

Forum

The hidden weight of the body

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The weight of body parts is largely hidden from conscious experience. People underestimate the weight of their limbs, whereas individuals in clinical populations often experience them as abnormally heavy. We argue that limb weight is a fundamental dimension of internal body representations and a conscious reflection of the functional state of sensorimotor processing.

A neglected dimension of bodily experience

The weight of our body parts is among the most ubiquitous features of everyday experience, yet remains largely hidden from conscious awareness. According to Newton's laws, the weight of a body part is mass times gravitational acceleration. Our *experience* of body part weight, however, is constructed by the brain. Perception of weight has been studied most extensively in relation to objects. A large literature on haptic perception has shown that the experienced weight of an object is linked to the effort required to support it against gravity. Yet little research has examined the felt weight of the body itself [1]. This dimension of body representation remains surprisingly underdeveloped given that the body must be supported against gravity, just like held objects.

The weightlessness experienced by astronauts has long fascinated both scientists and the public. In microgravity, the body

floats freely and is experienced as largely weightless, revealing, by its absence, one of the most fundamental signals of bodily existence. On Earth, the everyday experience of body weight is so familiar that it often remains unnoticed. Recent evidence shows that even when it is directly attended to, the perceived weight of body parts is systematically underestimated [2]. We argue that this hidden aspect of bodily experience is a fundamental parameter of internal body representations, with important links to sensorimotor function and embodiment (Figure 1).

Measuring experiences of body part weight

A recently developed psychophysical approach quantifies the perceived weight of body parts [2]. Participants compare the felt weight of their hand to the felt weight of an externally applied load suspended from the wrist with a wristband. The load is adjusted to determine the amount of weight perceived as equal to the hand itself. This is then compared with actual hand weight, measured by water displacement. Results from this paradigm show that people make consistent—but biased—judgments of hand weight: they can reliably match the felt weight of the hand to an external load, but the load they choose is typically 30–50% lighter than the hand's true physical weight. Thus, under normal conditions, we do not experience the full weight of our limbs.

What explains this misperception? One possibility is that the felt weight of body parts is actively suppressed to support motor behaviour. This suppression may help regulate drives to move and to rest. When body parts feel light, movements may require less perceived effort, promoting activity. When they feel heavy, movements may require more perceived effort, promoting rest. Consistent with this, 10 min of intense physical exertion increased the experienced heaviness of the hand [2],

suggesting that the return of body weight during fatigue discourages further activity.

Another possibility is that hand weight is underestimated because the hand is perceived as being smaller than it really is. Critically, however, participants slightly overestimate hand volume while underestimating hand weight [3]. This indicates that people underestimate the density of the hand, misperceiving the 'stuff' it is made of. Further evidence comes from multisensory illusions that alter perceived hand size, which produce corresponding changes in perceived hand weight, while keeping perceived hand density constant [4]. These findings show that perceived limb weight is tightly linked to internal body representations built from multisensory signals.

A recent study investigated how learning to use a finger-extending exoskeleton alters its perceived weight [5]. Following 20 min of training, there was a reduction in perceived exoskeleton weight, while the perceived weight of the physical hand remained unchanged. This selective change indicates that the incorporation of external objects into sensorimotor hand representations can reduce their experienced weight, effectively making them feel more like part of the body. Perceived weight may be a useful measure of embodiment, with lightness signalling integration with mental body representations.

Limb heaviness in clinical conditions

Underestimation of limb weight in healthy populations contrasts with reports of limb heaviness in clinical populations (Box 1). Stroke patients, for example, often describe their affected limbs as abnormally heavy [6]. Such heaviness is often linked to experiences of the body as being made of denser substances, such as lead, concrete, or coal, and to abnormal experiences of limb ownership and embodiment [7]. Recent research links

