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BRIEF REPORT

A Virtual Reality Study of Cognitive Biases in Body Dysmorphic Disorder

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Previous research shows that individuals with body dysmorphic disorder (BDD) misinterpret ambiguous social information in a negative and threatening manner. These erroneous threat appraisals are thought to maintain disorder symptomatology and psychosocial impairment by reinforcing individuals' distorted self-image and ideas of social undesirability. Thus, maladaptive interpretation biases represent an important treatment target for this population; however, existing bias assessments and modification protocols are limited by the hypothetical and distal nature of scenarios and do not capture momentary experiential threat processes. The current study tested virtual reality (VR) technology as a novel, in vivo means of eliciting, identifying, and measuring threat interpretation biases in a clinical sample to better understand the fear/threat structure activated during social interactions in BDD. Findings indicated that, relative to nonpsychiatric controls ($N = 25$), individuals with BDD ($N = 25$) evidenced greater in vivo threat interpretation biases and discomfort ratings (distress, fear, perceived threat, urge to check, urge to avoid) in response to interpersonal scenarios presented via VR. This pattern of findings was also observed for established dispositional interpretation bias measures. Study findings enhance our understanding of disorder maintenance and offer more nuanced treatment targets. This study represents a critical first step in the long-term goal of harnessing VR gaming technology to supercharge existing treatment approaches for this debilitating illness.

General Scientific Summary

This study is the first to demonstrate that erroneous threat interpretation biases characteristic of body dysmorphic disorder (BDD) can be reliably elicited and measured via a novel virtual reality (VR) paradigm. Compared to nonpsychiatric controls, participants with BDD evidenced greater threat interpretations and discomfort ratings in response to 13 brief ambiguous social scenarios presented in a virtual environment. The VR assessment was highly feasible and acceptable, and it may offer more ecologically valid information about momentary threat processes than previously established dispositional measures.

Keywords: body dysmorphic disorder, cognitive bias, virtual reality, assessment

Body dysmorphic disorder (BDD) is a highly understudied and debilitating psychiatric condition characterized by preoccupation with an imagined or slight flaw in one's physical appearance and time-consuming compulsive behaviors aimed at checking, hiding, fixing, or reducing perceived threat associated with appearance concerns (American Psychiatric Association, 2013). Individuals with BDD evidence markedly impaired psychosocial functioning, high rates of unemployment and disability, and lower quality of life compared to community and psychiatric samples (Marques et al., 2011). They also exhibit a problematic pattern of referential thinking and "mind reading," such that they believe that others are taking special notice of their appearance and judging, mocking, or rejecting them because of how they look (Phillips, 2009). Thoughts of this nature lead to negative/threatening interpretations of ambiguous social information. For instance, individuals with BDD commonly misinterpret neutral facial expressions as angry or contemptuous (Buhlmann et al., 2006) and erroneously interpret self-referent ambiguous situations, rating negative appearance-related outcomes as likely explanations of the ambiguity (Buhlmann et al., 2002; Clerkin & Teachman, 2008). Falsely perceiving ambiguous emotional expressions and social situa-

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tions as threatening or rejecting serves to reinforce BDD symptomatology and social avoidance (Buhlmann et al., 2006, 2011, 2013).

Recent studies have examined techniques for correcting these cognitive biases by training healthier interpretations of ambiguous social information (Buhlmann et al., 2011; Dietel et al., 2018; Premo et al., 2016; Summers & Cougle, 2016; Wilver & Cougle, 2019). However, existing methods of assessing and remediating these problematic threat biases are limited by the removed and hypothetical nature of scenario presentation. For instance, Buhlmann's Interpretations Questionnaire (IQ; Buhlmann et al., 2002) and the Word–Sentence Association Paradigm modified for BDD (BDD-WSAP; Summers & Cougle, 2016) are two dispositional measures that capture threat biases characteristic of BDD by asking participants to read and indicate their interpretations of hypothetical ambiguous situations. This approach relies on the individual's capacity to imagine themselves in a scenario and self-report based on expected beliefs or behaviors. Thus, the naturalistic experience of these social threat interpretations (i.e., momentary cognitions and discomfort) remains unclear. Establishing the nature of these processes in vivo is a critical next step.

