Virtual reality, embodiment and allusion: an ecological-enactive approach

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Giovanni Rolla, UFBA/Brazil
Guilherme N. de Vasconcelos, UFMG/Brazil
Nara M. de Figueiredo, UFSM/Brazil

Abstract: It is common in the cognitive and computational sciences to regard virtual reality (VR) as composed of illusory experiences, given its immersive character. In this paper, we adopt an ecological-enactive perspective on cognition (section 3) to evaluate the nature of VR and one's engagement with it. Based on a post-cognitivist conception of illusion, we reject the commonly held assumption that virtual reality experiences (VREs) are illusory (section 4). Our positive take on this issue is that VR devices, like other technological devices, can be embodied during use, which is why they can be the source of experiences (section 5). We then propose a new concept to interpret VREs, namely, *allusion*, which means that the subject acts *as if* the virtual experiences are real (section 6). This kind of engagement has a volitional aspect, which is evident in the onboarding of VR devices and which allows us to distinguish VREs from other experiences. We conclude that, even though we have experiences that afford certain interactions in VR, the strong continuity between cognitive and biological processes is not sustained therein. This characterizes a difference of kind—given the current state of technology—between VREs and fully fledged cognitive states, which nevertheless allows for constrained experimentation in cognitive science.

Keywords: virtual reality; immersion; enactivism; ecological psychology; illusion; allusion; embodiment.

1. Introduction

Over the last couple of decades, growing technological availability and processing power led to the widespread use of virtual reality (VR).[1] More recently, VR has become widely common for both personal use and research purposes (Heim, 2017). Nowadays, we see the increasing use of VR in experimental psychology (e.g. Regia-Corte et al., 2013; Schettler et al., 2019; see also Wilson & Soranzo, 2015), further solidifying its methodological relevance. However, a commonly held assumption yet to be addressed is that VR experiences (VREs) are illusions. In this paper, we critically examine that assumption by investigating the nature of VR and one's engagement therein. This is a pressing matter because, even though in the technical literature about VR one finds near overwhelming consensus that VREs are illusory, claims in that direction are seldom accompanied by the philosophical analysis they urgently require. More precisely, if VREs are illusory and if illusions are, in some very general sense, failures to perceive, it stands to reason that the scientific findings about perception using VR are ill-grounded. This, of course, is an undesirable conclusion, which we reject. On the other hand, others have argued in favor of a metaphysical realism regarding digital objects (Chalmers, 2022; Simonetta, 2015). Accordingly, what is perceived in VR would have the same ontological status as non-virtual or mundane percepts, which naturally leads to the idea that virtual objects are real and indistinguishable from non-virtual ones. This view, we believe, earns its plausibility by abstracting from how one must manipulate the VR device in order to "enter" the virtual environment, what is called the 'onboarding process' (Hovhannisyan et al., 2019). Although one might think that either VREs are illusory or veridical—and therefore indistinguishable from non-virtual experiences—, we believe this is a false dichotomy. It is our goal to avoid both extreme views and we do so by arguing that VREs can be analogous to non-virtual experiences in an important sense. Therefore, they are not illusory—yet, they fail to have the same *meaning* as (non-virtual) cognitive states. Briefly put, a virtual glass of orange juice seen and manipulated in VR does not quench

[1] During the 1990s, VR was associated with widely different experiences, from the manipulation of 3D-models in a computer screen using mouse and keyboard to experiences with CAVEs or systems composed by head-mounted displays (HMDs) and other accessories (Cruz-Neira et al., 1992; Robertson et al., 1993). In this paper we are interested in the current use of the term VR, which is used exclusively in relation to experiences with HMDs and with handheld controllers that simulate the user's hand movements.

one's thirst. We believe that clarifying the nature of such experiences can influence their status on methodological approaches in the cognitive sciences and help us to situate this kind of activity in our lives.

