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Blurring the boundaries of the self: Instagram's impact on bodily identity and multisensory experience among young adults

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ABSTRACT

Social media use is believed to shift users' focus to the outer body (i.e., physical appearance). However, this perspective may simplify the relationship between social media use and body perception. This study aimed to extend current knowledge by examining how three Instagram usage variables (i.e., daily time spent on Instagram, years of Instagram use, and Instagram beauty filter use) affect not only body image, but also individuals' inner body perception (i.e., interoception) and the integration of internal and external bodily experiences (i.e., embodiment). A sample of 95 young adults (64% women; *M* age = 25.8 years, *SD* = 4.25) completed self-reported measures of social media usage and body image concerns, underwent a heartbeat tracking task for assessing cardiac interoceptive accuracy and confidence, and experienced two virtual reality-based body illusions assessing face and full-body embodiment. Following multiple linear regression analyses, no social media usage variables were significantly associated with body image concerns or interoception. However, years of Instagram use and Instagram beauty filter use were uniquely associated with heightened susceptibility to face and full-body embodiment, respectively. We hypothesized that prolonged Instagram use and exposure to idealized, homogenized appearance-focused content may blur the perceptual boundary between self and others, a central process to bodily identity. Over time, this could contribute to an erosion of bodily identity. These results highlight a novel pathway through which social media use may shape self-perception: not by altering body image but by disrupting the integration of internal and external bodily experiences.

1. Introduction

In contemporary society, the body has become a central site of identity, self-presentation, and social interaction, especially within digital environments. Social media, in particular, has fundamentally reshaped how individuals relate to their bodies. Extensive research indicates that social media use, particularly interaction with appearance-focused platforms, is linked to body image concerns (Dane & Bhatia, 2023). However, this literature has primarily focused on external and appearance-based aspects of bodily experience, such as body shape dissatisfaction, weight concerns, and evaluations of physical attractiveness (Fioravanti et al., 2022; Holland & Tiggemann, 2016; Ryding & Kuss, 2020). Yet bodily experience extends beyond the "*outer*" body to encompass *internal* dimensions, including the capacity to perceive inner bodily states (i.e., interoception) and to integrate internal and external bodily signals into a coherent sense of self (i.e., embodiment), both fundamental to self-awareness (Badoud & Tsakiris, 2017; Tsakiris, 2017).

Additionally, existing social media research has focused predominately on the body as the primary site of appearance evaluation, largely overlooking the face. This omission is noteworthy given that the face is one of the most frequently shared forms of self-representation on social

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media, particularly through selfies (Belk, 2013), and target of beauty filters and photo-editing tools, widespread features across many platforms (Javornik et al., 2022).

Collectively, these gaps underscore the need for a more comprehensive account of how social media influences bodily self-perception. The present study addresses this by analyzing, for the first time, how social media use relates to multiple dimensions of bodily experience, spanning both face and body, and bridging external bodily perceptions with internal ones.

2. Literature review

2.1. Social Media's impact on the outer body

Body image concerns refer to cognitive and behavioural difficulties related to one's physical appearance, including preoccupation with perceived appearance flaws, appearance monitoring, camouflaging behaviours, avoidance of social situations, and reassurance-seeking. These concerns can vary along a continuum from non-clinical manifestations to severe, clinically significant symptoms (Schulte-van Maaren et al., 2014), and encompass not only body shape and weight, but also facial features. Importantly, body image concerns are consistently implicated in a range of adverse psychological outcomes associated with social media use, including depression, anxiety (Rodgers et al., 2023), eating disorders (Dane & Bhatia, 2023; Portingale et al., 2024a; Vincente-Benito & Ramírez-Durán, 2023), body dysmorphic disorder (Gupta et al., 2023), and muscle dysmorphia (Ganson et al., 2024).

Prior studies have linked different patterns of Instagram use with increased body image concerns (e.g., Tylka et al., 2023). In particular, higher daily Instagram use has been consistently linked to greater appearance-related preoccupations (Alfonso-Fuertes et al., 2023; Cohen et al., 2017; Sherlock & Wagstaff, 2019), often through maladaptive social comparisons (Alfonso-Fuertes et al., 2023; Sherlock & Wagstaff, 2019). This can increase perceived discrepancies between one's actual appearance and socially valued beauty standards, and lead users to engage with beauty filters and photo-editing tools (Riccio et al., 2024; Tremblay et al., 2021). Although these enhancements can temporarily boost self-esteem (Dijkslag et al., 2024), they also contribute to body image concerns (Schroeder & Behm-Morawitz, 2025), as individuals struggle to reconcile their offline appearance with their digitally enhanced personas (Dw & Subriadi, 2024; McGovern et al., 2022). Notably, similar emotional reactions may also emerge when spending time browsing or consuming appearance-related social media content shared by others, and engaging in more passive behaviors (Fardouly & Rapee, 2019; Tylka et al., 2023; Yang et al., 2020).

Over time, the use of beauty filters on social media can lead to a psychological phenomenon called “Snapchat dysmorphia” (Ramphul & Mejias, 2018; Tremblay et al., 2021), where individuals seek cosmetic procedures to replicate their filtered appearances. Together, these dynamics highlight how both immediate and prolonged exposure to Instagram's affordances may relate to body image outcomes.

2.2. Social Media's impact on the inner body

To date, no research has directly explored the impact of social media use on individuals' connection to their inner bodily experiences. A crucial lens for examining this dimension is interoception, defined as the process through which the nervous system monitors and interprets internal bodily states across all major biological systems (e.g., cardiovascular, gastrointestinal, and thermoregulatory) (Garfinkel et al., 2015). Interoception encompasses both accuracy (i.e., the ability to detect and track internal sensations) and confidence (i.e., the subjective belief in one's ability to accurately perceive their internal bodily signals) (Garfinkel et al., 2015). Research on clinical conditions characterized by profound bodily disconnection (e.g., depersonalization-derealization disorder, dissociative disorders, eating disorders) demonstrates that impaired interoception fundamentally undermines bodily awareness (Jenkinson et al., 2018; Malighetti et al., 2022; Schäflein et al., 2018; Sedeño et al., 2014).

The existing literature suggests that social media environments, through their attention on visual self-presentation and comparison, act as powerful triggers of self-objectification (Mink & Szymanski, 2022). According to the allocentric lock theory (ALT) (Riva, 2012), self-objectification locks individuals into an external, appearance-based self-representation, diverting attention away from internal bodily experiences. As a matter of fact, individuals who self-objectify demonstrate reduced cardiac interoceptive sensitivity, as their attention is focused on external bodily evaluations at the expense of internal sensations (Ainley & Tsakiris, 2013; Felig et al., 2022; Peat & Muehlenkamp, 2011).

Beyond self-objectification, social media use may contribute to a mind-body disconnection through other mechanisms. As a sedentary screen-based activity, it may inherently reduce opportunities for engagement with internal bodily sensation. Recent evidence indicates that screen-time behaviour (e.g., social media use) is associated with lower interoception than non-screen time activities (Wallman-Jones et al., 2023). Over time, in fact, reduced engagement with internal sensations may contribute to an “untrained” interoceptive pathway (Wallman-Jones et al., 2021): without sufficient bodily-focused activity, sympathetic activation may diminish, restricting the brain's ability to accurately recognise and respond to internal signals (Wallman-Jones et al., 2021).

Additionally, drawing from the competition of cues hypothesis (Pennebaker & Lightner, 1980), social media may compete for cognitive resources needed for interoceptive processing. As attention is directed toward external stimuli, fewer resources are available for internal sensory monitoring, further prioritizing external over internal cues. Consistent with this, engaging with screens (e.g., while navigating social media) has been linked to disruptions in embodied presence - the state of being completely aware of and engaged with one's body in the present moment (Puk, 2021) - suggesting how social media use distances individuals from their internal bodily experiences. Moreover, neuroimaging research demonstrates that problematic smartphone use modifies connectivity within the cingulate cortex, a key region involved in interoceptive processing, likely shifting users' attention away from internal bodily signals and toward external cues (Paik et al., 2019).

2.3. Embodiment illusions as a multisensory experience: the balance between internal and external body perceptions

Bodily self-consciousness refers to the ability to consciously perceive and recognise one's bodily states, processes, and actions as one's own (Mehling et al., 2009). Researchers have highlighted how this experience relies on an interplay between internal (interoceptive) signals, such as heartbeat or visceral sensations, and external (exteroceptive) inputs, like visual feedback (Badoud & Tsakiris, 2017; Mehling et al., 2009). Through a process called multisensory integration (MSI), the brain combines various sensory inputs across different modalities, creating a unified mental representation of the body, which is critical to maintaining a cohesive sense of bodily self-consciousness (Stein et al., 2020; Stein & Stanford, 2008; Tsakiris et al., 2011) (see Fig. 1).