Virtual reality (VR) technology has shown promise in recent years as an experiential approach to assessing, understanding, and treating psychiatric conditions (Freeman et al., 2017). However, this technology has not yet been harnessed to advance the understanding of BDD symptomatology. VR provides an immersive experience that simulates real-world scenarios and thus may be the optimal medium to examine in vivo threat appraisals during social interactions. A VR study of interpretive biases in BDD may extend and improve upon traditional measures by elucidating real-time, ecologically valid, cognitive–behavioral treatment targets.

Current Study

VR technology was tested as a novel means of eliciting and assessing interpretation biases in BDD. Nonpsychiatric ("healthy") controls (HCs) were chosen as a comparison group to establish initial differences in the target threat processes. The aims of the current study were as follows:

Aim 1: To compare BDD participants to HCs in their momentary interpretations of everyday social situations presented in VR (i.e., in vivo biases) and examine whether observed interpretation styles map onto those captured by established bias measures (i.e., IQ; BDD-WSAP). We anticipated that BDD participants would evidence greater endorsement of appearance-related threat interpretations and lower endorsement of benign interpretations across established measures and novel VR scenes.

Aim 2: To examine whether discomfort in VR environments distinguishes between groups; we hypothesized that BDD participants would exhibit greater threat, distress, urges to check appearance, and urges to avoid.

Aim 3: To test the feasibility, acceptability, and usability of VR in this population.

Method

Participants

Individuals with primary BDD ($N = 25$) and HCs ($N = 25$) were recruited through the hospital volunteer research registry and online study advertising portal. Procedures were approved by the institutional review board.

Inclusion criteria were age 18+ and primary BDD (BDD group; assessed via the Structured Clinical Interview for *DSM–5* [SCID]-BDD module; First et al., 2015) or no current psychiatric diagnosis (HC group, assessed via the Mini International Neuropsychiatric Interview [MINI]; Sheehan et al., 1998). Exclusion criteria were psychosis, active (hypo)manic episode, severe substance use disorder (six or more symptoms), or current suicidality. The clinical sample was 72% female ($N = 18$) with ages ranging from 18 to 57 ($M = 30.04$, $SD = 11.47$); 8% identified as Hispanic/Latino. The racial makeup was as follows: 52% Caucasian, 20% Asian, 8% African American, and 20% mixed race. The average age of onset for BDD diagnosis was 16 (range = 7–30; $SD = 6.48$); comorbidities are presented in Table 2. HCs were matched for average age (range = 22–37; $M = 29.78$, $SD = 4.18$) and sex ($N = 18$ females); 8% identified as Hispanic/Latino; racial makeup was 64% Caucasian, 28% Asian, 4% African American, and 4% mixed race.

Procedural Overview

A research assistant (RA) evaluated prospective participants via a phone screen. Once invited to the clinic, they were consented and assessed for eligibility by the principal investigator [PI] (first author) via clinical interview. Ineligible individuals were given $25 and dismissed, while those eligible received $75 for participating. Participants then completed self-report questionnaires, followed by the VR interpretive bias assessment (~30 min) and immersion measures.

Clinician-Administered Measures

Diagnostic Interview

All participants completed the interview with the PI. The BDD module of the SCID (First et al., 2015) was used to ascertain whether participants met diagnostic criteria for BDD (20% reviewed by an independent doctoral-level clinician with 100% agreement observed for BDD diagnosis; $n = 5$; $\kappa = 1$). The MINI (Sheehan et al., 1998) was used to determine presence of other *DSM–5* psychiatric disorders. Participants were considered for the HC group if they did not meet criteria for any current psychiatric conditions.

Yale–Brown Obsessive-Compulsive Scale Modified for BDD

The Yale–Brown Obsessive-Compulsive Scale Modified for BDD (BDD-YBOCS; Phillips et al., 1997) is a semistructured interview that assesses BDD symptom severity over the past week. Items are anchored to the individual's specific appearance concerns and rated by a trained clinician from 0 (*no symptomatology*) to 4 (*extreme symptomatology*). The BDD-YBOCS has demon-

strated excellent internal consistency (α = .92), sensitivity (90.2%), and specificity (Phillips et al., 2014). This measure was administered to the BDD group only.

