negative feelings are the *antecedents* of low body ownership in this condition or the negative feelings are the *consequence* of low body ownership is not clear. We believe that future studies on the treatment of this condition could determine the causal relationship between valence and body ownership, verifying whether enhancing positive feelings toward the body (or parts thereof) enhances embodiment or vice versa.

We propose that sense of body ownership can be included as a procedure of separation and connection, as defined by L&S. Body ownership demonstrably influences one's subjective experience of the world by shrinking or enlarging the perception of one's corporeal self. Further research on whether short and long-term changes in the sense of body ownership modulate its separation and connection power will be pivotal to understanding the potentially plastic nature of grounded procedures.

Highlighting the role of body ownership as a proxy for separation or connection is particularly relevant in contemporary society, where technological advances enable projection of the self into artificial bodies (e.g., robots and avatars). It is possible that, in the not-so-distant future, physical and social interactions will become more disembodied than ever, yet the psychological link between humans and their surrogates will still be deeply influenced by the ever-changing dynamics of corporeal awareness.

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Cleansing and separation procedures reflect resource concerns

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Abstract

We propose that procedures of separation have two functions, namely first, to establish the integrity of individual parts, and second, to make previously joint entities discreet and therefore countable. This allows taking stock of available resources, including evaluating the use of individual objects, a process that is especially adaptive under conditions of threat of contagious disease and resource scarcity.

Lee and Schwarz (L&S) outline a comprehensive model of how cleansing and other grounded procedures serve a common

purpose, namely to achieve a sense of separation. A key question, however, is *why* people aim to keep objects physically or psychologically separate from other entities. In other words, what is the benefit of doing so? One possibility is that such actions allow individuals to more easily keep track of what is important to them. Indeed, Schnall (2017) proposed that disgust can be considered to form part of a behavioral loss aversion system, with a conservation concern aimed at maximizing available resources. Physical cleansing serves to ensure the integrity of one's most precious commodity: a healthy body. It not only removes contaminants, but also facilitates a more general assessment of one's physical health. Taking such an inventory does not require disgust, however; the latter only arises when a threat to resources is perceived.

A key requirement to meeting this goal is to know where the relevant boundaries are, or, as the anthropologist Mary Douglas (1966) put it, to establish what is "matter out of place" (see also Duschinsky, Schnall, & Weiss, 2017). Implicit in this understanding is the metaphor of the body as a container (Schnall, 2014), which involves a differentiation between what is "inside" and "outside," and the boundaries arising from this distinction. Physical cleansing and separation facilitate a clearer appreciation of such boundaries, and establish the integrity of individual parts. Importantly, making previously joint entities identifiable also makes them countable, and the process of taking stock of material resources enables one to evaluate the use of individual objects. Indeed, it has been proposed that the number sense, that is, the ability to intuitively understand changes in quantities, is the result of a domain-specific cognitive mechanism that is already present in young infants (Wynn, 1998), and in a rudimentary form exists even in animals (Gallistel & Gelman, 2000). Thus, grounded procedures readily make apparent everything that counts.

To outline this logic, we consider a psychological condition for which excessive cleanliness coincides with a desire for keeping the environment orderly: obsessive-compulsive disorder (OCD). Although engaging in repetitive cleansing such as handwashing is typically thought of as the most prominent feature of the disorder, it often also involves a compulsion for counting (i.e., arithmomania) (American Psychiatric Association, 2013). For example, this can manifest itself in counting the bricks in a wall, or not wanting to step outside of tiles on the floor during walking. The obsession with counting can be seen as an amplified expression of grounded procedures of separation, involving a fixation not only on cleanliness, but also on quantities of material objects. Thus, it is plausible that one goal behind separation procedures is to provide assurance that one has what one needs, and for some people this is a constantly salient worry.

Also relevant in this context is OCD's close cousin, namely obsessive-compulsive personality disorder (OCPD). It not only involves a desire for cleanliness, but also a preoccupation with details, orderliness, cognitive rigidity, and miserliness – an inability to discard objects and a reluctance to spend money (American Psychiatric Association, 2013). In particular, cognitive rigidity, or the unwillingness to compromise, and the aversion to discard resources, is an example of the overlap between mental representations and sensorimotor modalities. That is, individuals with OCPD are reluctant to relinquish their beliefs as well as their belongings. Furthermore, they are precise with respect to how items are organized, such as the exact arranging of furniture, precise positioning of cushions, preference for set locations for belongings, distaste for untidy rooms, and care with their clothes

(Wellen et al., 2007). Such tidiness and particularity with the positioning of one's possessions suggest that this condition may be a extreme expression of the grounded procedures L&S describe.

Many psychiatric conditions fall on the extreme end of a continuum of thoughts and behaviors that, in moderation, are typically adaptive. Indeed, people often find it hard to give them up because such symptoms can come with undeniable benefits. For example, although OCPD is often debilitating with regard to personal relationships, it can be advantageous for career success: OCPD was found to be positively correlated with status and wealth, as measured by socioeconomic status, supervisory responsibilities at work, home ownership, and spacious living conditions (Ullrich, Farrington, & Coid, 2007). This may be because of the fact that individuals with OCPD show less temporal discounting than those without the condition – that is, they are superior at running the cost–benefit analyses that leaves them better-off in the long run (Pinto, Steinglass, Greene, Weber, & Simpson, 2014).