Bodily illusions such as the rubber hand illusion (RHI) and the full-body illusion (FBI) provide powerful empirical paradigms for exploring the plasticity of body perception (Tsakiris, 2010). These experimentally induced perceptual phenomena reveal how the deliberate manipulation and synchronization of visual, tactile, and proprioceptive (i.e., sense of body position) inputs can temporarily disrupt the integration of interoceptive and exteroceptive signals, reshaping the perception of one's body. For instance, the RHI demonstrates how synchronous tactile stimulation of a visible rubber hand and one's own unseen hand can induce the sensation that the rubber hand is part of one's body (termed “*embodiment*”) (Botvinick & Cohen, 1998). Similarly, immersive virtual reality (VR) technologies can elicit the FBI by aligning

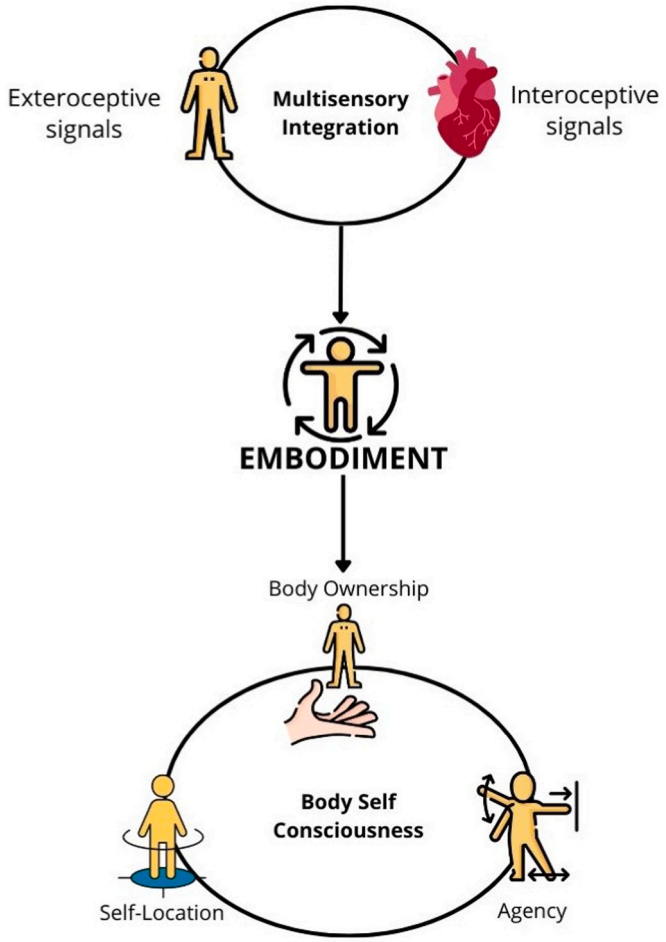

Fig. 1. A visual representation of embodiment as the integration of exteroceptive and interoceptive signals. The figure also presents the three core components of embodiment: body ownership, self-location, and agency.

virtual visual feedback with proprioceptive and tactile or motor cues (Keizer et al., 2016; Matamala-Gomez et al., 2021). As reported in Figure 1, three main features define embodiment: ownership (i.e., the sense that an external body or its properties are one's own), self-location (i.e., the sensation of being physically located in the external body), and agency (i.e., the feeling in control of the movements and actions of the external body in accordance with one's intention) (De Vignemont, 2011). The principles of body illusions and embodiment have recently been extended to facial self-perception, as evidenced by enfacement illusions, during which synchronous interpersonal multisensory stimulation (IMS) can result in the misattribution of another individual's facial features to the self-face (Porciello et al., 2018; Sforza et al., 2010; Tsakiris, 2008).

These experimental paradigms offer key insights into imbalances between internal and external inputs that can fundamentally shift the sense of bodily and facial self-perception by disrupting sensory integration. When accurate interoceptive representations are missing or weakened, one's self-model relies primarily on exteroceptive information (Porciello et al., 2018; Tsakiris et al., 2011), thereby increasing susceptibility to external influences and potentially undermining stable bodily self-consciousness (Badoud & Tsakiris, 2017). This is supported by evidence of increased susceptibility to FBIs (Tsakiris et al., 2011) and enfacement illusions (Tajadura-Jiménez & Tsakiris, 2014).

Predictive coding theory provides an important framework for understanding such interoceptive-exteroceptive interaction. According to this perspective, the brain constantly forms predictions about the likely causes of sensory inputs based on prior expectations (Friston, 2010; Seth, 2013). When prediction errors arise - that is, when sensory inputs deviate from expected signals - the brain updates its internal model to minimize discrepancies and maintain a coherent sense of bodily self (Friston, 2010). During body illusions, the brain synthesizes visual and tactile information to yield a single experience of ownership over an artificial body or body part. Notably, prediction errors occur because the artificial body lacks the internal bodily sensations normally associated with one's own body, thereby creating a mismatch between external sensory inputs and internal bodily representations. Consequently, individuals with high interoceptive accuracy may be less susceptible to these illusions, as precise interoceptive signals anchor their self-representation and reduce reliance on exteroceptive cues (Badoud & Tsakiris, 2017). Conversely, reduced interoceptive awareness may increase reliance on exteroceptive bodily information, distorting body representation (Brizzi et al., 2023). This is supported by consistent experimental evidence of increased susceptibility to body illusions among individuals with body image disturbance (Portingale et al., 2024c).

Given that social media use may weaken interoceptive awareness (Wallman-Jones et al., 2023) while amplifying external appearance focus (Bonell et al., 2021), and that the integration of interoceptive and exteroceptive signals is crucial for bodily self-consciousness (Tsakiris, 2017), social media use may influence how individuals process and integrate multisensory bodily information. If social media use shifts bodily self-representation away from internal signals and toward external cues, this may manifest as body image concerns, but also impaired interoception and disrupted bodily-self-consciousness. In other words, social media's impact may extend beyond concern with how the body *looks* to affect how the body *feels* and how coherently it is experienced as "*self*."

Yet, these relationships remain unexplored. Understanding such associations has important theoretical and clinical implications, and therefore warrants attention. Theoretically, it offers a unique opportunity to expand theoretical models of bodily-self-consciousness (e.g., predictive coding theory) and explore their applicability in digital settings. Clinically, it sheds insight into whether social media use is an important target in prevention and intervention strategies targeting distorted bodily experiences, such as those seen in conditions like eating disorders.

2.4. The current study

To capture distinct but complementary facets of social media experience, Instagram use was operationalized via three indicators. First, daily time spent on Instagram provides an estimate of the "dose" of users' exposure to appearance-focused and body-related social media content in their everyday lives. Second, years of Instagram use index long-term exposure to appearance-focused environments, potentially shaping more stable patterns of self-perception and bodily awareness over time. Finally, Instagram beauty filter use represents a more active and self-referential form of social media engagement, involving the deliberate modification and presentation of one's facial appearance. As highlighted in previous work (Tylka et al., 2023), different social media usage styles, including the frequency and/or duration of exposure and active engagement styles, may result in distinct psychological outcomes and, in turn, different bodily experiences.

Building on suggestions of Chorzępa et al. (2023), the present study aims therefore to (i) extend existing evidence on the link between social media use and body image concerns; (ii) advance current understanding by examining whether social media use is related to internal dimensions of bodily experience, such as interoception; and (iii) explore novel directions by investigating the relationship between social media use and embodiment responses to both body- and face-related multisensory illusions.

Based on these broad objectives, and to guide our investigation, we proposed three research questions identifying the specific variables and

relationships examined:

RQ1. Is Instagram usage (i.e., daily time spent on Instagram, years of Instagram use, and beauty filter use) associated with body image concerns among young adults?

RQ2. Is Instagram usage (i.e., daily time spent on Instagram, years of Instagram use, and beauty filter use) associated with a sense of disconnection from one's own body among young adults, as assessed through cardiac interoceptive accuracy and confidence?

RQ3. Is Instagram usage (i.e., daily time spent on Instagram, years of Instagram use, and beauty filter use) associated with differences in embodiment responses to full-body and face illusions among young adults?

Drawing from existing theoretical and empirical work (including conceptually related literature informing RQ2, as direct evidence linking social media use with interoceptive processes remains limited), we derived directional hypotheses for RQ1 and RQ2, while RQ3 remained exploratory We hypothesized that Instagram usage would be positively associated with more negative body image (i.e., greater body image concern) (H1) and an increased sense of bodily disconnection (i.e., lower interoceptive accuracy and confidence) (H2). Given the lack of existing literature on this topic, no hypothesis was specified for RQ3.

3. Methods

3.1. Participants

The final sample comprised 95 participants. Its size was determined via an a priori power analysis conducted using G*Power software (Faul et al., 2007). Based on the most complex linear multiple regression (six predictors: three social media variables and three controls) (two-tailed), the analysis assumed an effect size $f^2 = 0.15$, $\alpha = 0.05$, and 95% power, recommending a minimum of 89 participants to detect significant effects. The chosen effect size was informed by the relevant literature on the topic (Portingale et al., 2024c).