Brown Assessment of Beliefs Scale

The Brown Assessment of Beliefs Scale (BABS; Eisen et al., 1998) is a semistructured clinical interview evaluating BDD-related insight based on a core erroneous belief about their appearance (e.g., "I am deformed."). It has strong psychometric properties (internal consistency [α = .87], sensitivity [100%], and specificity [86%] for categorizing level of insight; Phillips et al., 2013). The BABS was administered to the BDD group.

Self-Report Measures

BDD-WASP

The BDD-WSAP (Summers & Cougle, 2016) is a method of assessing automatic BDD-related threat biases. Participants see 33 ambiguous appearance and/or social sentences (e.g., "You pass a mirror while shopping."). Each sentence is shown twice, once paired with a negative/threat interpretation word (e.g., "ugly") and once with a positive/benign interpretation word (e.g., "attractive"). Participants rate how related the word and the sentence are from 1 (*not at all related*) to 6 (*very related*); ratings are summed to create "threat/negative" (α = .98) and "benign/positive" (α = .95) subscales.

IQ

The IQ (Buhlmann et al., 2002) is a 33-item measure that assesses negatively biased interpretations across three types of scenarios (BDD/appearance-relevant, social-relevant, and general). Participants are shown an ambiguous scenario and asked to rate the likelihood of three interpretations coming to mind from 0 (*very unlikely*) to 4 (*very likely*). Out of the three possible interpretations, one reflects a negative interpretation. Participants' ratings of the negative interpretations are summed to form three subscales anchored to the content of the scenario: BDD/appearance threat interpretations (α = .97), social threat interpretations (α = .96), and general threat interpretations (α = .85).

VR Interpretive Bias Assessment

Equipment and Content

We worked with a VR company that specializes in stimuli for mental health treatment, Limbix (https://www.limbix.com), to customize content on a Pico Goblin VR headset. The 13 individual scenarios were produced by researchers at the hospital and Limbix, based on input from the study PI and the extant cognitive bias literature. Experimental scenes were filmed with a 360-degree camera, lasted between 18 and 105 s, and were set in various contexts. Each scene began with a paused image, during which participants were oriented to the setting and circumstances with a brief audio clip. Scenes contained ambiguous social cues that commonly evoke threat interpretations in BDD populations (see Table 1).

A neutral, nonsocial setting (i.e., forest scene) served as a "pallet cleanser" before and after each experimental scene. Participants saw the forest scene for the first 3 min of the VR experience to acclimate and again between each experimental stimulus for 30 s to reduce potential carryover effects.

Interpretation Assessment and Reactivity Ratings

Following each of the 13 experimental scenarios, participants were shown two possible interpretations of the social ambiguity presented in each scene (e.g., participant in mailroom when a woman enters, does a doubletake in the participant's direction, and apologizes). Participants rated the likelihood, from 0 (*not at all likely*) to 10 (*extremely likely*), of one benign interpretation (e.g., "She thought we may have known each other") and one appearance-related (threat) interpretation (e.g., "She apologized for staring at me because of how I look") as explanations of the scene ambiguity. Presentation of the benign versus appearance interpretation was alternated to reduce presentation effects; all participants rated both interpretations for every scene. Ratings

Table 1
List of Virtual Reality Scenarios With Ambiguous Social Cues Filmed for the Current Study

Context	Task/scenario (will also include ambiguous tone and facial expressions)
1. Waiting room[a]	Stranger picking a seat away from participant in waiting room
2. Doctor's office[b]	People looking toward participant in doctor's office
3. Work meeting[a]	Coworker comments on participant's appearance before a meeting and is sitting across from two attractive people whispering to each other
4. Waiting room[a]	Participant sitting across from someone who is visibly frustrated
5. Work meeting[b]	Participant giving a presentation to work colleagues
6. Break room[a]	Participant overhears a conversation about someone else's appearance
7. Mailroom[a]	Someone also getting their mail does a double take looking at participant
8. Elevator[a]	Attractive man joins participant in the elevator
9. Train station[b]	Man walks by in train station, smiles, and then looks back at participant
10. Bar[b]	Standing at bar and bartender does not take participant's order
11. Stage[a]	Participant is standing in a group for a group photo
12. Convenience store[a]	Two women look at participant and walk away to continue their conversation
13. Busy street[b]	Man walking by makes frustrated gesture toward participant

Note. Scenarios were filmed using a 360-degree camera. The order of scenes listed here represents the order in which the scenes were presented.
[a] Filmed by researchers at the hospital. [b] Filmed by Limbix (VR company).

