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Body image avoidance affects interpersonal distance perception: A virtual environment experiment

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Abstract

Objective: Eating disorders have a considerable influence on social contacts. The avoidance towards the own body may result in the avoidance of others. Previous research has found a preference for larger interaction distances in individuals with eating disorders (ED) as compared to control participants (CG). We aimed to replicate these findings and to investigate whether the body weight of the interactant moderates the effect.

Method: We recruited a female sample with mixed ED subtypes ($n = 21$) and a female CG ($n = 28$). Participants were immersed in a virtual environment and engaged in a number of fictitious social interactions. They approached a virtual person until a comfortable distance for interaction was reached. The approached virtual persons differed with respect to body weight in five levels (underweight to obese).

Results: Our results indicate that interpersonal distance varies as a U-shaped function of the avatar's body weight, and that higher levels of body avoidance, present in ED individuals, magnify this effect.

Conclusions: We discuss our results with regard to the role of perspective and disgust to provide a useful framework and to motivate future studies in the domain of body avoidance in social interactions.

Highlights

- We immersed individuals with eating disorders into a virtual environment and presented virtual people of different body weights
- Individuals with eating disorders maintain a larger interpersonal distance compared to healthy controls and underweight and obese virtual people evoke larger distances than normal-weighted virtual people
- It seems that this effect is attenuated in individuals with eating disorders, probably due to avoidance of their own body

KEYWORDS

eating disorder, body image, interpersonal distance, virtual reality

1 | INTRODUCTION

A negative, dysfunctional attitude towards the own body and heightened body dissatisfaction has become a normative discontent (e.g., Grogan, 2008) and consequently, achieving a thin, ideal body and being attractive represents a constant challenge in particular for young women (Tiggemann, Churches, Mitchell, & Brown, 2018). Striving for a thin and ideal body paired with high degrees of body dissatisfaction reflect the cognitive-affective components of body image disturbances (e.g., Cash, Theriault, & Annis, 2004) and as such pose specific risk factors for the development of eating disorders (ED; e.g., Stice, Rohde, Shaw, & Gau, 2011). Also, individuals with EDs typically experience a marked fear to gain weight, the so-called "fear of fat".

Fear of fat has been related to cognitive-affective components of body image (Milos et al., 2017) and is assumed to constitute a central underlying mechanism of behavioral symptoms for individuals with EDs (Murray et al., 2017). Research in the domain of fear of fat and body image disturbances has mostly focused on weight and eating behavior; however, there is recent evidence that it also impacts approach and avoidance behaviors to threatening body-related stimuli (Woud, Anschutz, Van Strien, & Becker, 2011). In addition, there is evidence from a personality perspective describing highly social avoidant/inhibited behaviors and interpersonal problems in individuals with EDs (e.g., Arcelus, Haslam, Farrow, & Meyer, 2013). For example, individuals with EDs often fear romantic intimacy (Cash et al., 2004), express negative attitudes towards friendships (Schutz & Paxton, 2007), and partake less in social activities than controls (Krug et al., 2013). However, despite first evidence, it remains unclear whether and how fear of fat and body image disturbances affect social interactions. Thus, in this study, we investigate the effects of cognitive-affective and behavioral components of body image in EDs on social distance behavior.

1.1 | Relation between body image and social interaction

Body image comprises self-perceptions, attitudes towards one's own body, feelings and behaviors (Cash et al., 2004). The cognitive and affective components reflect body-related schemes that contribute to the core symptoms of EDs, such as overconcern with weight, shape, and eating. Recently however, some motivational and behavioral components of the body image, such as avoidance and checking, have been attributed to these core symptoms (Bailey & Waller, 2017; Fairburn, Shafran, & Cooper, 1998). Also, avoidance-related behaviors expand to the social domain (Vocks, Bauer, & Legenbauer, 2018) and in consequence impact the social functioning of those suffering from EDs and body image disturbances (Krug et al., 2013). Both fear of fat and the behavioral symptoms of body image disturbances may result from approach and avoidance tendencies towards potentially threatening information (Woud et al., 2011) and as such may contribute to the maintenance of body image disturbances as well as EDs (Bailey & Waller, 2017).

Lately, a paradigm that tested approach and avoidance tendencies indirectly associated with the drive for thinness and fear of fat has emerged. Woud et al. (2011) used pictorial stimuli of thin and overweight models with a stimulus–response-compatibility task in a student sample. The participants had to move a manikin towards a thin or overweight model, or away from it. The results showed an approach bias in healthy females, that is, relatively faster approach reactions towards thin compared to overweight stimuli. Moreover, an avoidance-bias to overweight models was positively correlated with body dissatisfaction and eating pathology as well as the BMI of the participants. Based on this finding, Leins, Waldorf, Kollei, Rinck, and Steins-Loeber (2018) presented a computerized Approach-Avoidance task (AAT) using normal weight and underweight pictures to a transdiagnostic sample of women with various ED symptoms, as well as to healthy controls. They failed to replicate the former finding of an approach bias towards thin pictures, possibly due to the relatively low reliability of the AAT (Reinecke, Becker, & Rinck, 2010). Thus, further exploration with additional methodology is warranted, in particular as the role of body image avoidance - as a motivational symptom of fear of fat, or drive for thinness with an overconcern of weight and shape—remains unclear.