Inclusion criteria were: a) age 18 years or older, b) no self-reported medical or psychological conditions that may interfere with VR use (e.g., epilepsy) or significantly affect body image (e.g., eating disorders, psychotic disorders, severe depression; e.g., Crespi & Dinsdale, 2019; Georgiou et al., 2016; Portingale et al., 2024c); Portingale et al., 2024b), c) no self-reported medical conditions that may affect heart rate (e.g., heart disease) and d) no self-reported visual impairments that could impair the VR experience. Current Instagram use was not an inclusion criterion; we treated usage as a continuum, allowing participants to report any level of engagement (including zero usage for non-users), thereby capturing the full range of usage patterns.

The study received approval from the Ethical Board of the Catholic University of the Sacred Heart under protocol number 9524. Participants were volunteers and did not receive compensation for their involvement in the study.

3.2. Measures

3.2.1. Main predictors

Instagram Usage. Participants reported their: (i) average daily time spent on Instagram ("*How much time have you spent on Instagram in the past week (in minutes)*"), (ii) Instagram of Instagram use ("*How long have you been an Instagram user? (in years)?*"), and (iii) Instagram beauty filter use ("*Do you use Instagram beauty filters [filters that change your facial traits, for example making your nose smaller] (yes/no)?*". The binary beauty filter use variable is in line with prior research, which considered the presence versus absence of beauty filter use on social media as a meaningful behavioral threshold (e.g., Varman et al., 2021; Xu et al., 2023). To enhance accuracy, instructions before items (i) and (ii) guided participants to retrieve time spent on Instagram and account age directly from the settings in their Instagram application.

3.2.2. Additional predictors (control variables)

Sociodemographic Characteristics. Data were collected on age, gender, relationship status, ethnicity, sexual orientation, occupation, years of education, and history of diagnosed psychological conditions.

Trait-Based Empathy. The Interpersonal Reactivity Index (IRI) (Davis, 1980; Italian validation: Albiero et al., 2006) is a 28-item questionnaire that assesses trait-based empathy, on a 5-point Likert scale from 1 (*does not describe me well*) to 5 (*describes me very well*). The total score reflects the sum of all items, with greater values indicating higher trait empathy. In the current sample, the scale demonstrated acceptable internal consistency (Cronbach's alpha = 0.788).

Distress. The Depression, Anxiety, and Stress Scale (DASS-21) (Lovibond & Lovibond, 1995; Italian version: Bottesi et al., 2015) assesses distress levels over the past week, across 21 items rated on a 4-point Likert scale ranging from 0 (*never*) to 3 (*always*). The overall distress score is computed as the sum of all items multiplied by two. Higher ratings correspond to a greater level of distress. In the present sample, internal consistency was good (Cronbach's alpha = 0.893).

3.2.3. Dependent variables

Body Image Concern. The Body Image Concern Inventory (BICI) (Littleton et al., 2005; Italian validation: Luca et al., 2011) is a 19-item questionnaire measuring appearance concerns on a 5-point Likert scale, rated from 1 (*never*) to 5 (*always*). The BICI quantifies a specific type of body image concern named dysmorphic concern, which includes both cognitive (e.g., preoccupation regarding a perceived flaw in one's appearance) and behavioral components (e.g., monitoring or camouflaging the perceived defect, avoidance of social situations, and reassurance seeking, etc). Higher scores indicate greater body image concerns. Researchers generally argue that such scores should not be interpreted as inherently clinical (e.g., Collison & Mahlberg, 2019; Schulte-van Maaren et al., 2014) and on the contrary can be seen as a continuum of severity (Schulte-van Maaren et al., 2014). In our sample, internal consistency was excellent (Cronbach's alpha = 0.920).

Interceptive Accuracy and Confidence. We focused on cardiac interceptive measures given their ease of measurement compared to other interoceptive signals (e.g., gastric), and their involuntary nature - unlike respiration cannot be easily influenced by intentional control (Desmedt et al., 2023). Two interoceptive dimensions were assessed: accuracy and confidence.

Interoceptive accuracy was measured using the heartbeat tracking task (Schandry, 1981), in which participants were required to silently count their heartbeats over specific time intervals without manually checking their pulse, guessing, or estimating (Desmedt et al., 2020; Garfinkel et al., 2015). Following three 10 s practice sessions, participants completed three heartbeat counting trials of varying duration (25 s, 35 s, 45 s). During each trial, cardiac activity was recorded continuously using electrodes placed on the chest in Einthoven's triangle configuration via the BITalino PLUX Wireless Biosignals device. After each interval, participants reported the number of heartbeats perceived. Interoceptive accuracy was then calculated by comparing participants' estimates (counted heartbeats) with actual recorded heartbeats using the following formula (Di Lernia et al., 2020, 2023):

$$1/3\sum(1 - (|\text{recorded heartbeats} - \text{counted heartbeats}|) / \text{recorded heartbeats})$$

Scores range between 0 and 1, where lower values mean lower accuracy.

Additionally, interoceptive confidence was assessed as a measure of interoceptive metacognitive awareness (Di Lernia et al., 2023). Following each heartbeat counting trial, participants rated the degree of confidence regarding their response (i.e., estimated heartbeat count) using a visual analogue scale (VAS), which involved marking a point on

a 20 cm horizontal line, anchored at each end with the descriptors *"Not confident at all"* (0) and *"Fully confident"* (100). Confidence scores were calculated by measuring the distance (in centimeters) from the left anchor to the participant's mark and then dividing by two (Garfinkel et al., 2015).

Face and Full-Body Embodiment. Embodiment sensitivity was assessed using an adapted version of the embodiment questionnaire (EQ) developed by (Piryankova et al., 2014), previously employed in several Italian studies (Brizzi & Riva, 2024; Di Lernia et al., 2023; Serino et al., 2016). This 15-item questionnaire, rated on a 7-point Likert scale, evaluates the perception of the illusion across three core dimensions, namely, ownership (e.g., "*I felt like the virtual body was my body*"; 9 items), self-location (e.g., "*I felt like I was inside the virtual body*"; 4 items), and agency (e.g., "*I felt like I had control over the virtual body*"; 2 items). Scoring involved calculating the mean for each subscale (Piryankova et al., 2014). The same questionnaire was used for both the face illusion (FI) and FBI, with minor wording adjustments to reflect the relevant body part (face or body). Both adapted versions are provided in the *Supplementary Materials*. For all embodiment subscales (synchronous), internal consistency in the present sample was acceptable to excellent: face embodiment (Cronbach's alpha = 0.947 [ownership]; = 0.798 [location], = 0.913 [agency]), full-body embodiment (= .932 [ownership]; = 0.712 [location], = 0.953 [agency]).

3.2.4. Experimental paradigms

Embodiment was induced via two distinct VR-based illusions.

Face Illusion (FI). The FI was adapted from the traditional enfacement illusion experimental paradigm (Sforza et al., 2010; Tsakiris, 2008) to assess how embodiment illusion constructs apply to self-face representations. To reflect this, we termed the experience "face embodiment" rather than "enfacement". The procedure implemented visuo-tactile stimulation, one of the most robust techniques for inducing embodiment illusions (Brizzi et al., 2023). As illustrated in Fig. 2, participants viewed a bidimensional video through a VR headset, presented in an immersive cinema-like format, depicting a gender-matched real human face (male or female; BMIs within the healthy range: female: 21.8, male: 23.0). Participants observed the virtual human face through an allocentric (third-person) perspective being stroked on the cheek with vertical up-and-down motions using a soft brush, whilst the experimenter simultaneously applied identical tactile stimulation to the participant's own cheek using the same brush. The procedure included synchronous (*experimental*) and asynchronous (*control*) stimulation conditions, each lasting 120 s, comparable with previous enfacement illusion research (La Rocca et al., 2023; Sforza et al., 2010; Tsakiris, 2008). In the synchronous condition, tactile stimulation on the participant's own face and the virtual face took place in temporal synchrony. Visuo-tactile synchrony is the critical factor for inducing the illusion (Porciello et al., 2018). In the asynchronous condition, the same tactile stimulation was applied to the participant's face but with a temporal delay, thereby disrupting the alignment between visual and tactile inputs. This control condition served to confirm the specificity of any observed embodiment effects to multisensory synchrony (Porciello et al., 2018).