Table 2
Comorbid Disorders in Clinical Body Dysmorphic Disorder Sample (N = 25)

Comorbidity	*N*	Percentage
Major depressive disorder	18	72
Social phobia	10	40
Obsessive–compulsive disorder	5	20
Bulimia nervosa	5	20
Generalized anxiety disorder	3	12
Panic disorder	3	12
Agoraphobia	3	12
Posttraumatic stress disorder	2	12
Bipolar disorder	2	8
Marijuana use disorder (moderate)	2	8
Binge eating disorder	1	4

Note. The participants who met criteria for bipolar disorder were not in (hypo)manic episodes at the time of data collection.

were made within the headset (numbers shown horizontally in visual field). Across scenarios, ratings were averaged to form a "benign" and an "appearance-related" interpretation score.

Participants were also asked to rate peak experiences of the following during each scenario from 0 (*not at all*) to 10 (*extreme*): perceived threat, distress, urge to avoid situation, and urge to check appearance. Ratings were made within the headset; responses were averaged across scenarios to create mean scores for each of the four distress ratings.

VR Immersion Measures

Directly following the VR experience, participants rated the following questions on a scale from 0 (*not at all*) to 10 (*extremely*): "How would you rate the overall *acceptability* of the virtual reality portion of the study?" "How *engaged* were you in the virtual environment?" "How strong was your *sense of being present* in the virtual environment?" "How *realistic* did the virtual environments feel?" and "How similar was the content of the virtual environments to real-world experiences you've had?"

Results

The data were screened for violations of assumptions prior to analysis. No outliers were identified. Groups were matched for gender ($p = 1.00$) and average age ($p = .92$); no significant group differences were observed for predominant race/ethnicity ($p = .39$). The BDD group presented with moderately severe symptoms and poor insight; the observed severity was comparable to that of treatment-seeking samples (e.g., Wilhelm et al., 2019). Descriptives and group comparisons are presented in Table 4.

One-way multivariate analysis of variance (MANOVA) tests were conducted to examine group (BDD vs. HC) differences in variables of interest. Conceptually related outcomes were grouped as follows: (a) in vivo interpretation biases (appearance/threat and benign interpretations of VR stimuli), (b) dispositional interpretation biases (i.e., threat and benign interpretation subscales of BDD-WSAP; appearance, social, and general threat interpretation subscales of IQ), and (c) discomfort ratings during VR experience (i.e., perceived threat, distress, urge to avoid, and urge to check appearance). Significant MANOVAs were followed up with analyses of variance to evaluate group differences on individual constructs (see Table 4).

Of note, given that depression and social anxiety are also characterized by maladaptive interpretive biases (Everaert et al., 2017; Mobini et al., 2013), analyses were replicated controlling for co-occurring depression and social anxiety (multivariate analyses of covariance [MANCOVAs]). However, the patterns of findings were identical to those described below, suggesting that the observed group differences were not attributable to comorbidity.

In Vivo Interpretation Biases

Large effect sizes were observed for group comparisons. Individuals with BDD endorsed more appearance-focused (threat) interpretations in response to VR stimuli, compared to HCs. Conversely, HCs endorsed more benign interpretations of these scenarios, relative to the BDD group. Paired sample *t* tests examining within-group differences showed that the HC group rated the benign interpretations as significantly more likely explanations of the ambiguity than the appearance (threat) interpretations, $t(24) = 14.87$, $p < .001$. Interestingly, the BDD group rated the benign and appearance (threat) interpretations as equally plausible, $t(24) = -.27$, $p = .79$.

Appearance-related threat biases in response to the VR stimuli were highly correlated with participants' responses on the IQ and WSAP (see Table 3), further suggesting that the target cognitive schema was successfully activated via the novel in vivo paradigm (i.e., evidence of convergent validity for this new measure).