A reliable and ecologically valid paradigm to assess approach–avoidance-related social behavior is the stop-distance paradigm (Welsch, von Castell, & Hecht, 2019b), during which an interactant walks towards another person and stops at the point that is deemed most comfortable. This so-called interpersonal distance (IPD) approximates the size of personal space, which refers to a space in which intrusion of others causes discomfort and arousal (for a methodological discussion see Hayduk, 1983; Welsch, von Castell, & Hecht, 2019a). Personal space is a key component for social interaction as it extends the body schema to allow for interaction with the environment (Hall, 1966). As such personal space is strongly influenced by the appearance of the interactants, such as the facial expression, the body height, or sex (Caplan & Goldman, 1981; Hecht, Welsch, Viehoff, & Longo, 2019; Pazhoohi et al., 2018; Ruggiero et al., 2017;

Uzzell & Horne, 2006; Welsch et al., 2019b; Welsch, Hecht, & von Castell, 2018).

Given the suitability of this paradigm to assess approach and avoidance tendencies towards thin or fat individuals in EDs, surprisingly, we know of only one study that has employed the IPD paradigm in the context of EDs (Nandrino, Ducro, Iachini, & Coello, 2017). In this study, the authors used video clips of people either approaching the observer (first-person perspective) or of one person approaching another (third-person perspective). Participants were instructed to stop the video when a preferred IPD had been reached. Larger estimates of preferred IPD were found in patients with anorexia nervosa as compared to control participants in normal weighed interactants—in both the first-person and third-person perspective. However, it is still unclear whether this is due to a general bias to avoid social interactions or whether ED-specific features (e.g., body image distortions, body dissatisfaction) constitute this effect. Note that the authors did not manipulate the interactant character regarding appearance or weight. However, this would be of interest as ideal-weighted stimuli are more likely to produce approach tendencies, and avoidance towards fat stimuli is associated with body image disturbances (Woud et al., 2011). For example, people stereotypically attribute negative personality traits to fat bodies (Hu, Parde, Hill, Mahmood, & O′ Toole, 2018) and encounters with negatively valenced persons typically produce relatively larger IPDs (Iachini, Pagliaro, & Ruggiero, 2015; Ruggiero et al., 2017; Welsch et al., 2018). However, a preference for relatively larger IPDs is quite common in psychiatric disorders such as post-traumatic stress disorder (Bogovic, Mihanovic, Jokic-Begic, & Svagelj, 2014), schizophrenia (Schoretsanitis, Kutynia, Stegmayer, Strik, & Walther, 2016) or social anxiety (Perry, Levy-Gigi, Richter-Levin, & Shamay-Tsoory, 2015; Rinck et al., 2010). Thus, we have attempted to identify specific features that might constitute the preference for larger IPDs in individuals with EDs as compared to controls.

1.2 | Aim of the study

In sum, a large body of research suggests that cognitive and motivational components of the body image play a crucial role in developmental and maintenance processes of EDs. In recent years, alterations in the body image in EDs have been associated with social approach and avoidance tendencies and impairments in social interactions. However, evidence is preliminary and not conclusive. Hence, the aim of the present study was to further examine the relation of motivational components of the body image, operationalized as the self-reported degree of body image avoidance. We recorded approach- and avoidance-related social behavior towards potentially threatening or appealing stimuli relevant for EDs that is IPD towards thin and fat avatars. We realized this by applying the above-mentioned stop-distance procedure in a virtual environment with variably attractive avatars (male and female) to simulate encounters with a range of differently weighted persons. To replicate and extend present research, we assume that females with a diagnosis of an ED show larger IPD as compared to control participants without EDs (H1), that eating psychopathology assessed with the EDI-2, body-image-related behaviors assessed with the BCAQ and BMI of the person itself would be positively related to overall IPD (H2). We further expect that normal and ideal-weighted avatars produce the smallest IPDs as compared to fat and underweight avatars (H3); these effects may be particularly attenuated in EDs (Moody et al., 2017), as body weight is a salient emotional cues for individuals with EDs (H4). Finally, we hypothesized that women with high levels of body-image avoidance prefer relatively larger IPDs towards fat as compared to normal avatars, indicating stronger avoidance tendencies based on alleviated body weight (H5). We controlled the influence of depression levels because it is well documented that depression might influence approach/avoidance behavior (Struijs et al., 2017).

2 | METHOD AND MATERIALS

2.1 | Sample

In total, 57 female individuals participated in the study, $N = 23$ females met the criteria for EDs and $n = 34$ were classified as non-eating-disordered controls. All participants were between 18 to 30 years old and had normal or corrected-to-normal vision (inclusion criteria, see method section for assessments). Of these 57 female participants, 47 (82.46%) were enrolled in a full-time higher-education program, 7 (12.28%) were working in a full- or part-time job, and 3 (5.26%) participants attended high school at the moment of testing.

2.1.1 | Participants with a diagnosis of an eating disorder (ED)

We identified individuals with an ED via radio advertisements, via advertising in psychotherapy outpatient clinics, the local child and adolescent psychiatry inpatient ward in Mainz, and a local residential treatment center for female adolescents with EDs, as well as from the campus of the University of Mainz. Females who reported interest to participate in the study were screened for symptoms of EDs via telephone by a clinical psychologist with experience in diagnostics and treatment of EDs. Checklists for eating-disorder symptoms equivalent to SKID-I -screening questions, but based on the DMS-5 criteria (American Psychiatric Association, 2013) were used. Participants who met inclusion criteria, namely reporting binge eating and/or purging behavior as well as body image distortions according to DSM criteria, as well as those reporting underweight and symptoms within the anorexia nervosa category, were included in the study. Again, individuals with a BMI higher than 30 kg/m^2 were excluded. In the ED group, lowest BMI was 17.9 kg/m^2, highest BMI was 30.1 kg/m^2. This left 23 participants within the ED-group of which 12 participants were diagnosed with bulimia nervosa (two atypical), 4 with anorexia nervosa (two atypical), 3 individuals with a binge eating disorder, and 4 were diagnosed with another specified feeding or eating disorder. Due to a software error in the measurement system, data for two participants was unavailable, which left 21 individuals with ED in the ED group for the statistical analysis.