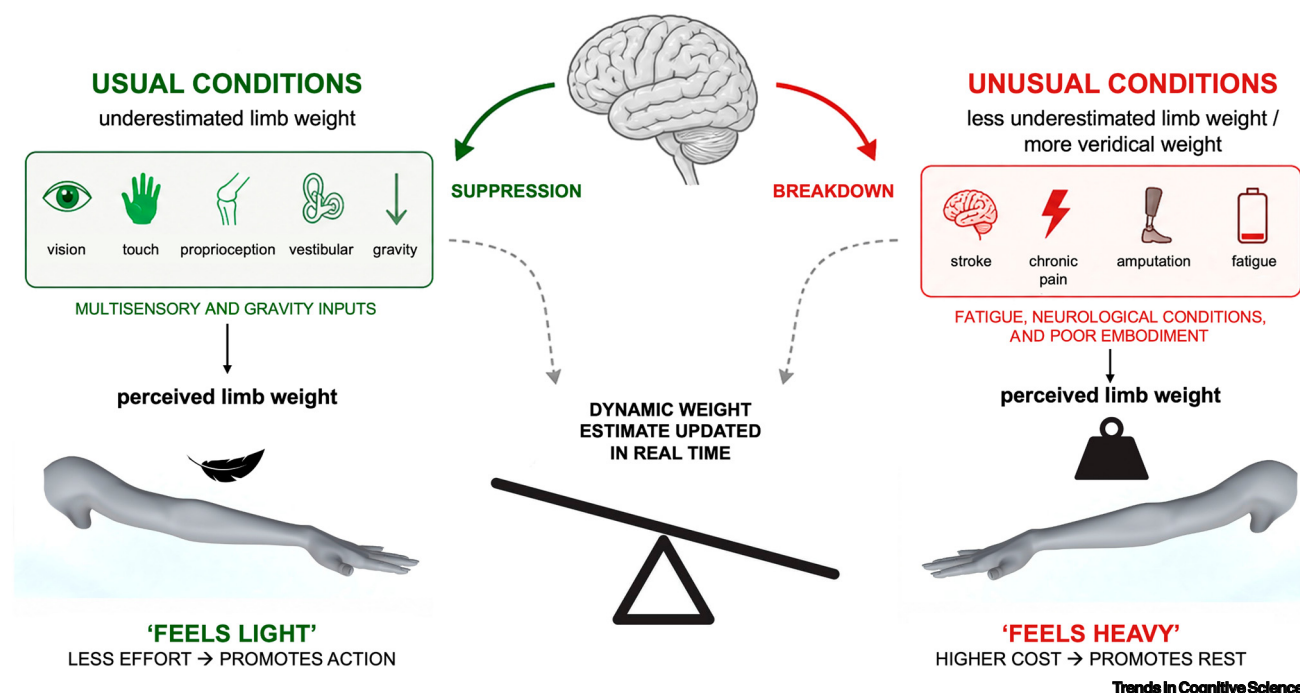


Figure 1. Experienced limb weight in usual and unusual states. Under ordinary circumstances, the weight of our body parts is suppressed, making the body feel light. In other cases, this suppression breaks down, and the weight of our body parts is experienced. This occurs in ordinary experiences of fatigue, as well as in clinical conditions, including post-stroke hemiplegia, chronic pain, and the use of prosthetic limbs.

such limb heaviness to post-stroke perceived limb weight [2]. These observations suggest that limb weight perception is not a niche perceptual phenomenon but a

fundamental parameter of sensorimotor representations by which the brain calibrates body perception for action.

Box 1. Phenomenology of body part heaviness

Under ordinary conditions, the weight of body parts remains hidden from awareness. Sometimes, however, this hidden aspect of experience emerges, resulting in sensations of heaviness.

Fatigue. Heaviness often emerges in fatigue and may motivate rest. Experimentally induced hand fatigue increases perceived hand weight [2]. This link is reflected in everyday linguistic idioms, including those in the native languages of all three authors:

- *English:* 'My eyelids are getting heavy'.
- *Portuguese:* 'Estou com os olhos pesados'. ['My eyes feel heavy'.]
- *Italian:* 'Sento le palpebre pesanti'. ['My eyelids feel heavy'.]

Post-stroke hemiplegia. Stroke patients often report that their affected limbs feel heavy. Louis Pasteur complained of his paretic arm: 'It is like lead; if only it could be cut off!' Other patients describe their limbs as being like 'a sack of coal' or 'concrete'.

Prosthesis use. Amputees often report that prosthetic limbs feel excessively heavy, even when the prostheses weigh less than a biological limb.

Pain. Chronic pain is linked to experiences of body part heaviness. One patient described his painful neck as feeling 'like an anvil'.

Return from microgravity. Astronauts have been struck by the heaviness of their bodies when returning to Earth, as in Chris Hadfield's comment: 'Right after I landed, I could feel the weight of my lips and tongue'.

Subjective complaints of heaviness are also reported in chronic pain conditions such as fibromyalgia [8] and complex regional pain syndrome (CRPS) [9]. One study used augmented reality to allow patients with CRPS who had a distorted body image to view their affected hand as they wished it to appear [9]. This intervention reduced pain and perceived hand heaviness.

Similarly, amputees frequently perceive prostheses as excessively heavy, although these devices are often physically lighter than biological limbs. Integrating prosthetic limbs into sensorimotor processing through intraneural stimulation can reduce their perceived weight while enhancing the sense of integration of the prosthesis as part of the user's body [10,11].