The rest of this paper is structured as follows. Section 2 highlights how traditional approaches have taken VREs to be illusory, a belief that stems from cognitivist assumptions. Next (section 3), we present the central features of ecological-enactive cognition (EEC) as a counterpoint to cognitivism. Those features are: embodiment, situatedness, sense-making, and agent-environment codetermination. In section 4, we advance an understanding of the concept of illusion for EEC, which allows us to see how VREs are not illusory. We then turn to the relation between the person and the VR equipment to show that this relation is best understood as a matter of *embodiment*, which is made possible by our trait of easily incorporating technological devices (broadly construed) into our lives (section 5). In section 6, our focus is on what happens *in* VR when one entertains VREs. We argue that this kind of experience is neither an illusion nor cognition proper, but an *as-if* experience that we label *allusion*. The distinction between illusion and allusion will help us explain why we feel reality-like effects and have reality-like experiences when using VR, but still can distinguish between virtual and non-virtual situations. Finally, in section 7, we conclude our argument by claiming that cognition and VREs are still importantly different, since cognition involves perceiving one's environment *as relevant for self-sustainment*, which is not the case in VR unless, again, understood as an allusory experience.

2. Preliminary views on virtual reality

The strong tendency within the specialized literature to think of VREs as essentially illusory is partially grounded on treating virtual experiences as "immersive". This is a metaphor that borrows from immersion in real water, which is 'the sensation of being surrounded by a completely other reality, as different as water is from the air, that takes over all of our attention, our whole perceptual apparatus' (Murray, 2016, pp. 98–99). Some authors use that concept to refer to the objective aspects of virtual experiences (Slater, 2009) or to the subjective feeling of 'being there', sometimes even conflating these two senses (see Hovhannisyan et al., 2019; Nilsson et al., 2016). Thus, according to McMahan (2003) and Nilsson et al. (2016), this polysemy in the specialized literature contributes to making *immersion* a vague concept (for a discussion, see Grabarczyk & Pokropski, 2016). Importantly, as pointed out by Nilsson et al. (2016) *immersion* has been used 'interchangeably with concepts such as *presence, involvement* and *engagement*' (2016, p. 109). The proximity between *immersion* and *presence* in the technical debate is especially critical since the latter has been classically defined in terms of perceptual mistakes. The International Society for Presence Research (ISPR), whose definitions have greatly influenced that debate, takes presence (a shortened version for 'telepresence') to be the

> *misperception* regarding the role of technology in an experience. [Accordingly,] a variety of stimuli provided by a virtual reality system can cause the user to perceive that s/he is moving through and interacting with the environment created by the technology rather than the user's actual physical environment' (ISPR, 2000, emphasis added) .

To give an example of how approaching VR in terms of *immersion* suggests that VREs are illusory, take Grau's (2003) comprehensive panorama of immersive experiences ranging from 60 BC to the 21st century. He argues that VR is not an entirely new phenomenon in this sense because 'the idea of installing an observer in a hermetically closed-off image space of *illusion* did not make its first appearance with the technical invention of computer-aided virtual realities' (Grau, 2003, pp. 4–5, emphasis added). A noteworthy exemplar from the early-1960s is the Sensorama Simulator, a booth-sized device that integrates visual projection, binaural audio, vibration, and a system that can project a breeze with odors. It was described as 'a device that creates for its user the *illusion* of being physically present in a different environment' (Heilig, n.d., p. 1, emphasis added). Notice that both Grau and Heilig treat immersive experiences as illusory, which carries on to VR even though immersion is not exclusive to VREs.[2]

[2] Immersion has been linked to other media that precede VR technology, for instance, videogames (McMahan, 2003; Thon, 2008), in-person role-playing games (Balzer, 2011; Lukka, 2014), narrative studies (Ryan, 2001, 2015) and art studies (Grau, 2003).

Other authors describe VR explicitly in terms of illusions, approaching it from the notion of *presence*, thus following the definitions of the ISPR. Lombard and Ditton (1997), for instance, propose in their seminal paper that presence should be defined as 'the perceptual *illusion* of nonmediation' (1997, p. 14, our emphasis). The illusion of nonmediation occurs 'when a person fails to perceive or acknowledge the existence of a medium in his/her communication environment and responds as he/she would if the medium were not there' (1997, p. 15). Slater (2009) offers a similar approach, for he claims that two kinds of illusion occur in VR, *place illusion*, which is 'the strong illusion of being in a place in spite of the sure knowledge that you are not there' (2009, p. 3551), and *plausibility illusion*, or the 'illusion that what is apparently happening is really happening (even though you know for sure that it is not)' (2009, p. 3553). In a recent paper, Slater (2018) also considers presence a perceptual illusion, but not a cognitive one. According to him, when in VR, the perceptual system perceives and commands an automatic and rapid reaction of the brain-body system, followed by the relatively slower cognitive system. The cognitive system then concludes, after the reactions, that what was perceived is not real. Generally speaking, what underpins the distinction between perception and cognition used by Slater is that the former is conceived as the passive reception of crude stimuli, whereas the latter is thought to involve a more reflective (thought-related) process, which is traditionally conceived as some sort of computation over internal representations about the sources of stimuli.