2.1.2 | Control group of individuals without eating disorders (CG)

Participants were recruited via advertisements in the Department of Psychology, across the campus of the Johannes Gutenberg-University Mainz, and in related online communities asking for participation in a virtual-reality task. The inclusion criteria for the CG was a body-mass-index (BMI) below 30 kg/m^2 to exclude those within the excessive weight range (weight range of subjects: 15.7 kg/m^2 to 28 kg/m^2) as well as no indication of depression on the PHQ-2. This left 28 (84.84%) of the initial 33 participants.

2.2 | Measurements

Self-report assessments included eating psychopathology, body avoidance and body checking behaviors, and depressiveness. Furthermore, to exclude participants with limited visual acuity, two small control tasks were performed in relation to visual abilities.

2.2.1 | Body image checking and avoidance questionnaire (BCAQ)

The BCAQ (Legenbauer et al., 2017) is a novel 27-item self-report inventory measuring body-related avoidance, checking and reassurance behavior. The questionnaire exhibits a three-factor structure (avoidance behavior, checking behavior and reassurance seeking), good psychometric properties regarding reliability (Cronbach's alpha between.79 and.92 for the subscales) and sufficient convergent and discriminant validity.

2.2.2 | Eating disorders inventory (EDI-2)

The EDI-2 is a self-report questionnaire to assess several constructs related to EDs, such as Drive for thinness, Body dissatisfaction or Perfectionism (Garner, 1991; Garner, Olmstead, & Polivy, 1983). The German version showed good reliability (Cronbach's alpha = .92) for the total scale. In the current study, we only administered the items of the scales “Drive for thinness,” “Bulimia,” and “Body dissatisfaction”. For sample-specific reliability of all scales, see Table 2.

2.2.3 | Patient health Questionnaire-2 (PHQ-2)

The PHQ-2 (Kroenke, Spitzer, & Williams, 2003) is a two-item self-report screening tool to assess the frequency of depressed mood and anhedonia for the past 2 weeks. The PHQ-2 demonstrated good internal consistency (Cronbach's alpha = .81), as well as good convergent, discriminant, and criterion validity (in terms of high levels of sensitivity and specificity for the detection of depressive disorders as assessed with the SCID) in a sample of medical outpatients (Löwe, Kroenke, & Gräfe, 2005).

2.2.4 | Body weight (BMI)

To determine body-weight status, BMI was calculated (kg/m^2). Body height (in cm) and weight (in kg) were measured with a tape measure and a standard digital scale respectively.

2.2.5 | Visual acuity and stereoscopic acuity

To assure visual acuity, which is the clarity of individual vision, the Freiburg Visual Acuity Test was applied (FrACT; Bach, 1996). In the present sample, visual acuity of all participants was 1.00 (Snellen fraction 6/6) or better. Stereoscopic acuity, relevant for the detectability of depth cues in our virtual environment, was tested using a digital version of the Titmus Test (Bennett & Rabbetts, 1998) with stereoscopic disparities of 800, 400, 200, 140, 100, 80, 60, 50, and 40 s of arc. The criterion for participation was that at least six of the nine trials had been answered correctly.

2.3 | Experimental task

2.3.1 | Apparatus and stimuli

Participants saw stereoscopic full-scale simulations on a large rear-projection screen (2.60 m wide × 1.95 m high). The 3D-projector (projectiondesign F10 AS3D) had a color resolution of 8 bits per channel, a display resolution of 1,400 × 1,050 (horizontal × vertical) pixels, and a refresh rate of 120 Hz. Participants wore LCD shutter-glasses (XPAND X102) synchronized via an infrared emitter, such that each eye received 60 pictures per second. Participants' individual inter-pupillary distance was taken into account when computing the stereoscopic disparity of the VR environment. Measured from a distance of 2.35 m from the screen, the physical field of view (FOV) was 58° horizontally and 45° vertically. The virtual FOV corresponded to the geometric FOV. The VR-environment resembled the surrounding laboratory, see Figure 1. The participants' movement was tracked with a sampling frequency of 30 Hz using an infrared sensor (Microsoft Kinect), and the projection was rendered according to the observer's eye position. The reference for the observer's distance to the avatar was the participant's spine.

Stimuli were presented using the VR-software Vizard (Worldviz, 2016). Avatars were designed in Makehuman 1.1.0 Nightly Build. Four different (two female, two male) Caucasian avatars were used to match avatar ethnicity with that of the participants. Each of these four avatars was presented in five different body forms, ranging from underweight to obese (see Table 1). Although different parameters were manipulated when editing the avatars (muscle tone, muscle weight etc.) we will call this experimental factor Avatar Weight. All avatars wore a gray shirt and black pants, see Figure 2. The virtual position of the avatars was 15 cm behind the projection screen throughout all trials. As body height can influence IPD (Caplan & Goldman, 1981), body-height of avatar and participant were matched in all experiments by scaling the avatar. To minimize effects of gaze direction (Argyle & Dean, 1965; Bailenson, Blascovich, Beall, & Loomis, 2001), the avatar's eyes were dynamically adjusted so that they looked directly at the observer's bridge of the nose. Overall realism of the avatars was judged good to medium ($M = 2.39$, $SD = 0.83$), as rated on a 5-point scale, ranging from 1 ("very good") to 5 ("bad") by all participants. Mean attractiveness ratings of avatars differed as a function of weight (see Table 1 or Figure S3).