Full-Body Illusion (FBI). The FBI paradigm was designed to induce embodiment over a full virtual body through visuo-tactile stimulation (Brizzi & Riva, 2024; Keizer et al., 2016; Serino et al., 2019). As shown in Fig. 2, participants wore a VR headset and were instructed to align their physical bodies with the spatial orientation of a gender-matched

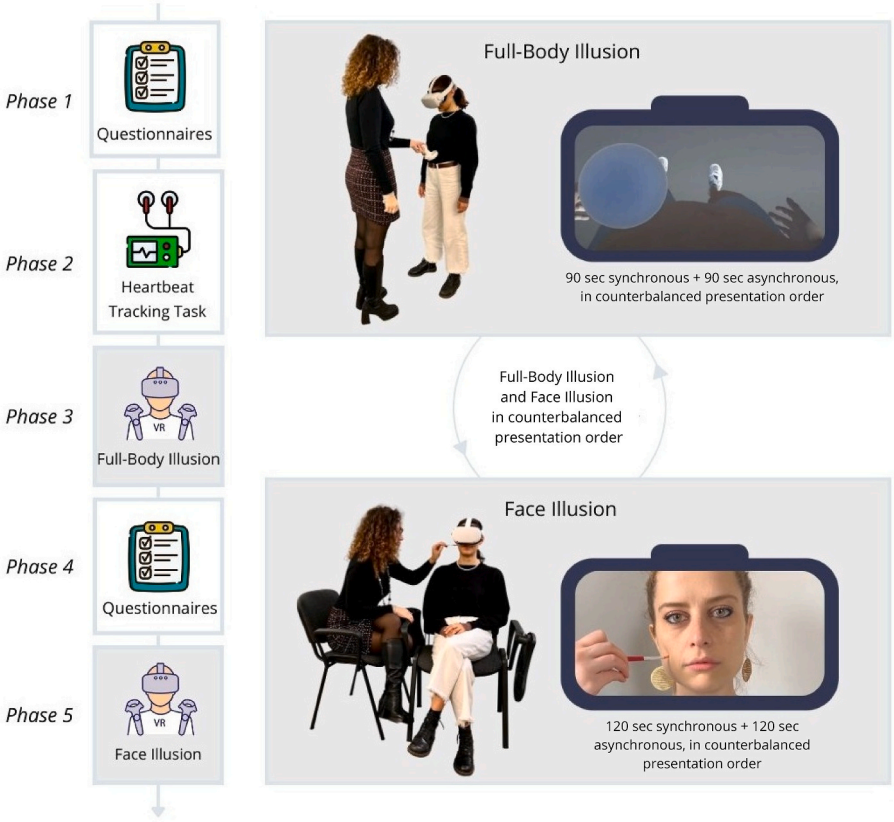

Fig. 2. An illustration of the experimental procedure. The left side of the figure illustrates the five main phases of the study, while the right side depicts two grey boxes presenting the induction of the Full-Body Illusion (FBI) and Face Illusion (FI) in virtual reality (VR). Within each grey box, the left image shows how the experimenter induced the illusion, and the right one the participant's corresponding visual perspective in VR. To ensure a balanced design, participants were randomly assigned to both the order of the illusion tasks (FBI or FI first) and the sequence of synchronous versus asynchronous visuo-tactile conditions. All participants underwent both FBI and FI, synchronous and asynchronous conditions.

virtual avatar (male or female; healthy BMI: 18.5) displayed from a first-person (egocentric) perspective. Participants observed the virtual abdomen being touched in lateral motions by a virtual ball, whilst the experimenter simultaneously applied the same tactile stimulation to the participant's own abdomen using the VR controller with a rounded end. The procedure included synchronous (*experimental*) and asynchronous (*control*) stimulation conditions, each lasting 90 s (comparable with previous FBI research, e.g., Brizzi & Riva, 2024; Keizer et al., 2016; Serino et al., 2019). In the synchronous condition, tactile stimulation on the actual abdomen and virtual abdomen took place in temporal synchrony. Such visuo-tactile congruence creates optimal conditions for MSI and embodiment of the virtual body (Serino & Dakanalis, 2017; Serino et al., 2016). In the asynchronous condition, tactile stimulation to the participant's abdomen was delayed by 10 s relative to the visual stimulation seen on the avatar, disrupting the visuo-tactile congruence necessary for embodiment (e.g., Brizzi et al., 2024; Brizzi & Riva, 2024). This control condition served to isolate the contribution of visuo-tactile synchrony to embodiment effects.

3.3. Procedure

Participants were recruited via social media advertisements using a snowball sampling approach, whereby a standardized message describing the study objectives and inclusion criteria was posted and shared. Interested individuals emailed the research team to schedule a laboratory session at the university, in Italy. Upon arrival, informed consent was obtained, eligibility was confirmed via self-declaration, and participants were informed of data confidentiality procedures and their right to withdraw at any time.

The experimental procedure comprised five phases (see Fig. 2). Phase 1 involved completion of baseline questionnaires (BICI and socio-demographic survey) to assess body image concerns without the influence of body illusions and to verify eligibility, respectively. The research team also confirmed the absence of medical conditions incompatible with VR use through self-declaration.

In Phase 2, participants performed the heartbeat tracking task, to assess baseline interoceptive accuracy. Heart rate data was recorded and monitored live by the experimenter on a tablet. Following three practice trials, participants estimated their heartbeat counts over three intervals of varying duration. After each interval, the experimenter recorded estimated and actual heartbeat counts, and participants rated their confidence in their responses via a VAS.

Phase 3 consisted of the first VR embodiment task - either the FBI or FI (see Fig. 2) - with task order randomized across participants. For each VR illusion, participants underwent both synchronous and asynchronous stimulation conditions, administered in randomized order. The EQ was then completed after each condition, via a tablet.

In Phase 4, following completion of the VR task, participants removed the VR headset and completed additional self-report measures (Instagram survey, DASS-21, and IRI) via a tablet. This 15-min phase also served as a latency period to minimize carryover effects between the two VR tasks.

Lastly, in Phase 5, participants completed the second VR task (i.e., whichever task was not completed in Phase 3, e.g., the FI, if the FBI was administered in Phase 3), following the same procedure described above. Importantly, all participants underwent both VR body illusions. The session concluded with a debriefing to address questions or concerns and explain study objectives. The full session lasted approximately 75 min.

3.4. Statistical analysis plan

3.4.1. Preliminary analyses

Statistical analyses were performed using R (Version 4.4.1; RStudio Team, 2023). Prior to main analyses, assumptions of multiple regression models were tested.

All models met the assumption of linearity and multicollinearity, as determined by visual assessment of residual plots and Variance Inflation Factors (VIFs) < 5. Homoscedasticity was evaluated using Breusch−Pagan tests, and error independence via Durbin-Watson tests; both assumptions were satisfied. Although Durbin-Watson values suggested minor autocorrelation in some models, values exceeded 1.5, indicating that any autocorrelation detected was unlikely to meaningfully bias the parameter estimates. Normality of residuals was assessed using Shapiro-Wilk tests and Q-Q plots and was upheld in most models. In the models where normality violations could not be resolved by transformation, bootstrapping was applied (5000 resamples with 95% CI).

Paired-samples t-tests confirmed that embodiment levels were significantly higher during the synchronous condition relative to the asynchronous condition for both FBI and FI (all $ps < 0.001$), suggesting that the embodiment procedure was effective (full results are presented in the *Supplementary Materials*, Table S1). This approach is supported by the theoretical rationale that stronger embodiment effects are observed following the synchronous condition (e.g., Brizzi et al., 2024; Brizzi & Riva, 2024). In addition, descriptive statistics were run, in order to provide information about the sample's characteristics.

3.4.2. Hypothesis testing

A series of multiple linear regression analyses were conducted to investigate the relationships between social media use (daily time spent on Instagram, years of Instagram use, and Instagram beauty filter use) and three outcome domains: body image concerns (RQ1), interoceptive accuracy and confidence (RQ2), and embodiment (location, ownership, and agency) across both face and full-body illusions (RQ3). All three social media variables were entered simultaneously as predictors to maximise statistical power and capture their combined effects. Multicollinearity among social media predictors was negligible (all VIFs ≈ 1; all bivariate correlations $r < 0.1$).

Given the substantial imbalance in beauty filter use (12 users vs. 83 non-users), additional balancing strategies were considered. Specifically, synthetic oversampling approaches (e.g., (Synthetic Minority Over-sampling Technique - SMOTE) and repeated random undersampling were evaluated as potential robustness strategies. However, both approaches introduced important methodological trade-offs in the present dataset: oversampling would have required generating a large proportion of synthetic minority-class observations from very few observed cases, while undersampling would have substantially reduced statistical power by discarding a large proportion of observed majority-group data. Primary analyses were therefore conducted on the original sample. Because of this limitation, findings involving beauty filter use should be interpreted cautiously and considered exploratory.

Control variables were selected based on established association with each outcome domain. For RQ1, overall distress (DASS-21) and gender were included given their known effects on body image concerns (Calogero & Thompson, 2010; Grogan, 2021; Luqman & Dixit, 2017; Mitchison et al., 2017). For RQ2, trait empathy (IRI), overall distress, and gender were used due to their potential impact on interoceptive outcomes (Heydrich et al., 2021; Ma-Kellams et al., 2024; Schulz & Vögele, 2015). Lastly, for RQ3, gender and trait empathy were entered in the models because of their possible influence on embodiment (Asai et al., 2011; Brizzi et al., 2024; Crespi & Dinsdale, 2019; Tajadura-Jiménez et al., 2012).

Exploratory analyses were also conducted for RQ3 using the embodiment subscale scores from the asynchronous conditions, to assess whether social media use predicted embodiment in the absence of multisensory congruence, thereby confirming the specificity of any effects to synchronous stimulation. Full results are presented in *Supplementary Materials*, Table S2.

4. Results

4.1. Characteristics of the sample

The final sample comprised 95 participants, which consisted of women (64%) and men (36%) with a mean age of 25.8 years (SD = 4.25). Participants were predominantly White, Caucasian, or European (88%). The majority identified as heterosexual (92%), single (45%), or in a non-cohabiting relationship (47%), with an average education level of 17.4 years (SD = 3.30). Most of the participants were students (56%). With respect to the sample's psychological history, 38% of the sample (n = 36) self-reported experiencing a psychological problem at some point in their lifetime. Detailed demographic and clinical characteristics of the final sample are presented in *Supplementary Materials*, Table S3.