Dispositional Interpretation Biases

Between-groups differences were replicated with large effect sizes in established measures of bias (i.e., BDD-WSAP; IQ). Compared to the HC group, BDD participants endorsed more negative interpretations of ambiguous appearance, social, and general scenarios presented in the IQ. While HCs endorsed more benign interpretations of appearance-related situations on the WSAP, the BDD group endorsed more negative/threat interpretations of these same situations. In line with the in vivo bias findings, within-group analyses indicated that the HC group rated benign interpretations as more likely to occur to them than threat interpretations, $t(24) = 14.36$, $p < .001$. Conversely, the BDD group rated threat interpretations as more likely to occur to them than benign interpretations, $t(24) = -3.52$, $p = .002$.

In Vivo Reactivity (Discomfort Ratings)

Individuals with BDD exhibited greater discomfort with the VR stimuli across all indices. That is, relative to their HC counterparts, the BDD group reported higher average ratings of perceived threat, distress, urge to avoid, and urge to check their appearance during the situation (large effect sizes were observed; Table 4). Discomfort ratings were positively correlated with threat interpretations and negatively correlated with benign interpretations (as measured by both in vivo and dispositional interpretation bias measures; Table 3).

VR Feasibility and Acceptability Ratings

Participants largely indicated that they experienced the sense of being "present" in the VR environment and rated the experience as

Table 3

Zero-Order Correlations Between In Vivo Measures and Subscales of Dispositional Interpretation Bias Measures (Body Dysmorphic Disorder and Healthy Control Groups; N = 50)

Variable	1	2	3	4	5	6	7	8	9	10
Virtual reality (in vivo) measures										
Interpretations										
1. Appearance (threat) rating	1									
2. Benign rating	−.461**	1								
Discomfort ratings										
3. Threat	.861***	−.300*	1							
4. Distress	.946***	−.473**	.900***	1						
5. Urge to avoid	.948***	−.433**	.896***	.970***	1					
6. Urge to check appearance	.915***	−.385**	.837***	.881***	.927***	1				
Established dispositional measures										
BDD-WSAP										
7. Threat bias	.889***	−.532***	.777***	.858***	.884***	.891***	1			
8. Benign bias	−.583***	.661***	−.479***	−.558***	−.549***	−.562***	−.580***	1		
IQ										
9. Appearance	.891***	−.605***	.709***	.835***	.865***	.880***	.926***	−.666***	1	
10. Social	.885***	−.591***	.683***	.807***	.833***	.853***	.901***	−.680***	.945***	1
11. General	.771***	−.442**	.636***	.691***	.725***	.754***	.798***	−.667***	.804***	.850***

Note. Visual reality (VR) measures reflect interpretations and reactivity anchored to the in vivo VR stimuli designed for the current study (averaged across the 13 ambiguous scenes). BDD-WSAP = Word–Sentence Association Paradigm modified for BDD; IQ = Interpretations Questionnaire.
* $p < .05$. ** $p < .01$. *** $p < .001$.

highly acceptable, engaging, realistic, and similar to situations they typically experience (*M*s ≥ 7.52; scale: 0 [*not at all*] to 10 [*extremely*]). Groups did not differ in these ratings (see Table 4). Participants also completed all 13 scenes without refusal, further suggesting that the novel VR paradigm is both feasible and acceptable.

Discussion

This study extends the cognitive bias literature by demonstrating that maladaptive threat interpretation biases characteristic of BDD can be reliably elicited and assessed in vivo via VR technology. Relative to nonpsychiatric controls, BDD participants endorsed greater appearance-related threat biases and fewer benign biases when presented with 13 brief scenes depicting everyday social ambiguity in a virtual setting. Likewise, individuals with BDD endorsed higher discomfort ratings across the experimental scenes than did their healthy control counterparts. Interpretation styles and discomfort ratings anchored to the VR paradigm were highly correlated with established dispositional measures of interpretation biases (IQ; BDD-WSAP); this convergence offers preliminary evidence for the validity of the novel VR measure. Large effect sizes were observed for group differences. Participants also largely rated the VR experience as acceptable, engaging, realistic, and similar to experiences they have encountered, and they indicated feeling a sense of "presence" in the virtual environment. This demonstrates initial feasibility and acceptability of the paradigm. Although continued research on this topic is needed, VR assessment may represent a more ecologically valid means of measuring maladaptive interpretive styles compared to traditional (dispositional) bias assessments, offering insight into momentary threat processes.