2.4 | Procedure

Participants were informed about the study protocol and were invited to the VR-Lab. Prior to the start of the actual experiment, the pre-tests to determine normal vision (FrACT and Titmus Test, see methods) were performed. Then, the experimenter explained the study procedure and eight training trials were performed

FIGURE 1 Apparatus of the experimental task with rear projection screen displaying an avatar with ideal weight, the platforms, and the Microsoft Kinect motion tracker

TABLE 1 Modeling parameters of the avatars in Makehuman and average attractiveness ratings M (*SD*)

	Underweight	Ideal weight	Normal weight	Overweight	Obese
Body weight	50%	75%	100%	125%	150%
Body fat	0%	25%	50%	75%	100%
Muscle mass	25%	75%	50%	25%	0%
Muscle tone	0%	100%	75%	50%	0%
Mean attractiveness	4.32(0.28)	5.66(0.36)	5.79(0.35)	4.38(0.28)	3.43(0.29)

Note: Percentages do not necessarily correspond to any anthropometric properties of the respective categories. For rendered images of the respective categories, see Figure 2. Attractiveness was rated from 1(unattractive) to 10 (very attractive).

TABLE 2 Questionnaire and BMI scores split by group

	CG	ED			
	M (*SD*)	M (*SD*)	*t*	*p*	Cronbach's alpha
Age	23.56(3.99)	22.62(3.46)	87	.389	
BMI	23.09(2.60)	22.62(3.58)	0.52	.603	
EDI-2					
Body dissatisfaction	25.93(7.53)	34.57(8.12)	−3.87	< .001	.81
Bulimia	17.04(5.35)	20.62(6.14)	−2.16	.036	.71
Drive for thinness	16.22(6.95)	26.67(6.09)	−5.45	< .001	.89
BCAQ					
Body checking	15.19(4.11)	22.66(7.12)	−4.59	< .001	.91
Body avoidance	22.04(6.94)	30.71(9.27)	−3.71	< .001	.86
Reassurance seeking	6.92(2.70)	9.30(3.01)	−2.89	.006	.71
PHQ-2					
Depression	0.56(0.58)	1.15(0.65)	−3.68	< .001	
Anhedonia	0.74(0.59)	1.25(0.70)	−2.22	.031	

Note: Age, BMI and the PHQ-2 are not based on multiple Items. Thus, Cronbach's alpha cannot be calculated.
Abbreviations: BCAQ, body image checking and avoidance questionnaire; BMI, body mass index; CG, control group; ED, individuals with eating disorders; EDI-2, eating disorders inventory; PHQ-2; patient health questionnaire-2.

using a male avatar with normal weight to familiarize each participant with the setup. We varied two experimental factors within participants: avatar sex (two male, two female), and Avatar Weight (underweight, ideal weight, normal weight, overweight and obese). Each factor-combination was presented twice, resulting in 40 trials. All trials were presented in randomized order for every participant. The participant was positioned in front of the avatar, facing it directly. Both the avatar and the participant were standing on platforms. Participants assumed a starting position at 2.50 m from the avatar and were told to align their body center with the respective starting position at the beginning of each trial. IPD was calculated as the distance between the participant's and the avatar's spine with a precision of 1 cm. The participants were told to walk towards the avatar until a comfortable distance for conversation had been reached, for a situation where the participant would have to ask a stranger for directions. After each trial, a black screen appeared and the participant went back to the next starting position. No time limit was given. Participants were instructed both in written and verbal form. After the experimental task, the participant rated the attractiveness of each avatar. Finally, a test battery was filled out and the participant was weighed on a scale, thanked, received payment (reimbursement of 8€) or partial course credit, and was debriefed.

2.5 | Ethical statement and funding

The study was approved by a local ethics committee of the Johannes Gutenberg-University Mainz (protocol number: 2016-JGU-psychEK-017). In accordance with the Declaration of Helsinki, participants gave written

FIGURE 2 Two of the four avatars used in the Experiment with the manipulation of body mass, body weight, as well as muscle mass and muscle tone (see also Table 1). Female avatars at the top, male avatars at the bottom. From left to right: underweight, ideal weight, normal weight, overweight and obese

informed consent and were debriefed after the experiments. This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

2.6 | Data preprocessing

Data were analyzed on the basis of the outlier-corrected individual distances for each combination of the experimental factors of avatar sex and weight. Fifty-one of 1960 (2.60%) measurements exceeding the initial distance of 2.50 m were classified as outliers and discarded. These outliers can be attributed to glitches of the thermal camera of the Microsoft Kinect. Second, using the Tukey-criterion, trials with distances above 1.5 times the interquartile range lower than the first or higher than the third quartile for each factor level combination were classified as outliers. This affected 4.71% (90 of 1909) of the cases. Furthermore, in the questionnaires, 15 out of 2.850 (0.52%) responses were missing. They were replaced with the individually predicted value based on the participant's responses in the respective higher order-factor.

3 | RESULTS

3.1 | Baseline characteristics, eating pathology and general IPD

All analyses were performed using the software "R," version 3.5.1 (R Core Team, 2013). The α-level was 5% in all analyses. To check for differences at baseline between the groups (ED, CG), Welsh-corrected *t*-tests were performed for psychosocial and disorder-related data (e.g., BMI) as well as for relevant questionnaires (BCAQ, EDI-2, PHQ). ED and CG differed on all eating-related scales. Levels of Body Dissatisfaction, Bulimia and Drive for Thinness as measured by the EDI-2 were significantly elevated within the ED sample as compared to CG, see Table 2. Regarding differences in BCAQ scales, EDs expressed significantly higher levels of Body Checking, Body Avoidance and Reassurance Seeking in the BCAQ. Also, EDs as compared to CGs, had higher levels of depression in the PHQ-2. Interestingly, the BMI did not differ between the groups. For internal correlations of the BCAQ, EDI-2 etc. see supplementary material S1.