As shown in Table 1, on average, participants spent 62.84 min on Instagram daily and had been on the platform for 7.66 years. Only a small proportion of participants (12.6%) reported using beauty filters. Descriptive statistics for the other modelled variables are also reported in Table 1.

4.2. Impact of social media use on body image, interoception, and embodiment

Only the results pertaining to the three social media use predictors (daily time spent on Instagram, years of Instagram use, and Instagram beauty filter use) are reported here; full model results including covariates (gender, psychological distress, and trait empathy) are presented in Table 2.

Across all multiple regression models, none of the three social media predictors significantly influenced body image concerns, interoceptive accuracy, or interoceptive confidence. Therefore, neither H1 nor H2 was supported.

With respect to H3, years of Instagram use was a significant predictor of both face embodiment ownership ($\beta = 0.14$, $SE = 0.06$, $t(81) = 2.29$, $p = .025$, full model $R^2 = .15$; Fig. 3) and face embodiment location ($\beta = 0.16$, $SE = 0.06$, $t(81) = 2.67$, $p = .009$, full model $R^2 = .19$; Fig. 4), suggesting that longer Instagram use history was associated with greater perceived ownership and self-location in relation to the virtual face.

Additionally, Instagram beauty filter use was a significant predictor of full-body embodiment agency ($\beta = 1.27$, $SE = 0.63$, $t(80) = 2.01$, $p = .048$, full model $R^2 = .13$; Fig. 5), such that beauty filters users reported higher perceived agency over the virtual full body.

Table 1
Descriptive statistics for modelled variables.

Variables	Statistics	Observed range
Daily time spent on Instagram (mins) *(M ± SD)*	62.84 ± 55.52	0–432
Years of Instagram use *(M ± SD)*	7.66 ± 2.75	2–12
Instagram beauty filter use (*n*, %)		
No *(M ± SD)*	83 (87.4%)	–
Yes ^ *(M ± SD)*	12 (12.6%)	–
Trait empathy *(M ± SD)*	96.93 ± 9.91	68–128
Distress *(M ± SD)*	28.44 ± 17.78	2–84
Body image concern *(M ± SD)*	48.32 ± 11.02	23–81
Interoceptive accuracy *(M ± SD)*	0.56 ± 0.26	0.00–0.99
Interoceptive confidence *(M ± SD)*	4.89 ± 2.30	0.00–9.20
Face embodiment		
Ownership *(M ± SD)*	2.84 ± 1.48	1.00–6.56
Location *(M ± SD)*	3.61 ± 1.52	1.00–6.50
Agency *(M ± SD)*	2.31 ± 1.56	1.00–7.00
Full-body embodiment		
Ownership *(M ± SD)*	4.03 ± 1.52	1.00–7.00
Location *(M ± SD)*	4.39 ± 1.38	1.00–7.00
Agency *(M ± SD)*	4.13 ± 1.99	1.00–7.00

Note.^Participants who reported using Instagram beauty filters (n = 12) were asked to specify their usage frequency using the response options: rarely, sometimes, often, and always. Frequencies were as follows: rarely (n = 5, 41.7%), sometimes (n = 6, 50.0%), often (n = 1, 8.3%), and always (n = 0, 0%).

Exploratory analyses using embodiment scores from the asynchronous conditions revealed no significant associations with any social media variable, supporting the specificity of the aforementioned effects to synchronous multisensory stimulation (see *Supplementary Materials*, Table S2).

5. Discussion

This study investigated how different dimensions of social media use (i.e., daily time spent on Instagram, years of Instagram use, and beauty filter use) relate to bodily experience among young adults, specifically external bodily self-perception (indexed via body image concerns), internal bodily processes (operationalized by interoceptive abilities), and their MSI (captured by embodiment illusion paradigms). To our knowledge, this is the first study to examine these relationships within a unified framework, providing novel insights into how digitally mediated environments may shape multiple dimensions of bodily self-experience. Contrary to our expectations, results showed that Instagram usage was unrelated to body image concerns or interoception. However, some important associations emerged concerning embodiment: years of Instagram use predicted greater susceptibility to face embodiment, whilst Instagram beauty filter use predicted greater susceptibility to full-body embodiment. These findings suggest that prolonged usage of social media platforms like Instagram and active engagement with appearance modification practices on these platforms may not independently affect inner and outer bodily domains, but rather the integration between them.

When using Instagram, users are subjected to simultaneous visual, tactile, and auditory stimulation (e.g., viewing photos, scrolling through posts, or listening to soundtracks on Stories or Reels), which could serve as a training ground for exteroceptive integration, particularly strengthening visual-tactile coupling, the same modalities involved in our study's embodiment paradigms. Over time, this engagement may potentially consolidate the neural pathways involved in visual-tactile integration (Shams & Seitz, 2008). Evidence from multisensory-plasticity research supports this idea, showing that prolonged exposure to environments requiring cross-modal sensory integration enhances MSI efficiency (e.g., Alwashmi et al., 2024; Shams & Seitz, 2008). Participants in the present study reported an average of 7.66 years of Instagram use, representing nearly 30% of their lifespans (M age = 25.8 years), a duration that is consistent with definitions of long-term social media exposure (da Silva Pinho et al., 2024) and sufficient for cumulative neuroplastic changes in MSI, as observed in MSI training studies (Paraskevopoulos & Herholz, 2013). Overall, these processes suggest that long-term, repeated Instagram use might gradually recalibrate the multisensory balance of bodily processing, possibly consolidating reliance on external sensory cues while weakening the stabilizing influence of internal bodily signals.

In parallel, a further progressive disattunement from interoceptive processes may occur due to Instagram's appearance-focused environment, which chronically directs attention toward external visual cues (how the face or body *looks*) rather than internal bodily sensations (how the face or body *feels*), increasing self-objectification (e.g., Yang et al., 2020) and thereby reducing interoceptive awareness (Watkins et al., 2025). This sustained outward focus could additionally reduce reliance on internal signals when constructing bodily self-representations (Badoud & Tsakiris, 2017).

A similar dual process likely occurs with Instagram beauty filter use. When users apply beauty filters, they experience coupled visual-tactile stimulation (e.g., watching facial features transform while swiping and tapping the screen), which may similarly enhance visual-tactile integration pathways (Alwashmi et al., 2024; Shams & Seitz, 2008). Simultaneously, interacting with digitally altered self-representations that look different from how the body actually feels might further shift bodily representation toward exteroceptive overreliance (Schroeder & Behm-Morawitz, 2025).

Table 2
Multiple regression results.

Outcome variable	Predictor	β (95% CIs [LB, UB])	*SE*	*t*	*p*	Multiple R^2
Body image concern	Daily time spent on Instagram (mins)	−0.00	0.02	−0.26	0.799	0.23
	Years of Instagram use	0.44	0.40	1.09	0.277	
	Instagram beauty filter use (yes)	3.17	3.09	1.03	0.307	
	Gender: male	−3.55	2.38	−1.50	0.139	
	Distress	0.27	0.06	4.38	**<0.001**	
Interoceptive accuracy	Daily time spent on Instagram (mins)	0.00	0.00	0.02	0.984	0.17
	Years of Instagram use	0.00	0.01	0.21	0.834	
	Instagram beauty filter use (yes)	−0.00	0.08	−0.05	0.962	
	Gender: male	0.19	0.06	2.91	**0.005**	
	Distress	−0.00	0.00	−2.42	**0.018**	
	Empathy	0.00	0.00	0.16	0.873	
Interoceptive confidence	Daily time spent on Instagram (mins)	0.00	0.00	0.89	0.377	0.21
	Years of Instagram use	0.01	0.09	0.16	0.871	
	Instagram beauty filter use (yes)	0.41	0.69	0.59	0.558	
	Gender: male	2.00	0.55	3.62	**0.001**	
	Distress	−0.03	0.01	−2.23	**0.029**	
	Empathy	0.01	0.03	0.45	0.655	
Face embodiment (ownership)	Daily time spent on Instagram (mins)	−0.00 [-0.01, 0.00]	0.00	−0.93	0.356	0.15
	Years of Instagram use	0.14 [0.02, 0.26]	0.06	2.29	**0.025**	
	Instagram beauty filter use (yes)	0.05 [-0.77, 1.03]	0.46	0.11	0.911	
	Gender: male	−0.04 [-0.80, 0.76]	0.37	−0.10	0.917	
	Empathy	0.04 [0.01, 0.07]	0.02	2.45	**0.017**	
Face embodiment (location)	Daily time spent on Instagram (mins)	−0.00	0.00	−0.51	0.609	0.19
	Years of Instagram use	0.16	0.06	2.67	**0.009**	
	Instagram beauty filter use (yes)	0.43	0.46	0.94	0.348	
	Gender: male	0.31	0.37	0.84	0.401	
	Empathy	0.06	0.02	3.47	**0.001**	
Face embodiment (agency)	Daily time spent on Instagram (mins)	−0.00 [-0.01, 0.00]	0.00	−0.50	0.620	0.06
	Years of Instagram use	0.04 [-0.12, 0.17]	0.07	0.60	0.547	
	Instagram beauty filter use (yes)	−0.45 [-1.21, 0.33]	0.52	−0.87	0.385	
	Gender: male	−0.56 [-1.33, 0.28]	0.42	−1.34	0.183	
	Empathy	0.01 [-0.02, 0.05]	0.02	0.43	0.671	
Full-body embodiment (ownership)	Daily time spent on Instagram (mins)	−0.00	0.00	−1.27	0.209	0.11
	Years of Instagram use	0.12	0.06	1.92	0.059	
	Instagram beauty filter use (yes)	0.43	0.48	0.89	0.376	
	Gender: male	0.86	0.39	2.21	**0.030**	
	Empathy	0.04	0.02	2.28	**0.025**	
Full-body mbodiment (location)	Daily time spent on Instagram (mins)	−0.00	0.00	−0.97	0.338	0.12
	Years of Instagram use	0.08	0.06	1.49	0.141	
	Instagram beauty filter use (yes)	0.84	0.44	1.91	0.060	
	Gender: male	0.92	0.36	2.57	**0.012**	
	Empathy	0.04	0.02	2.39	**0.019**	
Full-body embodiment (agency)	Daily time spent on Instagram (mins)	−0.00 [-0.01, 0.01]	0.00	−0.66	0.512	0.13
	Years of Instagram use	0.15 [-0.00, 0.30]	0.08	1.90	0.062	
	Instagram beauty filter use (yes)	1.27 [0.06, 2.54]	0.63	2.01	**0.048**	
	Gender: male	1.21 [0.15, 2.14]	0.51	2.37	**0.020**	
	Empathy	0.06 [0.01, 0.10]	0.02	2.57	**0.012**	