Certain limitations of the current study provide directions for future research. First, given the novel nature of the VR paradigm and equipment, there were some incidents of technical glitches (e.g., frozen frames), requiring the RA to troubleshoot technology during the session. Although participants generally rated the VR experience as acceptable and engaging, any glitches that occur within the headset (no matter how brief) create disruptions in "presence." Technology is ever advancing, and VR research must continually strive for a seamless transition from the real world to the virtual world. Given that the current study focused on task development and convergent validity, it will also be important for future studies to establish divergent validity (e.g., correlations between VR reactivity and general anxiety or depression).

Further, our VR scenes were designed to evoke ambiguous social themes that commonly trigger BDD-related interpretations. Analyses indicated that these scenes did in fact evoke the anticipated thought patterns in the BDD participants; however, something to consider is how diverse populations might differentially interpret these ambiguous exchanges. Although we included diversity in our actors with regard to gender, age, and race, the majority of the characters in the scenes were White women, potentially creating unintended confounds for diverse participants. Unfortunately, our sample was too small to test for racial differences. Researchers interested in building upon this work might consider varying physical characteristics of the individuals in the scenes either via more diverse actors or via an avatar-based VR paradigm that allows for adjustments in characters' appearance.

The above-listed considerations notwithstanding, this study has a number of methodological strengths (e.g., multimodal evaluation, clinical sample recruited from the community, contribution of a novel VR interpretation bias assessment) and is the first to demonstrate that VR technology can be successfully harnessed to better understand BDD-related symptomatology. Of note, the comparison group we utilized in the current study was a nonpsychiatric ("healthy") control; however, many other psychiatric illnesses are

Table 4
Descriptive Statistics and Multivariate Group Comparisons for Study Variables

Variable	BDD group ($N = 25$)			Controls ($N = 25$)			Group comparisons
	Mean/total[a]	(*SD*)	Range	Mean/total[a]	(*SD*)	Range	MANOVA (follow-up ANOVAs)
BDD-YBOCS total[a]	29.08	(4.15)	23–37				
BABS total[a]	14.76	(4.35)	4–22				
Dispositional interpretation bias							*$F(5, 44) = 32.28$, $p < .001$, Wilk's $\Lambda = 0.21$, $\eta_p^2 = .79$
BDD-WSAP Threat	3.85	(1.03)	1.76–5.70	1.82	(.62)	1.09–4.40	($F = 73.94$, $p < .001$, $\eta_p^2 = .61$)
BDD-WSAP Benign	3.00	(.72)	1.70–4.79	4.40	(.67)	2.73–5.73	($F = 48.30$, $p < .001$, $\eta_p^2 = .52$)
IQ Appearance total[a]	26.76	(8.31)	11–39	4.71	(4.37)	0–14	($F = 133.42$, $p < .001$, $\eta_p^2 = .74$)
IQ Social total[a]	28.16	(8.07)	13–40	8.21	(6.49)	0–19	($F = 90.43$, $p < .001$, $\eta_p^2 = .66$)
IQ General total[a]	22.48	(4.93)	13–34	10.92	(4.83)	0–20	($F = 68.83$, $p < .001$, $\eta_p^2 = .59$)
VR (in vivo) interpretations							*$F(2, 47) = 33.83$, $p < .001$, Wilk's $\Lambda = 0.41$, $\eta_p^2 = .59$
Appearance (threat) rating	5.56	(2.10)	.38–8.46	1.61	(1.15)	0–4.77	($F = 67.67$, $p < .001$, $\eta_p^2 = .59$)
Benign rating	5.40	(1.54)	2.46–8.15	6.65	(1.23)	3.77–6.65	($F = 10.00$, $p = .003$, $\eta_p^2 = .17$)
VR (in vivo) discomfort ratings							*$F(4, 45) = 19.24$, $p < .001$, Wilk's $\Lambda = 0.37$, $\eta_p^2 = .63$
Peak threat	3.67	(2.38)	0–8.00	.70	(1.00)	0–4.00	($F = 32.94$, $p < .001$, $\eta_p^2 = .41$)
Peak distress	4.76	(2.31)	.46–8.46	1.01	(1.11)	0–4.08	($F = 53.27$, $p < .001$, $\eta_p^2 = .53$)
Urge to avoid	5.25	(2.31)	.54–9.00	1.12	(1.22)	0–4.38	($F = 62.53$, $p < .001$, $\eta_p^2 = .57$)
Urge to check appearance	5.60	(2.54)	0–8.69	.83	(.96)	0–3.62	($F = 76.81$, $p < .001$, $\eta_p^2 = .62$)
VR immersion ratings							$F(5, 44) = .30$, $p = .91$, Wilk's $\Lambda = 0.97$, $\eta_p^2 = .03$
Acceptability	7.96	(1.70)	5–10	8.48	(1.39)	5–10	($p = .24$)
Engaging	7.60	(2.04)	2–10	7.84	(1.46)	5–10	($p = .68$)
Sense of presence	7.52	(2.00)	2–10	7.72	(1.37)	5–10	($p = .64$)
Realistic	7.56	(1.85)	4–10	7.68	(1.80)	2–10	($p = .82$)
Similarity to real life	7.56	(1.83)	2–10	7.72	(2.25)	2–10	($p = .78$)