Gonzalez-Franco and Lanier (2017) similarly present a comprehensive review of what they consider to be VR illusions, boldly claiming that 'illusory experiences are not a consequence of using VR, but the very foundation of its operation' (2017, p. 3). The authors propose a neuroscientific model to explain why and how VR illusions can occur, borrowing from the predictive processing paradigm (see Clark, 2013, 2016). According to them, 'VR illusions occur when media instrumentation stimulates neural bottom-up multisensory processing, sensorimotor self-awareness frameworks, and cognitive top-down prediction manipulations and furthermore allows these to reconcile in such a way that semantic violations are infrequent' (Gonzalez-Franco & Lanier, 2017, p. 6). Again, when it comes to the epistemic status of VREs, illusion seems to be the key concept.

It is, therefore, not hard to see why the concept of *illusion* became so central to explanations regarding VREs: an *immersant*[3] perceives and acts according to what is presented to them through VR, ignoring—to a great extent—the "real world". It is this process of disregarding what lies outside of VR that allows VREs to be fluid, engaging and entertaining. This is a commonsensical use of 'illusion', and as such it may offer prima facie compelling approximations. But there may be more to the claim that VREs are illusory than mere commonsense. As indicated, the technical discussion is riddled with cognitivist assumptions, such as: a) perception is the reception of raw stimuli, which therefore requires b) computations over internal representations to put together those stimuli as complex perceptual states about their distal sources. From this, it is natural to assume that c) illusion is a faulty representational state in which the received stimuli do not correspond to existing distal sources. If those assumptions are in place, it is tempting, if not straightforwardly necessary, to consider VREs illusory.

However, cognitivism is no longer the only game in town. Recent developments in the cognitive sciences have challenged those assumptions, thus opening new ways of understanding the ontological and epistemological statuses of VREs. Since the 90's the so-called 'pragmatic turn' (Engel et al., 2013) in the cognitive sciences has advanced a prolific program that takes the interactions between embodied agents and their environment to be central for understanding the cognitive performances. Hence the label 'embodied cognition' (for a detailed discussion, see Anderson, 2003). Two prominent branches of the research program on embodied cognition are ecological psychology and enactivism, which we present and discuss in the next section. Our goal is to motivate a conception of VREs that eschews its widely assumed illusory character, but without implying that VREs are identical to non-virtual experiences. We advance an ecological-enactive view to show how non-virtual experiences have a meaning of their own, their biological relevance, which is absent in VR.

3. Ecological-enactive cognition: a brief overview

[3] 'Immersant' is a neologism created by the VR artist Char Davies to describe a person that is immersed in VR.

Ecological psychology was initially developed by James Gibson (1966, 1979/2015) and Eleanor Gibson (1969), turning into a prolific research program in its own right. Enactivism received its name in the work of Francisco Varela, Evan Thompson and Eleanor Rosch (1991/2016), even though some of its core ideas appear in Varela's previous work with Humberto Maturana (Maturana & Varela, 1980). Although there have been occasional doubts about the compatibility between enactivism and ecological psychology (e.g. Heft, 2020; and even Varela et al., 1991/2016), recent developments have shown that not only do they share common roots (Barrett, 2019; Crippen, 2020; Heras-Escribano, 2019b) but can be put to work together in a proficient manner as an integrated view (Baggs & Chemero, 2021; Carvalho & Rolla, 2020; Gallagher, 2017; Kiverstein & Rietveld, 2018; Rolla & Novaes, 2022; Travieso et al., 2020). For these reasons, we base our argument on a combined approach that considers cognition ecological *and* enactive—'EEC' for short.