To test for H1, we averaged IPD across all experimental manipulations. Overall IPD differed substantially between the two groups, $t(46) = -2.53$, $p = .015$, Cohen's $d = -0.73$. In line with Nandrino et al. (2017), IPD was larger in individuals with EDs ($M = 133.09$, $SD = 35.23$) as compared to controls ($M = 112.21$, $SD = 21.58$).

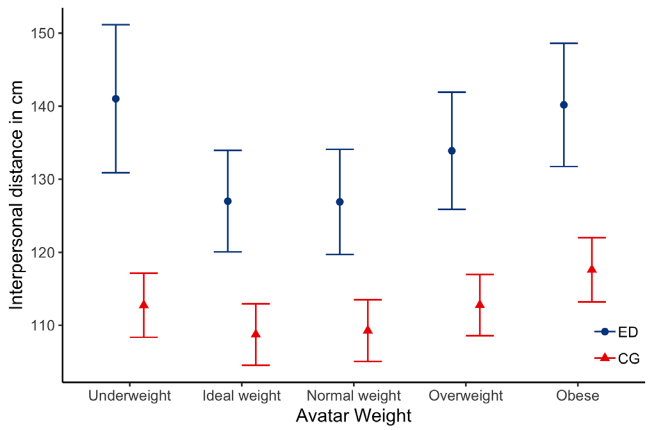

FIGURE 3 Mean interpersonal distance (IPD) in centimeters (cm) as a function of avatar weight and group (ED, eating disordered sample; CG, controls). Error bars indicate one +/− standard error of the mean

3.2 | Association of absolute interpersonal distance and body-image-related characteristics

To assess associations between approach and avoidance tendencies (H2), Pearson correlations with BCAQ subscales, EDI-2, PHQ and IPD scores were conducted over all participants. We computed the correlations with IPD, averaged over all experimental trials, for all questionnaire scales as well as BMI. Neither the EDI-2 scales, the BCAQ checking and reassurance subscales nor the BMI were significantly associated with IPD, all $r < .18$, $p > .22$. In contrast, we found a medium-sized association between Body Avoidance (BCAQ subscale) and IPD, $r = .40$, $p = .004$. Moreover, a significant and unexpected positive correlation of depression and overall IPD appeared, $r = .38$, $p = .008$, but not with anhedonia, $r = .18$, $p = .230$, as measured by the PHQ-2.

3.3 | Modeling interpersonal distance with respect to avatar weight

We visualized the effect of Avatar weight on IPD by plotting Avatar Weight against mean IPD aggregated over all repetitions split for CG and ED participants (see Figure 3). Descriptively, avatars with ideal weight produced the shortest interpersonal distance whereas any deviation from ideal weight increased interpersonal distance. As assumed, participants with EDs maintain larger IPDs as compared to the CG. Moreover, the U-curve of Avatar Weight and IPD was even more pronounced in ED as compared to CG participants (for a descriptive plot for every subgroup see Figure S4).

We analyzed the data with a linear mixed model analysis.[1] We modeled random intercepts for every participant and every avatar and used random-effect slopes for each Gender of Avatar (AIC = 14,480). Fixed effects were added to the regression model in five subsequent steps to observe the increase of goodness-of-fit. In step 1, we added Avatar Weight and Group to the random effects of the model. This significantly increased the goodness-of-fit, $\chi^2(9) = 77.16$, $p < .001$, AIC = 14,421. Next, we added the BA-scale of the BCAQ to the model, which again significantly increased the model-fit, $\chi^2(10) = 110.42$, $p < .001$, AIC = 14,331.[2] The model explained a substantial part of the variance in the data, $R^2 = 87.87\%$. For the sake of brevity, only the results relevant for H3, H4 and H5 are reported:

We found a significant effect of Avatar Weight, $F(4, 612.35) = 7.51$, $p < .001$; normal weight as baseline; $b_{\text{underweight}} = 6.69$, $SE = 4.42$, $t(1{,}194.18) = 1.51$, $p = .130$; $b_{\text{ideal weight}} = -3.432$, $SE = 4.45$, $t(1{,}204.82) = -0.77$, $p = .441$; $b_{\text{overweight}} = 4.75$, $SE = 4.46$, $t(1{,}207.16) = 1.07$, $p =. 287$; $b_{\text{obese}} = 14.36$, $SE = 4.41$, $t(1{,}191.13) = 3.25$, $p < .001$. In support of H3, obese avatars produced significantly larger interpersonal distances as compared to the normal weight avatars.

The effect of Avatar Weight differed across both groups as indicated by an Avatar Weight × Group interaction, $F(4, 1{,}702.77) = 9.69$, $p < .001$; normal weight and CG as baseline; $b_{\text{underweight} \times \text{ED}} = -33.40$, $SE = 6.20$, $t(1{,}702.84) = -5.39$, $p < .001$; $b_{\text{ideal weight} \times \text{ED}} = -0.91$, $SE = 6.14$, $t(1{,}700.96) = -0.15$, $p = .883$; $b_{\text{overweight} \times \text{ED}} = -8.25$, $SE = 6.17$, $t(1{,}702.89) = -1.34$,

p = .181; $b_{\text{obese} \times \text{ED}} = -15.39$, $SE = 6.20$, $t(1{,}701.67) = -2.48$, $p = .013$. Accordingly, when controlling for levels of BA, the curve of IPD and Avatar weight is relatively flat in ED participants, which is not in support of H4.