Keeping track of what one owns has clear benefits in general, but it is especially useful in times of scarcity or crisis, and when preparing for possible adversity. For example, highly successful navy submarine personnel were found to score highly on OCPD measures and adherence to rules and regulations (Moes, Lall, & Johnson, 1996). Indeed, grounded procedures are essential in the military, where every item is carefully inventoried and tracked: there is no room for error in assessing equipment when lives are literally at stake.

Grounded procedures involving resource concerns, whether expressed in normal or exaggerated forms, are especially adaptive under conditions of widespread contagious disease, as is the case for the current COVID-19 pandemic. When individuals need to stay away from others who pose a risk of infection, social relationships no longer constitute a source of support. In the early days of the pandemic, stockpiling supplies was maligned in the media as "panic buying." But accumulating materials goods, and monitoring their use and availability, are adaptive when there is a constant threat to one's health. Indeed, in uncertain times it is sensible to run a life's inventory, and ensure that all that is precious is in its rightful place.

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Proper understanding of grounded procedures of separation needs a dual inheritance approach

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Abstract

Grounded procedures of separation are conceptualized as a learned concept. The simultaneous cultural universality of the general idea and immense diversity of its implementations might be better understood through the lens of dual inheritance theories. By drawing on examples from developmental psychology and emotion theorizing, we argue that an innate blueprint might underlie learned implementations of cleansing that vary widely.

The central concept in Lee and Schwarz's (L&S's) model is *grounded procedures of separation*. These are argued to link sensorimotor processes to cognitive processes, specifically physical cleansing to mental dissociation. The concept has to do some heavy lifting to piece together various phenomena: It is more or less explicitly argued to be culturally universal. It is thought to be activated by the emotion of disgust, by engaging in actual cleansing without prior disgust, and even by only remotely associated behavior such as enclosing a note in an envelope. Bafflingly, many behaviors cited as implementing separation through cleansing are either pretend (participants hands are clean to begin with), or are even confounded with the opposite of separation, namely application (e.g., hand sanitizer) or outright contamination (e.g., burning incense). Clearly, learning is required here. Asking a concept to do such heavy lifting requires empirical and theoretical conscientiousness.

Empirically, the integration would benefit tremendously from evidence that the described experimental manipulations do in fact activate mental procedures of separation independently from the downstream consequences (i.e., manipulation checks). Those do not seem to be common in the cited studies.

Theoretically, paying more attention to how the concept of separation is developed ontogenetically will provide a more solid basis for the simultaneous universality and flexibility. The notions of grounding and simulation as used in the target article are based on Barsalou (1999). This seminal paper also theorized how perceptual symbols, the basis for simulations, develop in the first place. Barsalou focused on how these symbols are learned in a process of selective attention and subsequent storing of schematic sensory-motor states in long-term memory. That is presumably also the process assumed by L&S. Repeated experience of physical cleansing is schematized in a separation procedure concept. This concept is also subsequently evoked during mental dissociation (e.g., of the self from failure). The universality of that process might be explained by the fact that all humans have experience cleaning themselves, but that doesn't explain the rich variation on the theme.

However, Barsalou (1999) also noted that the learning process is likely to be influenced by genetic predispositions, for example through constraining the processing of space, objects, movement, and emotion. In his view, "a simulator is both a 'rational' and an 'empirical' system, reflecting intertwined genetic and experiential histories" (p. 586). Such intertwining of genetic and experiential determination is compatible with assumptions of dual inheritance approaches that argue that human biology and culture co-evolve and jointly determine behavior (Boyd, 2017; Boyd & Richerson, 1985; Fiske, 2000; Henrich, 2016). The costs of learning are outweighed by the benefits of acquiring accumulated and locally adaptive knowledge.

Simultaneous universality of basic principles and variability of actual implementations also occurs in phenomena that are already studied from a dual inheritance approach, namely core cognition concepts in developmental psychology and emotion research.

In developmental psychology, the core cognition approach argues that infants' learning is guided by a stock of innate primitives that include conceptual representations (Carey, 2009; Spelke, 2017). This includes basic cognitive concepts (e.g., magnitude and agency) and social concepts (e.g., authority and equality; Sheehy-Skeffington & Thomsen, 2020; Thomsen, Frankenhuis, Ingold-Smith, & Carey, 2011): Although large and up imply power universally in general, exactly what needs to be large and up is learned from culture (Schubert, 2020). Interestingly, the approach assumes that these core concepts are combined (Spelke, 2017) or complemented by culturally driven learning (Carey, 2009). The primitives are assumed to mostly remain active and constant throughout the lifespan, and can surface in adults when higher cognitive processes are taxed by mental load. This approach has concentrated on perception and cognition but could easily be extended to include behavioral output to accommodate procedures such as separation.

In emotion psychology, recent theorizing argues that emotions can be understood as combinations of innate functions that map appraisals onto motivations on the one hand, and culturally learned implementations on the other hand (Fiske, 2020; Fiske, Seibt, & Schubert, 2019). Both have to be learned in context, but their learning is directed by innate blueprints, explaining simultaneous universality and variation of such emotions (Zickfeld et al., 2019).