participants, except one who exhibited a mixed feeling, regarded the virtual avatar experience as providing them with an “accurate” understanding of others’ perspectives on their bodies:

[The virtual avatar experience was] helpful just because you get that 360° view and like you see yourself from all angles. It's like that's exactly what you look like... You can't argue with it...you know exactly where you stand. Rather than like going through the day [with] these thoughts in your head, like, “Does this make my thighs look big, or are those people like thinking this about me?”...You look at your virtual scan, just like, “Oh that's it; that's exactly me.” ... I think that was helpful more than hurtful... You can think like, “Oh I know exactly this is what I look like,” and that's what other people are seeing when they see me, so you don't have to like wonder, I guess, which is helpful. (P14).

As the account above reflects, this newfound understanding of others’ perceptions of the body often (but not always) was regarded as useful or valuable information in shaping self-body perceptions. Interesting to note here, however, was P16’s response to the virtual avatar experience. P16 experienced symptoms of body dysmorphia a few years ago, but had no clinical treatment at the time of the program participation. P16

expressed both positive and negative perspectives on her virtual avatar experience as such:

Good, it was the one that actually represented me. I don't think it looks a lot like me, to be totally honest. I mean some parts of it definitely do, but others, I think, are very different, but that's only because I've come to know my own body very well, and I know what looks like the avatar and what doesn't. I mean, for the most part, it was just a cool experience....kind of mixed. (P16).

P16's reactions to the virtual avatar experience, different from the rest of the participants, seemed to reflect her initial resistance to body perception changes when she was exposed to the virtual avatar stimulus. However, the clinical effect of the virtual avatar experience was beyond the scope of the current research work suggesting further investigation with clinical samples.

In addition to exploring participants' overall/general experience of engaging with their virtual avatars, we considered how their experiences varied across the four different contextual scenarios (university campus, office, retail boutique, and beach) in which the virtual avatars were situated. A clear preference for one scenario did not emerge. However, participants expressed a preference for viewing their avatars in scenarios where they could specifically relate to or identify with the situation or the dress worn or where they perceived that their avatars looked "better" in their eyes (e.g., thinner/more attractive); when the reverse was true, participants reviewed the scenarios and their avatars less positively. The university campus scenario was least favored context, eliciting negative comments from the most participants, all of whom perceived that the clothing (t-shirt and pants) for that scenario was ill-fitting/baggy and added weight to their frames:

[The campus] one was interesting. I think that the clothes made it a little more like unflattering, maybe. Maybe it's because I don't really wear clothes like that, but I thought that one was not my favorite because...the clothes made you look a little bigger, I think. (P13).

In some cases, participants were able to experience "surrogate satisfaction" in simulated contexts as a result of their virtual avatar experiences, such that they gathered indirect evidence through these technology-driven experiences to envision a satisfying future reality for themselves (e.g., Riva, 2005, 2020; Rothbaum et al. 2014):

I really like the office one because that's kind of what I hope to do when I'm older, so it was cool. I was like kind of projecting myself into the scene and imagining what it would be like to work at a big, fancy office like that, so I really liked that one. And, then the beach one, because my family is planning a trip to Mexico for next Christmas, so I was kind of going into that like, "Yeah, beaches and warm sands." (P10).

In other cases, participants' reactions to given contexts—and in particular, the clothing worn by their avatars in those contexts—took them by surprise. As illustrated in the excerpts below, seeing themselves in clothing that they previously had dismissed as "not for me" sometimes resulted in perspective transformations supporting improved body image and an expanded sense of possibilities for appearance management. P17 shared her reflection on wearing swimsuits as such:

I kind of get anxious when I have to wear swimsuits in front of people 'cause I'm just

so, like really self-conscious. But, I think looking at my body in a swimsuit [in the virtual context] was so much different than the way I thought it was going to look. So, that was kind of nice to see that it's not like this horrible thing. (P17).