Note. Bootstrapped 95% confidence intervals (CIs) applied to models with assumption violations. LB = lower bound, UB = upper bound. Degrees of freedom differ across models due to listwise delection of missing data: df = 83 for the body image concern model; df = 81 for the interoceptive accuracy, interoceptive confidence, and face embodiment models; df = 80 for the full-body embodiment models. Significant *p* values (<0.05) are bolded.

Viewed together, this pattern suggests that, although common mechanisms may underlie embodiment across domains (face and full body), body representations are shaped by *distinct* multisensory processes that operate at *different* levels of bodily plasticity. Consistent with this interpretation, our results raise the possibility that multisensory processes associated with prolonged social media use uniquely influence self-face representation, but not the virtual body, suggesting a face-specific process of identification characterized by heightened malleability. This is particularly noteworthy because faces, unlike other body parts, convey complex visual and social cues; this unique feature makes them more resistant to perceptual illusions (Porciello et al., 2018). Furthermore, the FI employed an allocentric reference frame, typically less effective than the egocentric perspective used in the FBI at eliciting strong embodiment (Brizzi & Riva, 2024; Petkova et al., 2011). This is also confirmed by our results, which show greater embodiment scores for the FBI than the FI. Thus, additional influences may be at play.

Riva's (2018) body matrix framework can support the interpretation of our findings. This theory proposes that bodily self-representation (that is, how the self is defined and self-other boundaries are maintained, termed the *body matrix*) comprises three broad domains built over time through perception, MSI, and memory: (i) foundational body representations named *Protoself* (the *Sentient Body:* i.e., inner bodily sensations from interoceptive signals experienced through egocentric reference frames), (ii) intermediate body representations called *Core Self* (the *Spatial* and *Active Body*: i.e., the sense of spatial location and agency respectively, experienced through egocentric reference frames), and (iii) higher level body representations, termed *Autobiographical Self* (the *Personal, Objectified,* and *Social Body*: i.e., the sense of body ownership, the body as perceived by others, and the body as a social construct, in corresponding order, experienced through allocentric representations of the body across time and social contexts).

Our results suggest that social media selectively influences specific layers within the hierarchical organization of body representations. In particular, years of Instagram use, representing prolonged exposure, predicted face-specific embodiment in an FI allocentric paradigm and may reflect changes in what Riva defines *Spatial* and *Personal Bodies* (2018). This outcome aligns with changes at both the *Core Self* and, more importantly, the *Autobiographical Self*, the latter being the socially

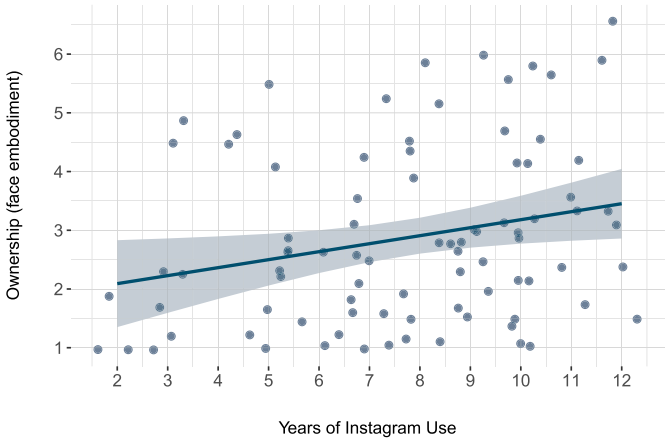

Fig. 3. Association between *years of Instagram use* and *sense of ownership* (face embodiment) following the FI. The solid line represents the model-predicted effect derived from the multiple linear regression model controlling for daily time spent on Instagram, Instagram beauty filter use, gender, and empathy. The shaded ribbon depicts the 95% confidence interval, and points correspond to observed data.

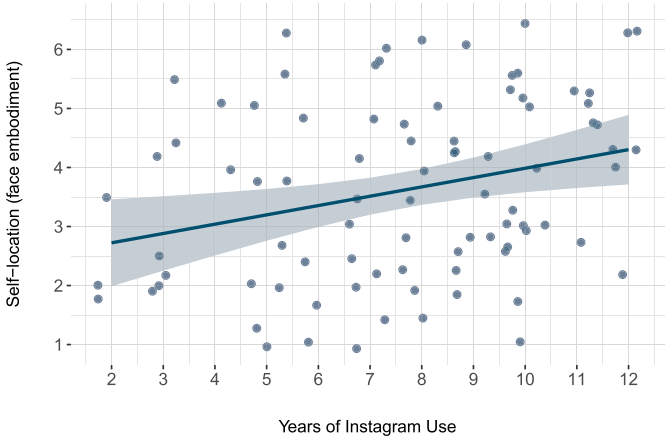

Fig. 4. Association between *years of Instagram use* and *sense of self-location* (face embodiment) following the FI. The solid line represents the model-predicted effect derived from the multiple linear regression model controlling for daily time spent on Instagram, Instagram beauty filter use, gender, and empathy. The shaded ribbon depicts the 95% confidence interval, and points correspond to observed data.

grounded, reflective layer that encodes how the body is represented across time and social contexts. This is meaningful because both the face and allocentric perspective are inherently social: faces carry greater identity and social significance than bodies because they serve as primary cues for self-recognition, emotional communication, and social evaluation (O'Toole et al., 2011; Rice et al., 2013; Tsakiris, 2017), while allocentric reference frames reflect how the body appears to others, in an observer-like perspective, linking self-perception to external, socially mediated viewpoints (Riva, 2012).

In contrast, beauty filter use, which appeared occasional rather than habitual in our sample (92% of participants reporting filter use indicated using filters only "*rarely*" or "*sometimes*"), predicted full-body embodiment in the egocentric FBI paradigm at the level of *Active Body*, possibly indicating transient sensorimotor modulation without consolidation into long-term body memory.

Importantly, the aspects of social media usage examined in the present study failed to influence either the most abstract (high level, *Social Body*) or foundational (low level, *Sentient Body*) domains of body representation. Regarding the former, our outcomes did not replicate

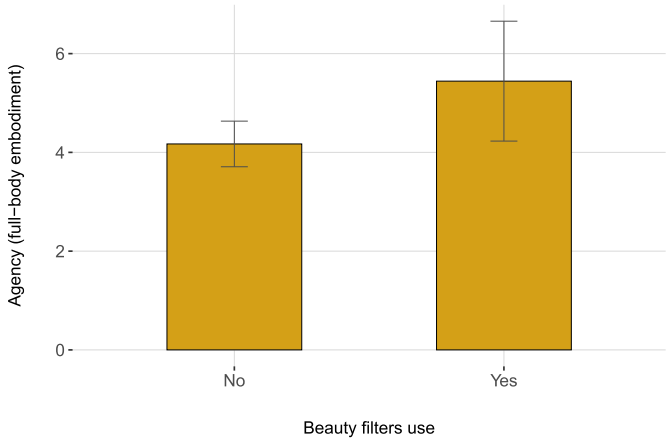

Fig. 5. Association between *beauty filter use* and *agency* (full body embodiment) following the FBI. Model-adjusted means of *agency* (full body embodiment) following the FBI by *Instagram beauty filter use*. Bars represent estimated marginal means (EMMs) derived from the linear model, adjusted for years of Instagram use, daily time spent on Instagram, gender, and empathy. Error bars indicate the standard error of the mean.

previous research suggesting straightforward relationships between social media use and body image concerns (Dane & Bhatia, 2023). This discrepancy aligns with previous reviews highlighting inconsistencies in the literature, where some studies found significant associations (e.g., Holland & Tiggemann, 2016), while others did not (e.g., Cohen et al., 2017), probably suggesting the influence of moderating or mediating factors (Keles et al., 2019; Saiphoo & Vahedi, 2019). Moreover, we hypothesize that the specific body image dimensions assessed may be critical. The most widely cited models conceptualize body image as comprising affective, cognitive, and behavioral dimensions (Cash & Smolak, 2011). The BICI, as used in our study, focuses on cognitive and behavioral concerns rather than affective dimensions (e.g., satisfaction), which may be more sensitive to social media influences (e.g., Fardouly & Vartanian, 2016; Portingale et al., 2024a). This methodological difference could account for varying social media effects across body image dimensions.