Surprisingly, the effect of Avatar Weight was also affected by Body Avoidance, $F(4,\ 1{,}702.77) = 9.69$, $p < .001$. The curve that describes the relation between Avatar Weight and IPD is slightly flattened with increasing BA: normal weight as baseline; $b_{\text{underweight} \times \text{BA}} = -0.21$, $SE = 0.28$, $t(1{,}702.96) = -0.74$, $p = .460$; $b_{\text{ideal weight} \times \text{BA}} = 0.20$, $SE = 0.28$, $t(1{,}703.64) = 0.72$, $p = .474$; $b_{\text{overweight} \times \text{BA}} = -0.08$, $SE = 0.28$, $t(1{,}705.60) = -0.29$, $p =. 773$; $b_{\text{obese} \times \text{BA}} = -0.39$, $SE = 0.28$, $t(1{,}702.03) = -1.41$, $p = .159$.

Note that, the latter two effects were driven by the three-way interaction of Avatar Weight × Group × BA, which reached significance; $F(4,\ 1{,}703.37) = 11.45$, $p < .001$. Interestingly, the flattening effect of Body Avoidance on the IPD-weight-curve was reversed in EDs; normal weight avatars and controls as baseline; $b_{\text{underweight} \times \text{BA} \times \text{ED}} = 1.92$, $SE = 0.34$, $t(1{,}703.56) = 5.73$, $p < .001$; $b_{\text{ideal-weight} \times \text{BA} \times \text{ED}} = -0.01$, $SE = 0.33$, $t(1{,}702.26) = -0.03$, $p = .977$; $b_{\text{overweight} \times \text{BA} \times \text{ED}} = 0.54$, $SE = 0.33$, $t(1{,}703.66) = 1.61$, $p = .107$; $b_{\text{obese} \times \text{BA} \times \text{ED}} = 1.00$, $SE = 0.34$, $t(1{,}702.03) = 2.99$, $p < .001$. With an increase of Body Avoidance in EDs, underweight and obese avatars produced comparably larger IPDs than normal weight avatars, see also Figure 4 and Figure S2 in the supplementary material. Thus, although the groups do differ in IPD with respect to Avatar Weight, see Figure 3, this is largely due to Body Avoidance within the ED group. Consequently, the data support H5 in favor of H4. Neither the main effect of BA, Group, or their interaction reached significance, all p-values > .104.[3]

4 | GENERAL DISCUSSION

The present study is the first one to assess IPD towards thin and fat stimuli in a VR task in a sample of individuals with EDs. In sum, Avatar Weight modulated IPD both in participants with EDs and CG participants. Participants preferred larger distances toward avatars whose body shape suggested deviation from ideal weight. In addition, we found larger mean IPD in the ED group than in the CG. Body image avoidance and depression were positively correlated with IPD, and the U-shaped function of Avatar Weight and IPD grew steeper with an increase of body image avoidance behavior. However, the latter effect was only present in the ED sample.

Thus, our results replicate and extend the existing research. Similar to Nandrino et al. (2017), we found larger IPD's in the ED sample than in controls. This supports the assumption that social interactions are impacted by ED. Participants with EDs feel comfortable at larger distances. Nandrino et al. (2017) assumed that this finding is associated with a regulation of emotional strain, namely arousal, which arises when individuals with a diagnosed ED are involved in a social interaction. Indeed, there is great overlap between anxiety disorders and EDs in general (e.g., Kaye, Bulik, Barbarich, & Masters, 2004; Pallister & Waller, 2008; Radix, Rinck, Becker, & Legenbauer, 2018). Lately, specific types and facets of anxieties have been analyzed to better understand the interplay between anxiety and ED pathology (e.g., White & Warren, 2014). In particular, social anxieties, such as fear of negative evaluation (De Boer et al., 2013) or social appearance anxiety (Hart et al., 2008), have been shown to be associated with body dissatisfaction and disordered eating behavior.

Whereas social insecurity and fear of evaluation may have been triggered by all of our avatars, effects of high Body Avoidance scores on IPD were specific to extreme avatar weight (in both directions). When controlling for Body Avoidance, the differences in IPD between groups vanished completely. If a main effect of anxiety of social evaluation had driven the differences between the groups in the present study, then the interaction effects with the avatar's body weight should not have occurred. This is in line with reports that body image avoidance seems unrelated to anxiety in EDs (Bamford, Attoe, Mountford, Morgan, & Sly, 2014). Likewise, recent findings using AAT paradigms to assess approach and avoidance tendencies in patients with anxiety or depressive disorders remained inconclusive (Struijs et al., 2017). Thus, we assume that not social anxiety per se, but rather the avoidance of body evaluation causes a preference for relatively larger IPDs in EDs.

The preference for larger distances in EDs associated with Body Avoidance is specific to underweight and obese stimuli. This might be due to a fundamentally different social norm for distances in interactions with overweight people. Interestingly, the distance we consider to be appropriate between two avatars is very similar to the distance we prefer between ourselves and an avatar (Hecht et al., 2019; Welsch et al., 2018). Would ED's who keep larger distances to an obese avatar also estimate larger distances between two avatars (one avatar being obese)? This could be studied by employing a stop-distance procedure using first- and third-person approaches, comparable to Welsch et al. (2018), with obese and underweight avatars in a normal weight control sample and individuals with EDs.