Changes in self-body perceptions

All participants expressed some measure of surprise about the appearance of their virtual avatars, with participants experiencing their avatars as smaller (P10, 17), larger (P12, 13, 15, 16), and/or more favorably shaped/contoured/proportioned (P11, 13, 15, 16) than their mental/imagined images of their bodies. Of particular interest to note here (and as reflected in the aforementioned accounting of participant experiences of their avatars) is that not all participants regarded their avatars in a “singular” way (i.e., as patently “better” or “worse” than their “real” bodies). This sentiment is aptly illustrated by the following excerpt from P16's exit interview:

My stomach definitely looked flatter, which I don't see it being flat all the time. (And), like my chest looked a lot like firmer and a lot more like perkier. Just more up and nicer and stuff, when I know that my chest is a lot like lower and sags a little bit more, just because I do have a bigger chest and stuff. But, like my arms looked pretty much the same, which I've never really had a huge issue with, and my thighs pretty much just look the same, but I could not stop looking at my calves, because the virtual experience made them look a lot bigger than they actually are in real life. 'Cause I know they're not that big. (P16).

In turn, participants' varying perceptions of their avatars gave rise to different experiences of their self-body perceptions, which we characterize below. Some participants, such as P17 and P10, came to recognize their body image distortion (i.e., size overestimation) through their engagement with their virtual avatars, whom they perceived to be smaller than their “real” bodies. As the quotes below illuminate, this recognition prompted P17 to be adopt a more forgiving, self-compassionate stance toward herself and P10 to regard herself as “normal” and to gain confidence in wearing new styles of clothing (much like Participant 18, quoted above):

Um, it was kind of eye-opening. Like, I didn't really realize that I see myself as bigger than I am until now, so it was kind of interesting to realize that. I guess, kind of relieved in a way. Like it's nice to know that I shouldn't be so hard on myself. So that's how I feel. (P17).

So, I think it's definitely like I was thinking originally before it that I was bigger than I was. So, it definitely made me realize that I am pretty much the same size. It's not a huge difference between [me and] other people. [Now], I'm definitely more comfortable wearing whatever I want to wear....(P10).

Conversely, P12 shared that she perceived her virtual avatar to be larger than her mental image of her “real” body (e.g., her stomach), prompting her to experience feelings of self-consciousness and negativity about her body and appearance:

I did not like how [my avatar looked]. ... I don't know, I just didn't think I looked like that...it kind of made me feel self-conscious. Just kind of bad about myself. Yeah.

Not like that bad but just kind of like I didn't think I looked like that, yeah. ... Like I know I'm short. I think, hopefully, I don't look like that. I don't know, it was just kind of weird. My stomach was way bigger than I thought. Yeah. (P12).

At another juncture in her interview, P12 also expressed that, when viewing the avatar, she had difficulty focusing on the gestalt of the avatar's appearance, instead concentrating her attention on her "problem areas," as she might during body checking (cf, Park, 2017).

Importantly, other participants who perceived their avatars to be larger than their imaged perceptions of their "real" bodies did not experience exclusively negative self-body perceptions, likely because their perceptions about their avatar's body size were paralleled by positive perceptions about their avatar's body shape/contours/proportions. Such was the case for P13, who admired her avatar's proportions in the retail boutique context, and who seemed to take away from the virtual avatar experience a sense that she deserved to have more confidence in her bodily appearance, which also offered an anecdotal evidence of the unlocking process of P13's stored allocentric body perception by the new egocentric sensory input of her virtual avatar:

Oh, I thought [the retail boutique with the dress] was really good, too...[It] made me feel better about my proportions, specifically. I think the outfit was a lot more flattering. ... some of [the contexts] made me feel bigger than I actually am, but I think on some of them, it was actually kind of eye-opening to see, like, if that's how I actually look, then maybe I should have better outlook on how I look. (P13).