Concerning the foundational domain of body representation, our results also did not confirm the hypothesized effects on interoception and we found no detachment of individuals from their inner bodily sensations. One likely explanation is methodological: we relied on social media metrics (e.g., time spent on Instagram) and "static" interoceptive variables (e.g., interoceptive accuracy and confidence), which may not capture the *dynamic* nature of social media engagement and interoceptive processes (i.e., characterized by continuous change and fluctuation). The embodiment-disembodiment-re-embodiment scheme (Buongiorno, 2019) posits that digital technology engagement unfolds in cycles whereby individuals become embodied in devices while simultaneously disembodied from their physical selves, creating a duality that heightens focus on external representation (the "observed" self) at the expense of internal bodily awareness. Importantly, this framework suggests that state-like fluctuations in bodily awareness during social media use may be more relevant than trait-like dispositions. Supporting this view, Wallman-Jones et al. (2023) employed real-time tracking to capture interoceptive changes during screen-based activities including social media use, revealing associations missed by static measures. Furthermore, dynamic assessments may be necessary to better capture immersive flow-like states (i.e., states of deep engagement and intrinsic reward) induced by social media use (Brailovskaia & Margraf, 2024; Kwak et al., 2014; Wallman-Jones et al., 2023), which may temporarily suppress interoceptive awareness. Lastly, social media may have influenced interoception through indirect mechanisms not captured in the current analyses: for example, by

impacting body image or psychological distress, which subsequently altered interoceptive awareness and accuracy.

5.1. The digital Erosion of Bodily Identity Hypothesis: A dose-dependent effect on the body matrix

Building on the associations outlined above, our findings could suggest a dose-dependent relationship between Instagram use and the integrity of bodily representation, in a way that is consistent with and extends Riva's (2018) body matrix framework. *Prolonged* Instagram use was associated with face embodiment via an allocentric paradigm, while *intermittent* beauty filter engagement predicted body embodiment via an egocentric one. This pattern reveals that the *dose* of digital exposure - defined by its duration and persistence - might modulate embodiment at distinct hierarchical levels of the self: the social-reflective level (face, allocentric perspective) and the sensorimotor one (body, egocentric perspective).

This dissociation maps onto the hierarchical structure of bodily self-representation. The face, more than other body parts, serves as a primary anchor of bodily identity (i.e., the stable, perceptual experience of one's body as uniquely "mine", distinguishing the self from other individuals) (Rice et al., 2013; Tsakiris, 2010). The body, though central to movement and spatial awareness, carries fewer social and identity-defining connotations (Rice et al., 2013). Accordingly, sustained exposure over years may provide sufficient repetition to influence higher layers of the body matrix, gradually eroding not only spatial and sensorimotor body awareness (*Core Self*), but also the socially grounded, higher-level representations of bodily identity (*Autobiographical Self*). In contrast, intermittent engagement, such as occasional beauty filter use, may transiently modulate sensorimotor dimensions without consolidating into long-term body memory or disrupting identity.

Drawing on predictive coding frameworks (Apps & Tsakiris, 2014; Tsakiris, 2017), which posit that perceptual learning continuously updates body representations to maintain the sense of "mineness," we propose the *Digital Erosion of Bodily Identity Hypothesis*: prolonged social media exposure might interfere with identity-anchoring body representations through repetitive engagement with the homogenized beauty standards proposed on Instagram. The widespread portrayal of idealized, standardized appearance aesthetics on the platform fosters indeed an environment where "*everyone looks the same*" (Provenzano et al., 2024), potentially blurring perceptual self-other boundaries: if everyone looks the same, everyone *is* the same. This hypothesis aligns with and extends Riva et al.'s (2024) disembodied disconnect framework, which proposes that social media reshapes the embodied foundations of social connection between "me" and "others". While Riva et al. (2024) emphasize interpersonal disembodiment, our findings extend this idea, highlighting a complementary, intrapersonal erosion of self-other boundaries at the bodily level.

Notably, the hypothesized erosion of bodily identity appears specific to facial identity. This is perhaps unsurprising given that the face is more closely tied to selfhood and social recognition than the body (Porciello et al., 2018; Tsakiris, 2017). Indeed, the FI paradigm has been widely used to investigate the perceptual boundaries between self and other (Apps & Tsakiris, 2014; Porciello et al., 2018; Tsakiris, 2010), highlighting how MSI at the facial level shapes both bodily identity and social cognition.

In essence, shifting facial representations, as the most identity-defining body part, may require more sustained Instagram exposure before change manifests, but once disrupted, the consequences may extend deeply into the narrative and interpersonal domains of selfhood. Direct causal testing of our hypothesis is, however, necessary to validate the proposed dose-dependent model and determine whether digital

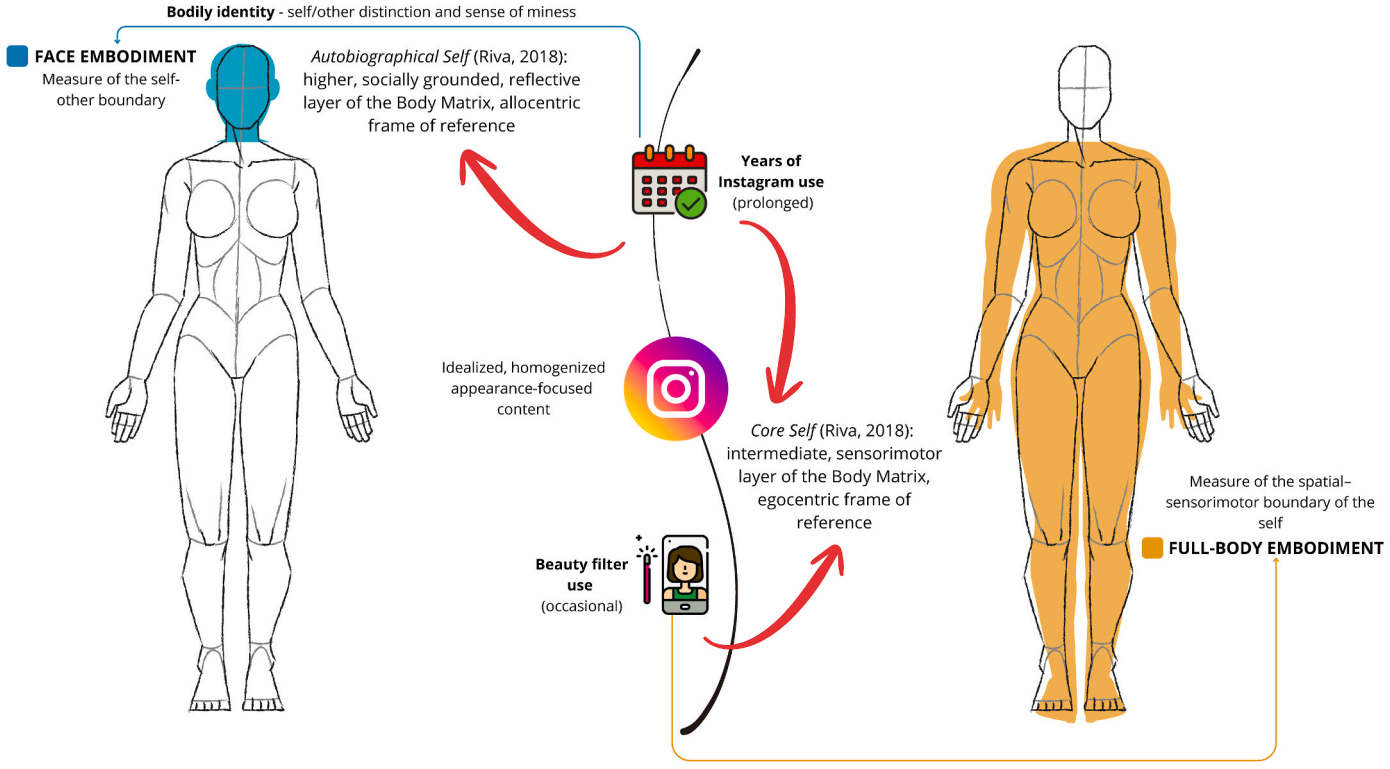

Fig. 6. A visual representation of the *Erosion of Bodily Identity Hypothesis*. The figure illustrates a dose-dependent relationship between social media use and bodily self-representation within Riva's (2018) body matrix framework. Prolonged Instagram use (in years) is proposed to affect higher, allocentric layers of the *Autobiographical Self* (face embodiment), whereas occasional beauty filter use modulates lower, egocentric layers of the Core Self (full-body embodiment). Exposure to idealized, homogenized content may gradually erode perceptual self-other distinctiveness. The proposed construct of bodily identity - the sense of one's body as uniquely "mine" - is conceptually situated along the blue line, representing the influence of prolonged Instagram use on self-other boundaries (specifically, weakened boundaries).

exposure causally contributes to the erosion of bodily identity. A visual representation of the proposed *Digital Erosion of Bodily Identity Hypothesis* is presented in Fig. 6.