Fundamentally, EEC diverges from cognitivist views by rejecting representationalism. Representationalism is the view according to which cognition is essentially representational, where representations have, at the very least, semantic content and satisfying conditions, i.e., are capable of being true or false, accurate or inaccurate about something else (Hutto & Myin, 2013). For EEC, the idea that cognition needs to be supplemented by internal representations stems from the misconception that cognitive agents passively receive crude stimuli about their surroundings. This arbitrarily assumes that sensation comes first, whereas cognition and action come later. However, as Dewey correctly puts it, thereby anticipating the embodied turn in the cognitive sciences:

> Upon analysis, we find that we begin not with a sensory stimulus but with a sensori-motor coordination, the optical-ocular, and that in a certain sense it is the movement which is primary, and the sensation which is secondary, the movement of body, head and eye muscles determining the quality of what is experienced. In other words, the real beginning is with the act of seeing; it is looking, and not a sensation of light (Dewey, 1896, pp. 358–359).

EEC follows Dewey's take and claims that cognition consists not in representing distal sources of crude stimuli, but in the organism's active exploration of its surroundings. According to the enactivist emphasis on autonomy, active exploration depends on developing *sensorimotor schemes*, that is, coordinated patterns of sensation and movement selected by the agent in virtue of their success in organisms-environment engagements (Di Paolo et al., 2017). Given the emphasis on picking up information for action by ecological psychologists, active exploration is construed as requiring the detection of *affordances*. Affordances are the possibilities for action that are directly (non-representationally) perceived by an organism in an environment (Gibson, 2015; see also Chemero, 2009; Heras-Escribano, 2019a). Accordingly, organisms with different kinds of bodies can detect and explore different sets of affordances and, therefore, can exhibit different cognitive performances in their respective environments.[4] Thus, the environment from an EEC's perspective is the surroundings of an organism considered *in relation to* its capacities and interests (Heras-Escribano, 2020). Hence EEC commits to strong forms of embodiment and situatedness: cognition *constitutively* depends on bodily morphology and on the environmental layout explored by an organism, i.e., its situation. EEC's emphasis on active exploration and its commitment to strong forms of embodiment and situatedness show that mental representations do not play any essential explanatory role—at least considering cognitive states about the immediate environment—, for the organism can explore the world directly without need for internal mediation (Brooks, 1991).

The continuous organismic-environment engagements by active exploration stem from the fact that living beings are conceived as thermodynamically open systems in far from equilibrium conditions (Moreno & Mossio, 2015). This means that organisms must interact with their environments by detecting affordances and inhibitions to maintain their functional organization. Without exchanging nutrients and energy with their

[4] Moreover, given the organism's developmental history and its acquired dispositions and abilities (which include culturally acquired ones in our case) different subsets of affordances may be detectable by individuals with a similar bodily morphology. Baggs and Chemero (2021) explain this possibility by a distinction between the environment as the habitat—where affordances exist in relation to a typical or ideal member of a species—and the environment as the *umwelt*—where the habitat is considered as the point of view of a specific individual.

environment, biological systems disintegrate, and for this reason, cognition is intrinsically linked with self-sustainment. More precisely, when interacting with their environment, living beings make sense of their surroundings by identifying the valence (positive or negative) of environmental encounters, which are therefore meaningful for their self-maintenance. Hence the idea of *sense-making*, which EEC inherits from autopoietic theory (Maturana & Varela, 1980).[5] Meaning, therefore, resides not in a subjective realm, which is traditionally supposed to be detached from environmental encounters, but in the organism-environment engagements that dictate the organism's strive for self-sustainment.[6] In short, EEC takes life and cognition to be in strong continuity (Kirchhoff & Froese, 2017; Thompson, 2007). We will return to this point in the final sections of this paper because it establishes a limit for the approximation between VRE and cognition.

Another important feature of EEC is the idea of *organism-environment codetermination*, which usually refers to how organisms develop strategies to engage with specific environmental features at an ontogenetic scale (e.g. Di Paolo et al., 2017). Recently, organism-environment codetermination has been linked to niche construction theory (Heras-Escribano, 2020; Rolla & Figueiredo, 2021; see also Werner, 2020), thus providing an evolutionary outlook to codetermination and complementing earlier enactivists accounts of evolution (Thompson, 2007; Varela et al., 2016)[7]. Niche construction theory affirms that organismic activity in a given environment, if sufficiently stable, becomes a non-genetic or ecological inheritance for its descendants (Laland et al., 2000a, 2000b; Odling-Smee et al., 2003). The altered environment inherited by an organism's offspring affects how it engages with it, ensuring a loop that, at large time scales, influences the species' evolutionary pathways. Accordingly, organisms are not exclusively subject to external selective pressures over their genes, for they contribute