Note. BDD = body dysmorphic disorder; MANOVA = multivariate analysis of variance; ANOVA = analysis of variance; BDD-YBOCS = Yale–Brown Obsessive–Compulsive Scale modified for body dysmorphic disorder; BABS = Brown Assessment of Beliefs Scale; BDD-WSAP = Word–Sentence Association Paradigm modified for BDD; IQ = Interpretations Questionnaire; VR = virtual reality.
[a] Total scores are represented for variables that include the word "total" in the name; otherwise, values represent average scores/ratings.
* Indicates that the overall MANOVA was significant.

also characterized by disorder-specific cognitive distortions. Although we replicated analyses covarying for comorbid depression and social anxiety (MANCOVAs) and found that comorbidity did not account for study findings, future iterations of this work might seek to compare individuals with BDD to other clinical groups to better understand nuances in biases between psychiatric conditions and diagnostic specificity. Researchers may also test the utility of the VR paradigm designed for the current study as a transdiagnostic bias assessment, as it may be applicable to other disorders characterized by appearance concerns such as eating pathology or certain presentations of social anxiety. Likewise, researchers might consider controlling for current/previous medication or cognitive behavioral therapy to better understand the potential protective influences of treatment history on bias development. Moreover, researchers might evaluate the elements of scenes/contexts that make them salient to the individual, placing greater emphasis on understanding within-person variability in cognitions and reactivity, beyond simple group differences (e.g., repeated-measures design).

Although advancing interpretation bias assessment was the primary goal of this work, the current study may also have broader implications for novel treatment applications moving forward. Notably, during the VR portion of our study, within-group analyses revealed that the BDD group was equally likely to endorse the benign and the appearance-related (threat) interpretation. This pattern of findings is encouraging, as dispositional measures (e.g., the BDD-WSAP) typically indicate that these individuals are more likely to entertain the threat interpretation over the benign interpretation. It is possible that this differential pattern of findings suggests that, when faced with ambiguous social information in the moment, these individuals may be open to multiple explanations of the ambiguity. Perhaps there is a brief window of opportunity in which individuals with BDD have flexibility in their thinking that is not there when they are removed either hypothetically or temporally from a situation (in which case, they may be more likely to resolve ambiguity with negative/threat-related explanations). If this is the case, an intervention that capitalizes on this transient flexibility and teaches individuals with BDD to further entertain healthier interpretive styles could be particularly valuable. Existing research indicates that VR treatments translate to significant behavior change in real-life situations (Morina et al., 2015). Accordingly, VR may have utility as an intervention tool for individuals with BDD by facilitating in vivo remediation of maladaptive cognitions thought to maintain this debilitating illness (e.g., a VR-enhanced interpretation bias modification protocol).

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