5.2. Practical implications

The present findings, pending replication and extension, have important implications for individuals, clinicians, and digital platforms. At the individual and clinical level, if prolonged Instagram use disrupts bodily identity (i.e., creates challenges in preserving a distinct sense of self), this may contribute to significant psychological consequences (Dennison et al., 2023), such as anxiety, depression (Higgins et al., 1985), and identity diffusion, negatively impacting self-esteem and overall well-being (Sica et al., 2014). Clinicians could, therefore, focus on strengthening clients' connection between internal signals and external self-representation, helping them develop an awareness of how long-term social media usage may affect their sense of self and identity. Given that our findings implicate overreliance on exteroceptive (visual-tactile) cues, theoretically at the expense of interoceptive stabilization, interventions promoting interoceptive attention (e.g., mindfulness-based therapies) could help recalibrate the balance between inner and outer bodily experiences, ultimately reducing body disconnection. At a platform and policy level, our findings highlight the importance of modifying Instagram algorithms to diversify facial and bodily representation in users' feeds, reducing repetitive exposure to standardized beauty norms that may drive perceptual self-other blurring. Instead, algorithms could promote content that fosters self-expression through personal interests, skills, and values. Such efforts could shift platform norms, influencing the content users consume and fostering greater individuality. Platforms might also provide temporal nudges highlighting cumulative platform exposure (years of use) rather than merely daily screen time, as long-term exposure may pose a greater risk to identity stability. Digital literacy initiatives should also consider highlighting the negative effects of prolonged exposure to homogenized content (Paxton et al., 2022). Finally, the continued promotion of body-positivity movements remains important, not only in enhancing resilience against unrealistic beauty ideals but in actively encouraging users to preserve a strong sense of bodily identity (Rodgers et al., 2022).

5.3. Strengths, limitations, and future directions

Beyond the innovative aspects of this study (examining previously unexplored constructs in social media research, employing a novel methodological paradigm, and introducing a new possible theoretical framework for future investigations), our work also presents several methodological strengths. These include a sufficiently powered sample and the inclusion of potentially important confounding factors in our models, which enhances the robustness of our findings. Another strength is our mixed-gender sample, addressing the gender imbalance in previous embodiment-body image research (Portingale et al., 2024c).

Nonetheless, several methodological limitations warrant consideration. First, the differing methodologies for inducing embodiment, including the perspectives involved (first-person for the FI vs. third-person for the FBI), technologies used (real human faces for the FI vs. digital, virtual bodies for the FBI), and variations in tactile stimulation durations (120 s for the FI vs. 90 s for the FBI), limit comparability across the paradigms. Future studies should standardize experimental stimuli and procedures to enhance comparability and the reliability of findings.

Second, the cross-sectional design limits causal inferences; longitudinal studies are needed to explore the directionality of the assessed relationships and examine developmental trajectories, including whether and how social media usage impacts the potentially dynamic interaction between inner and outer bodily domains over time.

Third, reliance on self-reported data to exclude participants with psychological disorders may have introduced bias. Future research should implement validated clinical assessments or diagnostic screening tools to ensure more reliable exclusion criteria. Particular attention should be given to individuals with clinical body-image related conditions, due to their heightened susceptibility to the negative effects of social media (e.g., Imperatori et al., 2022; Shome et al., 2020), elevated social media engagement (e.g., Alsaidan et al., 2020), and the saliene of face-specific concerns among these populations (Portingale et al., 2024b, Portingale et al., 2025).

Fourth, the current study did not control for age, as the sample showed minimal age-based variability. However, age may influence social media's effects on embodiment, with younger individuals, raised in digital environments, potentially responding differently to body illusions than older individuals (Jones & Noppeney, 2021). Longitudinal studies across age groups could reveal developmental differences in the impact of social media on MSI. Additionally, the study's limited generalizability, due to its predominantly White, university-educated sample, calls for future research to include more diverse cultural and geographic groups, such as Asian populations, who may experience greater self-face disturbances (Frederick et al., 2016; Portingale et al., 2024d).

Fifth, to capture body image, the present study relied solely on the BICI (Littleton et al., 2005). However, its emphasis on appearance concerns and cognitive and behavioural dimensions of body image may limit its sensitivity to capture broader domain-specific aspects of body image, such as body satisfaction and appearance-based self-worth. Future studies should incorporate multidimensional measures to comprehensively assess all body image components.

Finally, our sample included a relatively small proportion of participants reporting beauty filter use, resulting in a substantial imbalance between filter users and non-users. Accordingly, as noted in the *Methods* section, findings involving beauty filter use should be interpreted cautiously and considered exploratory. Although this distribution likely reflects naturalistic patterns of Instagram engagement (Varman et al., 2021), future studies should recruit larger and more balanced samples of beauty-filter users to determine whether the present findings replicate reliably across independent datasets. Moreover, it is important to acknowledge that the “No” category in the present study specifically reflected the absence of active beauty-filter use (i.e., intentional digital modification of one's own appearance) rather than the absence of appearance-related Instagram engagement more broadly. The present operationalisation was intentionally designed to capture active self-modification behaviours; however, it did not distinguish between users who engage extensively with appearance-related content as passive consumers and users who engage with Instagram primarily for non-appearance-related purposes altogether. Similarly, the measure did not capture potentially important dimensions of beauty-filter engagement itself, including frequency of use, type of filter (e.g., cosmetic overlays versus facial restructuring such as eye enlargment), extent of facial/body modification, or underlying motivational factors (e.g., enhancement versus transformation). Future research should therefore adopt more nuanced classifications capable of differentiating between active appearance modification, passive appearance-related content consumption, and non-appearance-oriented social media engagement, while also employing more granular assessments of beauty-filter use. Such approaches would provide a more detailed understanding of how different forms and intensities of digital bodily exposure relate to body image, interoception, embodiment, and body disconnection, particularly among high-engagement users such as active content creators or influencers.

Additionally, future studies should also explore mediating mechanisms to further clarify the interplay between the variables we considered, such as trait self-objectification. Relatedly, researchers should also test how social media usage affects other layers of the body matrix, which influence how self-other boundaries are maintained, such as the *Objectified Body,* which taps into self-objectification (Riva, 2018). Furthermore, investigating the multisensory nature of social media experiences by deconstructing MSI components (e.g., visual, tactile,

auditory) is an important next step to understanding their role in body disconnection and interoceptive disruption. In this direction, machine learning approaches could expose subtle behavioral traces of social media engagement (e.g., Morini et al., 2025a; Morini et al., 2025b; Morini et al., 2026) or MSI (De Gaspari et al., 2023) that traditional statistical approaches do not measure. These patterns could serve as predictive markers for body image concerns, interoceptive deficits, or susceptibility to body illusions. Lastly, future work should investigate how social media use impacts adolescents' bodily identity, since adolescents are consistent Instagram users (Anderson & Jiang, 2018), and adolescence is a critical stage for social identity formation and susceptibility to idealized social media standards (Erikson, 1959; Field et al., 2024).

Overall, in a world increasingly shaped by the proliferation of digital technologies and digitally mediated bodily selves, our study provides novel evidence that digital exposure can alter the multisensory foundations of bodily identity, emphasizing the need to integrate the theoretical concept of digital embodiment into contemporary models of the self.

CRediT authorship contribution statement

Maria Sansoni: Writing – review & editing, Writing – original draft, Visualization, Software, Project administration, Methodology, Investigation, Data curation, Conceptualization. **Jade Portingale:** Writing – review & editing, Writing – original draft, Visualization, Validation, Formal analysis. **Stefano De Gaspari:** Writing – review & editing, Software, Investigation. **Giulia Brizzi:** Writing – review & editing, Visualization, Software. **Magdalena Chorzępa:** Writing – review & editing, Software, Investigation, Data curation. **Giuseppe Riva:** Writing – review & editing, Supervision, Resources.

Declaration of generative AI and AI-assisted technologies

During the preparation of this work the author(s) occasionally used ChatGPT (OpenAI) to make minor improvements to phrasing. After using this tool, the author(s) reviewed and edited the content as needed and take full responsibility for the content of the published article.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.chb.2026.109054.

Data availability

Data will be made available on request.

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