[5] These ideas are related to autonomy and closure, two concepts central for early enactivist accounts. As Moreno and Mossio (2015) carefully discuss, however, their account differs from the original construal of biological autonomy found in autopoietic theory. These differences are not relevant for our purposes here.
[6] For simplicity, we conceive other organisms and social relations as part of the environment when it comes to organism-environment relations.
[7] The theory of natural drift was first proposed by Maturana and Mpodozis (1992, 2000) as an attempt to describe evolution in autopoietic terms. It is also present in Varela et al. (1991/2016), later being refined in Thompson (2007) under the label of enactive evolution.

actively to their own evolutionary processes. As Raimondi puts it, discussing autopoietic accounts of evolution:

> Organism and niche are primitively interrelated. It follows that what is preserved and reproduced over generations is in fact an *ontogenic phenotype-ontogenic niche configuration*: that is, a dynamic pattern of relations realized in the relational domain over a lifespan, specifying an adaptive ontogenic co-drift (Raimondi, 2021, p. 7, emphasis by the author).

In the case of hominins, codetermination involved the manipulation and cumulative development of artifacts, a process that began around 2,6 mya (Malafouris, 2014; Sterelny, 2012). Since at least the emergence of behavioral modernity for *Homo sapiens* (50 to 10 kya), we find evidence of cultural practices such as burials, paintings, fishing, sculpturing, and so on (Menary, 2015). Crucial to our point is the fact that human existence has since then been intrinsically linked to the cumulative use of *culturally shared* artifacts. Plausibly, artifact manipulation and transformation were essential to the historical development of increasingly sophisticated cognitive performances which are—to the best of our knowledge—distinctive to humankind. In this sense, human-made niches involve the objects' physical structures, their affordances, their social function, and the behavioral patterns that are socially enacted by engaging with them, thereby influencing our evolutionary pathways (Heras-Escribano, 2020; see also Malafouris, 2013). In short, behaviorally modern human nature *is* culturally embedded. As Gibson elegantly puts it, referring to cultural environments (or human-made niches):

> This is not a *new* environment—an artificial environment distinct from the natural environment—but the same old environment modified by man. It is a mistake to separate the natural from the artificial as if there were two environments; artifacts have to be manufactured from natural substances. It is also a mistake to separate the cultural environment from the natural environment, as if there were a world of mental products distinct from the world of material products (Gibson, 2015, p. 122).[8]

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[8] Gibson concludes this passage with a high note that is not directly relevant for our purposes in this paper, but which should not be neglected. He writes: 'There is only one world, however diverse, and all animals live in it, although we human animals have altered it to suit ourselves. We have done so wastefully, thoughtlessly, and, if we do not mend our ways, fatally. (ibid.)

To summarize, the overall ideas are that cognition is embodied and situated for action, and that the organism's evolutionary background and its historical interaction with the environmental layout play a crucial role in explaining its cognitive performances. Cognition is thus thought of in continuity with biological processes, for it emerges as the organism makes sense of environmental encounters that afford (or inhibit) its self-sustainment. In our case, the evolutionary processes that allowed the emergence of distinctively human cognitive capacities are linked with manipulating and incorporating technological (broadly conceived) artifacts. This last point is important because it is the basis for our proposal on how VR devices become incorporated during use (section 5). But first, we want to discuss what EEC takes illusions to be in order to advance an alternative to the mainstream construal of VREs.

4. Illusions in the ecological-enactive approach

As we saw in section 2, there is a tendency to think of VREs as illusory, but whether this is correct depends on what an illusory experience *is*. In this section, we review a notion of illusion within the EEC paradigm, which will allow us to reject the widely held view that experiences in VR are illusory.

The concept of *illusion* is central to traditional cognitive psychology—given how cognitive psychologists attempt to understand perception through what goes amiss, so to speak, when one undergoes an illusory state. But because traditional cognitive psychology assumes that perception is representational, illusion is thus treated as a matter of *misrepresentation* or *misinterpretation* (e.g. APA, n.d.; Howe & Purves, 2005; Reynolds, 1988). This implies the sort of internal calculation regarding the distal source of stimuli that fails to capture external states of affairs. However, as we have seen, the pervasive and often tacitly assumed representationalism is the fundamental point of contention raised by EEC.