In line with Leutgeb, Leitner, Klug, and Schienle (2016), it is considerable that disgust is involved in the effects of Body Avoidance on IPD. We hold, akin to

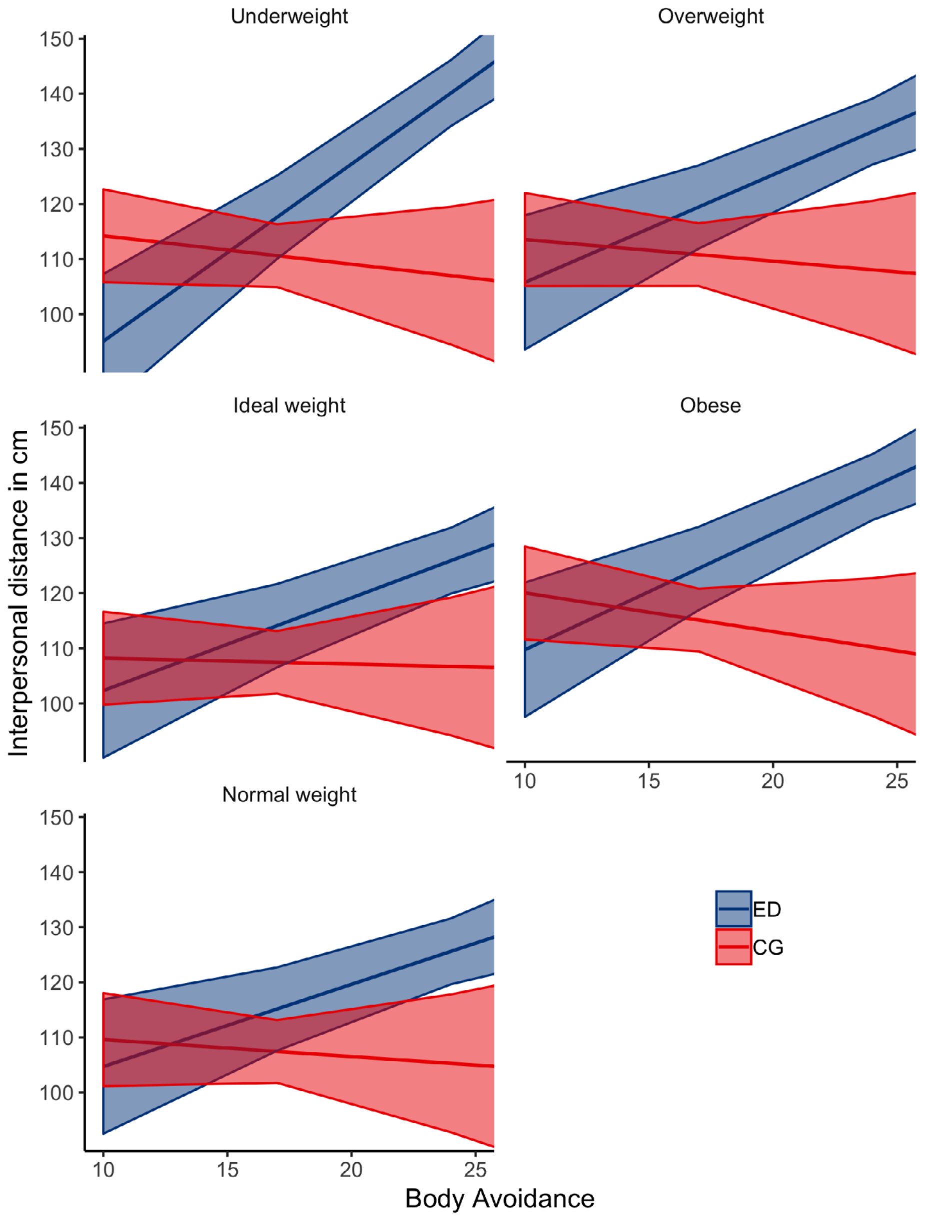

FIGURE 4 Mean predicted interpersonal distance in centimeters (cm) as a function of BA as measured by the BCAQ separated by avatar weight and group. Areas around the regression lines indicate 95% pointwise confidence bands based on standard error of the mean

Woud et al. (2011) that fear of fat is associated with body image avoidance, but we suspect that disgust rather than anxiety triggered the behavioral manifestation of the fear of fat. State anxiety can indeed be unrelated to the level of how much a person engages in body image avoidance behaviors (Bamford et al., 2014). Moreover, fear of fat seems to be a less likely explanation than disgust as a mechanism underlying the larger IPD towards underweighted avatars, as attractiveness was not strongly affected by the manipulation of avatar weight. Given that underweight is normally attractive for women with EDs, but obesity is not, a straightforward fear of fat should have produced shorter distances toward underweight avatars – not the U-shaped function we found. Future studies are warranted to further investigate whether underweight and overweight/obese interactants trigger different approach/avoidance processes and to which extent disgust at non-ideal bodies and/or fear of fat could be mechanisms for these differences or similarities.

Our data failed to show associations between IPD and eating pathology, BMI, and body dissatisfaction. At first sight, this may seem odd, however, other studies obtained similar results in related domains. Using an AAT approach, Leins et al. (2018) failed to find an approach bias towards thin figures, or associations between BMI and body dissatisfaction in a clinical sample. Thus, it may be that in a clinical sample, features that normally impact social interactions, such as body dissatisfaction, a heightened BMI, or drive to thinness, are overridden by more powerful underlying (dysfunctional) processes. Exploring the influence of body-image avoidance behavior with the IPD paradigm may help to further enlighten the picture.

4.1 | Limitations, implications and future research

A preference for larger IPDs in EDs may alter social behavior in EDs. People who keep greater distances produce discomfort in others (Thompson, Aiello, & Epstein, 1979) and are judged to be less likable (Schiffenbauer & Schiavo, 1976). This may have detrimental effects for the social interactions of individuals with EDs and could result in a decline of their social contacts. Our experiment does not speak to this, but it could be investigated by studying long-term IPD preferences and social behavior.