Like P13, P16 regarded her virtual avatar image as different in appearance than her "real" body in ways that she perceived both positively and negatively (see her quote at the beginning of this section). Although she acknowledged that the virtual avatar experience afforded her a new perspective, she shared that it did not shift her perspective on her self/body. In explaining this conclusion, she cited her intimate familiarity with her body and her tendency to discount the image of the virtual avatar owing to technology shortcomings:

... [the virtual avatar experience] kind of just gave me a new perspective of what it means to see myself in a different way, but at the same time, it's very different to see yourself virtually like in a video game, sort of, versus real life. And, I've had a very long personal journey with my body, so I know what was accurate in the virtual experience and what maybe wasn't as accurate. And, some of that was good, some of that was bad. So, it was kind of a mixed experience. (P16).

In comparison to P13, P16's narrative above illustrates the way in which egocentric sensory input gained through the virtual avatar experience did not induce changes in her locked allocentric perspective on the body, perhaps owing to her prior history of body dysfunction symptoms.

Self-concepts in real life

For many participants, then, engaging with virtual avatars formed the foundation for the development of some positively-charged self-body perceptions, increased body confidence/acceptance, and enhanced self-esteem /self-esteem-related traits:

Yeah, I think I feel better and I think I'm just able to see more positive things about myself, whether it's like my personality or my physical appearance... I'm more comfortable with myself [now]. I think that other people see me as better than I used to, ya know? (P13).

In turn, these perceptions seemed to have laid a groundwork for real-life behavioral changes, which induced modification of participants' allocentric perspectives based on the new sensory input retrieved from the virtual avatar experience. For instance, participants shared that their positive self-body perceptions supported changes in their physical appearance management (e.g., expanding options about what to wear/what might look attractive on their bodies) and/or psychosocial self-concepts. Participants who were able to move toward increased body confidence/acceptance also expressed that they were able to adopt a more self-compassionate and balanced attitude toward nutrition and exercise routines, whereby they were more forgiving of themselves if they occasionally experienced a "lapse" in adherence to their nutrition or exercise regimens. In P17's case, this self-compassion also extended to a diminished focus on weight/weight gain:

I think I was exercising to the point where my body was just like kind of worn out because I wouldn't really take any rest days or anything. And, so now, I've learned that I just need to give my body the time it needs to like regenerate and rest. ... I think I was just like really, really focused on losing a lot of weight. ... Um, I think I was just really scared of gaining it back and so now I'm kind of getting to the point where it's like even if I were to gain a couple pounds back, like I'm okay, it's not going to be the end of the world. (P17).

Feeling more confident about the body frequently positioned participants to be more confident in social settings and in their interpersonal relationships, as well. Most notably, for several participants, the virtual avatar experienced seemed to support an improved sense of self and body image and the confidence to separate self-concept (to some degree) from others' evaluations, a possibility that also may have been advanced by the self-compassion content integrated in the body positivity portion of the program:

Yeah, I think [the virtual avatar experience] made me...like uh worry less about what other people think. Like maybe I'll worry less about what other people think because of that. Um and I think it would just made me feel better about how I look specifically just because of the, I like saw the proportions and I think that was really um it like made me like have a little more positive feedback about myself. (P13).

This emboldened sense of confidence in interacting with others transcended across exchanges with friends/peers, significant others, and family members, helping participants to see themselves as "normal," attractive people and diminishing the energy and concern that had previously invested in monitoring others' perceptions of them. The following narrative also evinces the multimodal effect of the VR-based intervention program when it was combined with other body positivity factors such as positive social interactions with others in unlocking one's stored allocentric perspective of the body:

I've definitely done the whole double check everything before I walk out the door thing less since I've started [the program]. And then started to feel a lot more confi-

dent with my significant other about like my body and cause one of my big concerns was like I was having trouble feeling comfortable in intimate scenarios because I was like, "Oh gosh, I'm just so gross, I don't want anyone to ever have to see me like that." But this has really helped with that concern in making me feel like, "You're just a normal person. You just look like a regular person. You don't have anything to worry about." ... That kind of stuff like I've found I can just relax and focus on hanging out with people rather than focusing on what they're thinking of me. (P18).