Favela and Chemero (2016) thus propose an understanding of illusions that does not fall prey to representationalism. They emphasize that, for ecological psychology (and EEC by extension), perception and action are mutually constitutive, and that the actions an animal can perform in a given environment depend on its morphological features—hence, on its evolutionary background. Thus, perception (note: not *veridical* perception) occurs when, in evolutionary appropriate environmental conditions, the organism performs certain actions with success. Humans, for instance, are typically able to discriminate the distance between objects and their point of view by moving. That is, we generate an optic flow through motion parallax that allows us to directly discriminate between what is closer from what is further away from us, an embodied process that does not necessitate internal computations and representations. Given this general conception of perception, illusions are conceived in contrast to perceptual states, being therefore defined as 'attempts to perceive in evolutionarily atypical conditions' (Favela & Chemero, 2016, p. 77).

In order to clarify the definition above, consider the following example. One kind of evolutionarily atypical condition is the settings where subjects are faced with static pictures and drawings that cannot be manipulated nor interacted with, leading to the typical illusory experiences studied by cognitive psychology. Another, more prosaic one, is the attempt to visually perceive objects across different media, such as air and water, which causes us to mislocate submerged objects. One such case is the famous stick-in-water illusion, which under specific conditions is a genuine illusion for EEC. The explanation here is straightforward: given that we did not evolve to retrieve information for action across different media (unlike, for instance, gannets, which evolved amphibious vision for underwater predation, see Cronin, 2012), we may at first fail to see that the stick is not broken. If, on the other hand, the (human) agent is not restricted to observing the stick from a distance and is allowed to manipulate it, taking it out of the water, etc., then the impression of illusion is gone.

As another example, consider the famous Müller-Lyer illusion (Fig. 1). Notably, it persists even if one traces the lines with a rule and finds out they have the same objective length. EEC's explanation here is that the environmental conditions continue to be evolutionarily atypical because bidimensional figures are seldom encountered in real life. In short, bidimensional illusions assume that the observer is located at infinity *and* can perceive the image in its integrity, which is straightforwardly evolutionary atypical for beings like us. Given this atypical condition, it is unsurprising that the illusion is still there even after measurement—one still *seems* to see one line bigger than the other. In contrast, consider the following example inspired by the same illusion. Imagine two tv antennas resembling the Müller-Lyer lines and an agent with the practical task of storing them in a cardboard box. Because a person can typically manipulate the antennas to accommodate them, there is no illusion about which antenna would fit in the box, which one is bigger, and so on. What changes in this case is that the agent is able to engage with the objects instead of focusing their view at a specific part of a static image.

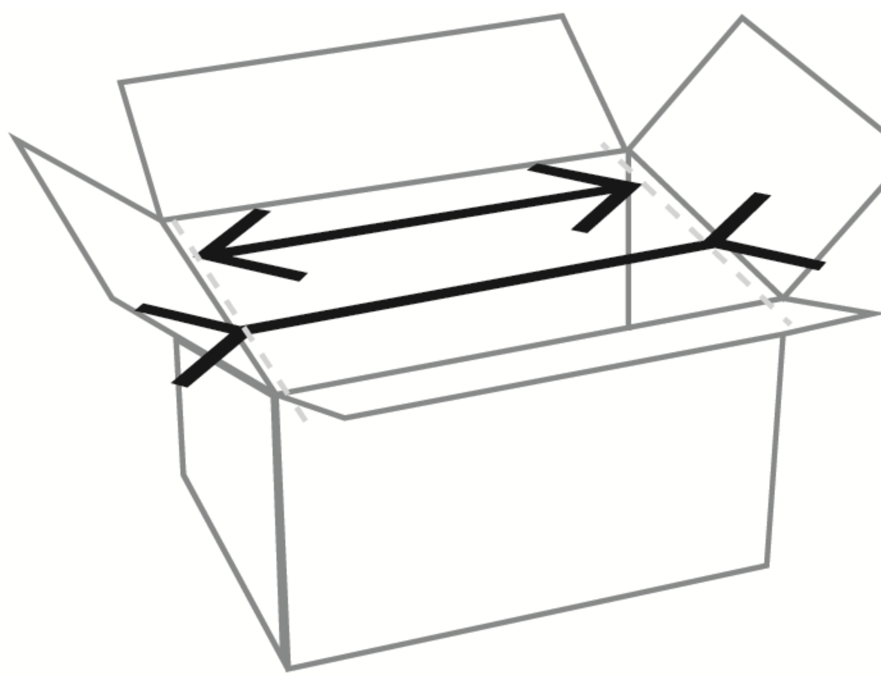

Fig. 1. Two TV antennas resembling the Müller-Lyer lines being stored in a cardboard box: there is no doubt about which one fits the box

Now, having established that illusions are failed attempts to perceive in evolutionarily atypical conditions, we can assess whether VRE should be taken as illusory, which is the topic of our following sections.