A strength of our study is the use of a virtual reality environment in combination with a well-established stop-distance-paradigm for the assessment of IPD. The virtual reality environment allowed us to manipulate avatar weight and gender while posture, expression, body height, and perspective remained controlled during all trials. Moreover, through our statistical analysis, we could reveal that group differences in IPD are mainly based on the effect of self-reported Body Avoidance (i.e., the Body Avoidance scale of the BCAQ) on IPD preferences.

To better understand the underlying mechanisms of the effects of avatar weight and Body Avoidance on IPD, especially in individuals with EDs, further studies should control for the level of experienced emotions such as disgust, anxiety, or strain. Furthermore, it is of interest to investigate whether body rumination (i.e., thinking and evaluating one's own body) during the approach to the avatar modulates IPD. This could further clarify the cognitive processes that may prompt participants with ED and high Body Avoidance to stop at larger distances especially when approaching underweight and obese avatars.

There are several limitations that need to be mentioned: We used self-report assessments to capture ED symptoms and did not perform a clinical structured interview in the control group. Thus, we might have missed—if not recognized by the participant itself—any psychopathological problems regarding ED symptoms as well as other psychopathological features. However, the EDI-2 is a well-validated questionnaire that is often used as a screener for ED psychopathology (Segura-Garcia et al., 2015). Also, social anxiety disorder (Rinck et al., 2010; Swinbourne et al., 2012) or personality disorders (Fineberg et al., 2018; Schienle, Wabnegger, Schongassner, & Leutgeb, 2015) were not monitored. They might have contributed to the finding of larger IPD in EDs as compared to CG. Note, however, that this could not explain the change in the effect of Avatar weight on IPD between samples. Note also that we did screen for depression in the CG but not for other personal characteristics such as sexual orientation (Uzzell & Horne, 2006) or experienced trauma (Bogovic, Ivezic, & Filipcic, 2016; Fineberg et al., 2018; Maier et al., 2019), which could have influenced IPD.

The ED-sample used in this study suffered from a range of eating disorders (bulimia nervosa, anorexia nervosa, binge eating disorder, other specified feeding or eating disorder), which could have potentially decreased statistical power due to heterogeneous effects of the subsamples. However, there were no strong indications of such heterogeneity at the descriptive level (see Figure S4). Although eating behavior as well as body checking (e.g., Legenbauer et al., 2017) strongly differ among EDs, the characteristic of interest in our study, Body Avoidance, is typically shared across these EDs (Legenbauer et al., 2017; for a meta-analysis see Walker, White, & Srinivasan, 2018).

Furthermore, we focused on attitudinal as well as behavioral aspects of body image and did not include other aspects of body image such as perceptual or affective components. Future studies may use global for example, the quality of life as well as more fine-grained multidimensional measures of the body image such as perceptual or affective components (e.g., Cash et al., 2004). Also, we could not exactly measure the body weight of the avatar and thus the percentages in Table 1 do not necessarily correspond to any anthropometric properties of the respective categories. We have used an average-weighted avatar and have then modeled the other avatars on this basis. The latter have not been independently assessed with regard to their perceived BMI, thus, our label of the smaller, leaner, more muscular avatar as ideal-weighted may be called into question. However, we think that our modeling of avatar weight was appropriate, as attractiveness ratings were highest in ideal-and normal-weighted avatars as compared to obese and underweight avatars (see Figure S3). Nevertheless, future studies could probe into this issue by not only assessing the attractiveness but also the perceived morphometric properties of the avatars such as the estimated weight, height, and body-circumference.

Nandrino et al. (2017) showed that social skills could be influenced by the duration of a given ED. As we had not obtained information about ED-durations, we cannot differentiate our data with respect to this variable. Future research should pursue this dimension. Also, given our heterogeneous ED- sample, we do encourage independent replication in larger subsamples of EDs.

In sum, we have expanded the findings of Nandrino et al. (2017) by showing that the larger IPD in individuals with EDs was influenced by the level of Body Avoidance. Most importantly, IPD was modulated by the body weight of the avatars in a U-shaped manner. Extremely thin and fat avatars produced larger distances than did normal-weighted avatars. This was attenuated in EDs, probably due to an avoidance of their own body.

CONFLICT OF INTEREST

The authors declare no potential conflict of interest.

ENDNOTES

[1] In order to analyze interactions of the experimental manipulations and personal variables, we computed linear mixed models (LMM) using the lme4 package (Bates, Mächler, Bolker, & Walker, 2015) on the basis of individual trials (Baayen, Davidson, & Bates, 2008). Model selection prior to analysis was based on likelihood ratio-tests comparing the fit (maximum likelihood) of the concurrent models. To estimate the significance of fixed effects, models were refitted based on restricted maximum-likelihood estimates, and degrees of freedom were approximated using the Satterwhaite-method for Wald *t*-test and *F*-test type III. Estimates of R^2 are based on the MuMIn package by Barton (2013).

[2] The Body Avoidance-model fitted significantly better than a model with the Body-Checking scale, $\chi^2(0) = 103.72$, $p < .001$, AIC = 14,572, or the Reassurance Seeking scale of the BCAQ, $\chi^2(0) = 84.05$, $p < .001$, AIC = 14,415.

[3] We ran an additional analysis controlling for levels of Depression via the PHQ-2 as well as by controlling for attractiveness of the avatar. However, this did not change the pattern of the results. Furthermore, variation in IPD for every avatar was not related to variation in attractiveness judgements.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.

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