Discussion

Through this study, we investigated the effects of having a virtual avatar experience on one's self-concepts within the realm of body image. We particularly looked at the phenomena through the lens of the allocentric lock theory. To summarize the study findings (as illustrated in Fig. 4), the study participants' self-body perceptions showed improvement in all three dimensions including the actual, ideal and ought self after the body positivity program, which confirmed that the body positivity program provided an excellent service to the intervention program as a psychological buffer, prior to implementing the virtual avatar stimulus. To elaborate, the gap among the three self-images became narrower after the body positivity program, suggesting a positive shift in the study participants' body perceptions after the psychological buffer program. Further, after having the virtual avatar stimulus, the gap between the actual self and ought self continued to diminish, whereas the gap between the actual self versus ideal self exhibited a slight increase. Namely, after the virtual avatar experience, even when the participants recognized their body bigger or fatter (i.e., "falling short") than how they had thought before participating in the intervention program, they seemed to demonstrate self-acceptance by lowering their internal expectation on how they should look like (i.e., the ought self) to the level closer to their actual body, instead of being critical to the self, by trying to meet their body to the contemporary society's beauty standards (i.e., the ideal self).

The quantitative assessment of the two self-concepts—self-esteem and self-compassion—verified the altered processing of bodily memory and its positive outcomes in participants both after the body positivity program and after the virtual avatar experience program. Despite of the negative return of the participants' body perception on the ideal self (that once increased after the body positivity program) to the baseline state after the virtual avatar experience, the psychosocial measures of their self-concepts had shown positive consequences. We believe the results offer a promising outlook to the VR-based intervention program that we implemented in this study, as an effective clinical approach for the treatment of body image disturbance and its associated complications, since it seems to be able to turn the participants' self-concepts in a positive direction, while fostering self-acceptance, thus allowing them to focus on what they can change within their control, rather than trying to reach unrealistic beauty ideals. This outcome interestingly corresponded with previous research in that those who are compassionate toward the self tend to focus on trying to change that which they can in the self, rather than that which they cannot (Leary et al. 2007).

The exit interviews enriched the quantitative findings from this study by illuminating understanding about how engaging with the avatars shaped participants' perceptions

of their actual bodies and by lending additional insights into the practical benefits of the virtual avatar experience among young female adults who have experienced some level of body image concern. For example, the interviews deepened our understanding of changes in participants' self-body perceptions, revealing that because their perceptions of their avatars were sometimes multifaceted, even participants who came to see themselves as larger as a result of their engagement with their avatars sometimes still experienced positive feelings about their bodies related to their improved impressions of their body contours/shape/proportions. Additionally, the exit interview data suggest that the virtual avatar experience provided the foundation for other positively-charged body image outcomes, such as (a) gaining an enhanced understanding of others' views of the body, (b) envisioning enriching future possibilities for themselves (e.g., including but not limited to appearance management), (c) showing themselves self-compassion relative to varied body image issues, and (d) separating their self-concepts from external evaluations. These outcomes are of particular interest, as in past research, demonstrating compassion toward the self has been found to support positive and/or buffer against negative body image outcomes (see Braun et al. 2016 for a review). Further, researchers have proposed that "healthy" perspectives on the body and self are those that are not contingent upon others' evaluations (Aspinwall & Taylor, 1993; Beach & Tesser; Neff, 2003a). As a summative reflection on the study findings, through this research work, we discovered that the stored allocentric representations of the body could be released by the visual egocentric VR-based intervention approach, which positive effects were more observable when the virtual avatar experience was presented as multimodal sensory inputs (Riva & Dakanalis, 2018) such as using the body positivity program as a psychological buffer or having real-life behavioral changes along with the visual stimulation, as discovered in this study.