5. **The embodiment of virtual reality devices**

In this section, we analyze what goes on at the level of the individual wearing VR equipment. We do so by mostly setting aside what goes on *in* the virtual environment, which we will discuss in more details in the next section. Our main goal is to highlight how using the equipment so prolifically is only possible because we are easily coupled with technological devices. 'Technology' is understood here broadly, for it includes both the very first material engagements that helped shaping the human evolutionary pathways (see Ihde & Malafouris, 2019; Malafouris, 2013) as well as more recent developments, as they are typically referred to by the layperson's use of that term.

As we have argued in section 3, human evolutionary history is the history of thinking and doing through material means, which involved (and continues to involve) the cumulative increment of culturally shared artifacts. The manipulation of technological devices thus enables us to perform unprecedented cognitive acts and to enhance our inherited and developed capacities. Under certain conditions, device manipulation can be described as a matter of *embodiment* (Schettler et al., 2019). From a phenomenological point of view, embodiment refers to how successfully manipulating a tool or an equipment enables the user to abstract from some of its features during use. By doing so (typically unconsciously), the user seamlessly performs the relevant actions as if the object is a part of their own body. The object therefore is temporarily integrated into the user's cognitive system and becomes transiently "transparent". It ceases to be perceived as an object due to its transformation into a means to perceive with (Malafouris, 2013). From a complex systems perspective, 'embodiment' refers to how the tool is integrated into the self-organized system (the individual) in its coupling with the environment, potentially generating new ways of exploring the environment or modifying previously existing ways. For embodiment to happen, 'the whole system (e.g., human body + tool) must exhibit the expected signatures of self-organization and complexity, such as a fractal organization of its different scales' (Schettler et al. 2019, p. 12).[9]

[9] Notice that we are not advocating for the extended mind thesis (Clark & Chalmers, 1998), which says that minds can be extended by external devices that play the same function as biological ones. Although very similar, a crucial difference is that the extended mind relies on functionalism, which says that what matters for some structure to earn the title of cognitive is the function it performs, regardless of its materiality. It is well-known that functionalism is inimical to embodied cognition (Rowlands, 2010) and that is why we do

To see the import of these last points to our main discussion, consider first how VR equipment is built precisely for creatures like us, that is, all technical features of VR devices are designed with our bodily morphology in mind. For instance, the six degrees of freedom one can experience in most advanced devices (forward/back, up/down, left/right, yaw, pitch, and roll) is an attempt to simulate our usual possibilities of movement and interaction within tridimensional spaces. The fact that that synchronization between the person and its avatar works in generating VREs is not an incidental feature or a perceptual error, but the result of a successful coupling between user and device. Even in cases where the avatar has atypical or non-human features, there are some requirements for the coupling to take place. That is, the virtual environment must simulate visual and auditory percepts in accordance with the user's autonomous movements. Consider the cases where users engage in certain tasks by virtually embodying creatures with different morphologies, as discussed by Won et al. (2015). Their study shows that the subjects could control a substantially different body (e.g., one with a third arm sticking out from the avatar's chest), but they did not do so immediately after entering VR. They had to *learn* to accommodate to the new avatar by performing actions that were mapped to the new (virtual) limb. For instance, a yaw with their right wrist controls the grabbing movement of the virtual arm. Once a higher level of control was attained, subjects could execute the designed task as intended. Although at first glance this kind of case might suggest that there is something evolutionarily atypical taking place, reviewing it under the light of what we discussed in section 3 shows quite the opposite. In fact, the experiments by Won and colleagues perfectly illustrate how our easiness to embody tools and instruments during use and through learning, when it comes to VR, allows us to control avatars with different features than most humans.

The point about learning how to control the avatar leads us to a second important consideration. Wearing a VR equipment involves a gradual *onboarding process* (Hovhannisyan et al., 2019). The onboarding happens as individuals put on and manipulate the VR equipment, such as the head-mounted display (HMD) and the controllers that provide haptic feedback while tracking hands positions and gestures.