Functional significance of experiences of limb weight

In each of these clinical groups, perceived heaviness is linked to disrupted integration of the limb into sensorimotor body representations. We propose that these patients do *not* misperceive limb weight but instead experience it more veridically than usual. If healthy individuals underestimate limb weight [2], then experiences of heaviness may reflect a reduction in this underestimation. On this view, heaviness arises from a perceptual shift towards physical reality that feels abnormal because it deviates from the ordinary, nonveridical representation. This is consistent with broader arguments that distortions of body representation are functional parts of healthy cognition [12]. This reframes perceived limb weight as a core representational variable rather than a secondary perceptual bias. When one lifts another person's body parts, those parts feel surprisingly heavy, an observation widely noted by healthcare professionals, parents of young children, and anatomists. Lifting one's own limbs does not produce the same experience of heaviness exactly because the weight of one's own body parts is actively suppressed by the brain.

The perceived weight of body parts is not read from a single input but is actively constructed from converging visual, somatosensory, proprioceptive, and vestibular signals. Gravity is a critical input. Astronauts returning from spaceflight commonly report a pronounced return of bodily heaviness, in sharp contrast to their experiences of weightlessness during microgravity exposure. Indeed, parabolic flight studies inducing both microgravity and hypergravity demonstrate that perceived body part weight tracks gravitational changes [13]. The brain must therefore continuously estimate gravitational strength to construct body weight

perception in real time. Perceived body weight is therefore not a fixed internal representation but a dynamic estimate, continuously shaped by sensory input and sensorimotor context.

Concluding remarks

Experiences of bodily heaviness have been reported for centuries, for example, in Louis Pasteur's description of his paretic hand (Box 1). Such complaints, however, have often been treated as vague or even metaphorical symptoms. Instead, emerging evidence suggests that perceived limb weight is a quantifiable and theoretically important dimension of body representation. We propose that perceived limb weight is not a passive readout of physical reality but an actively constructed, functionally regulated parameter of body representation. The brain suppresses the felt weight of the body under everyday conditions, a hidden but consequential feature of how we represent and inhabit our bodies. Much research has investigated the phasic sensory suppression that accompanies actions. Suppression of limb weight, in contrast, would reflect tonic modulation of sensorimotor 'set'. Such continuous suppression may be analogous to suppression of tactile signals from clothing or Ganzfeld phenomena in vision, where a homogeneous coloured visual field gradually fades to grey.

This suppression appears to serve motor functions, lowering the perceived cost of movement and sustaining the drive to act. When it breaks down, as may occur with fatigue, stroke, or chronic pain, heaviness emerges not as a distortion but as an unwanted glimpse of physical truth. Gravity, multisensory signals, and sensorimotor learning all shape this estimate in real time, revealing perceived body weight as a dynamic variable continuously revised by

the brain. We suggest that limb weight perception deserves recognition as a core dimension of body image and self-awareness, with broad implications for sensorimotor neuroscience, clinical rehabilitation, and our understanding of how the brain constructs the experience of embodiment.

Declaration of interests

The authors declare no competing interests.

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References

1. Lackner, J.R. and DiZio, P.A. (2000) Aspects of body self-calibration. *Trends Cogn. Sci.* 4, 279–288
2. Ferrè, E.R. et al. (2023) Systematic underestimation of human hand weight. *Curr. Biol.* 33, R758–R759
3. Cadete, D. et al. (2025) Underestimation of human hand density. *Cortex* 189, 140–147
4. Cadete, D. et al. (2025) Perceived hand size and perceived hand weight. *Cognition* 254, 105998
5. Radziun, D. et al. (2026) Sensorimotor training lightens the perceived weight of body augmentation devices. *bioRxiv* <https://doi.org/10.64898/2026.04.17.718984>
6. Kuppaswamy, A. et al. (2016) Limb heaviness: a perceptual phenomenon associated with poststroke fatigue? *Neurorehabil. Neural Repair* 30, 360–362
7. Critchley, M. (1955) Personification of paralysed limbs in hemiplegics. *Br. Med. J.* 2, 284–286
8. Martínez, E. et al. (2019) A distorted body schema and susceptibility to experiencing anomalous somatosensory sensations in fibromyalgia syndrome. *Clin. J. Pain* 35, 887–893
9. Lewis, J.S. et al. (2021) Visual illusions modulate body perception disturbance and pain in Complex Regional Pain Syndrome: a randomized trial. *Eur. J. Pain* 25, 1551–1563
10. Preatoni, G. et al. (2021) Lightening the perceived prosthesis weight with neural embodiment promoted by sensory feedback. *Curr. Biol.* 31, 1065–1071.e4
11. Song, H. et al. (2024) Continuous neural control of a bionic limb restores biomimetic gait after amputation. *Nat. Med.* 30, 2010–2019
12. Longo, M.R. (2022) Distortion of mental body representations. *Trends Cogn. Sci.* 26, 241–254
13. Ferrè, E.R. et al. (2019) A gravitational contribution to perceived body weight. *Sci. Rep.* 9, 11448