The unique contributions of the present study to the current body of knowledge are as follows: First, we adopted 3D body scanning technology as a pioneering approach to create anthropometrically-correct virtual avatars based on the study participants' actual body physique. This approach has recently been emerging in virtual avatar creation, in the domain of body image research and beyond, in which body presence is a critical element of the domain's knowledge discovery. Second, we developed a comprehensive intervention program consisting of the body positivity program and the virtual avatar experience program, and empirically tested it with human participants. Our intervention program's originality must be found in how we structured the body positivity program as a psychological buffer, as well as how we integrated the novel technical application of virtual 3D body technology into the holistic interventive approach. Third, we evaluated the effect of experiencing virtual avatars from the perspective of the allocentric lock theory – particularly how having such a visual stimulation of virtual avatars (i.e., the egocentric sensory input) could modify one's locked bodily memory and whether one's self-concepts could measure the degree (as well as the direction) of the changed body perception. We believe that this assessment method using the psychosocial self-concept constructs, particularly self-compassion, is a first-of-its-kind in the context of virtual avatars and body image.

Conclusions

This study's limitations must also be acknowledged. First, although the data collected from this study generated meaningful outcomes, it would be beneficial to operate the VR-based intervention program with a larger sample size that represents diverse demographic and clinical backgrounds. Second, although identified in this study was a subtle trend of the participants' preferences on the different contexts, it was still uncertain whether the preferences were primarily due to the backgrounds that the avatars were situated or the look of the clothes depicted on the virtual avatar in a given context. Moreover, the background effect on the participants' body perception—whether the participants' self-body images could have been perceived more or less thin depending on the backgrounds—was beyond this study's scope. Therefore, it will be appropriate to conduct a follow-up study to examine the relationships among the contextual backgrounds, clothes worn on the virtual avatars, and the viewers' preferences and body perceptions.

In this study, we recruited a convenient sample of young college female students with some level of body image concern from a U.S. 4-year university, representing a single geographical location. For future research, we recommend evaluating the effectiveness of the intervention program with clinical samples of various age, gender, ethnicity, and so on. Moreover, it will be interesting to compare the influence of cultural backgrounds in program participants, in which a varying level of social pressure to follow the hegemonic ideal is present. Additionally, it will be important to evaluate the program's longitudinal effects through consistent exposure to the virtual avatar experience. To this end, it will be critical to establish partnerships with local psychological counselling and medical services, as a cautionary measure for the execution of such long-term research with clinical samples.

Further, the outcomes of this study could be expanded to various spin-off applications including e-commerce and fashion. For example, the avatar creation technique using 3D body scanning presents practical potential to be used in virtual fitting rooms, where consumers try on and purchase clothes in virtual retail space. While the technical approach, envisaged in this study, seems promising in the application context, more important for researchers and developers are to have comprehensive insights into the human side, such as the impacts of having the virtual avatar experience on the viewers (i.e., consumers in the retail context) and grasp the mechanism of how to guide the experience in a positive direction. Therefore, future research is desirable to evaluate the VR avatar integration in the open (or commercial) contexts, and find proactive solutions to avoid possible adverse side effects of using virtual avatars in the general public. Nonetheless the lessons we learned from this study, it has also made us realize many areas that we still don't know and we should investigate further, before implementing it in real settings. We hope this study will open up new research opportunities for many emerging research fields, and promote interest among researchers who seek innovative modes of clinical treatment for patients with body image disturbance, or novel applications of virtual 3D technology beyond how is currently implemented.

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Authors' contributions

JP and JO both planned and developed the contents of the intervention program. JO was responsible for facilitating the body positivity program and JP was the primary researcher who created virtual avatar stimuli based on 3D body scans and operated the virtual avatar experience program. JP and JO equally contributed to the writing of the manuscript. All authors read and approved the final manuscript.

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Declarations

Competing interests

The authors declare that they have no competing interests.

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