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not treat VR devices as extending one's mind, but as becoming embodied or incorporated during use (see also Sterelny, 2010).

During onboarding, there is a distinguishing moment before the coupling takes place when one sees the virtual environment and even the digital avatar's hands as if they were beyond the body's usual limits. To use a phenomenological distinction, the visible parts of the digital body are not yet perceived as a *lived body*, that is, a source and location of experiences (see Fuchs, 2020). It is only when the agent grabs the controllers represented by the digital hands with their physical hands (which are until then digitally invisible), that the former are perceived as parts of the individual's own body. As Hovhannisyan and colleagues (2019) point out, the coordination between one's physical and digital body requires the gradual development of sensorimotor mastery. From that point on, the individual's actions in their actual environment are progressively synchronized with its VR correlate. Thus, due to the sensorimotor mastery, 'the "headset-as-blindfold" eventually becomes a "headset-as-window-into-the-virtual-world", such that the physical qualities of the headset, as well as those of the rest of the augmented interface, recede into the background of the individual's awareness' (Hovhannisyan et al., 2019, p. 229). Conversely, a HMD unplugged on a table is not yet a window into the virtual world, but a rather expensive, heavy and impractical blindfold. [10]

Recently, Chalmers (2022) has claimed that VREs are generally not illusory, but he foresees some interesting exceptions. One of the cases Chalmers discusses is an imaginary one in which someone puts a lightweight HMD on a sleeping person as a prank—and when they wake up, they supposedly have the illusion of being somewhere else. But is this imaginary example persuasive—does it indicate that at least some VREs may be illusory?

Notice first that the VR equipment has certain weight, texture and even smell, or more generally, a feel of its own which is abstracted after the onboarding. However, if we deliberately ignore the fact that the individual has to *actively manipulate* and *wear* that

[10] For the VR experience to happen flawlessly, there are other conditions that should be met, otherwise the user can experience what is known as *cybersickness*—a phenomenon similar to motion sickness that causes eye fatigue, disorientation, and nausea (LaViola, 2000). Cybersickness is usually associated with high-latency time, or the delay between the user performing an action and the corresponding system response. However, a recent work by Chang et al. (2020) demonstrates that latency is just one of several variables that could interfere in VREs. Aside from latency, authors identify other hardware-related causes for VR sickness (e.g., display type and mode, field-of-view, flickering), as well as causes related to content (e.g., graphic realism, duration, etc.), and also human factors (e.g., age, gender, prior experience with VR or lack thereof, etc.).

equipment, it does seem plausible to think that VR can be a source of illusions, as in Chalmers's example. But the onboarding process is not an incidental feature of VR use; it is rather a constitutive aspect of the experience. Moreover, even granting that Chalmer's imaginary HMD is uncommonly light—which is necessary for the putative illusory character of his example—it is hard to see how the "illusion" could last. The pranked individual could easily perform a series of gestures that would reveal the presence of the equipment, such as trying to touch their own face. In fact, it seems the only way this example provides support for the claim that some VREs are illusory is under the assumption that perception is static—and then one could pinpoint a certain moment, a fragment of a perceptual event, in which the individual would falsely believe that they are somewhere else. But again, this snapshot conception of perception is straightforwardly rejected by EEC, given the intrinsic relationship between perception and action. As an analogy, imagine that, unbeknownst to you, someone puts a headset on you and plays David Chalmer's YouTube hit *Zombie Blues*. You may even be startled by the sudden guitar riff and the less than pristine vocals by the philosopher himself. But it is up to you to remove the headset—and then it is implausible (to say the least) to describe you as having an *illusion* of being in a rock concert.

Now, given the definition of illusion as a failed attempt to perceive in evolutionarily atypical conditions, as discussed in section 4, we can conclude that cases of embodiment with technological devices are not sources of illusions (consider an analogy: how odd would it be to say that a blind person has "haptic illusions" by using a cane?). Instead, manipulating cultural artifacts is precisely what made us behaviorally modern humans, as seen in section 3. Like our forebearers thought *through* and *with* clay manipulation (Malafouris, 2014), we still embody technological devices, broadly construed, in our everyday lives. Those include, for instance, pen and paper, notepads, computers, cell phones and so on. In this sense, engaging with VR technology is not radically different from wearing glasses or using a cane. Even though VR allows us to experience a glimpse of fascinating imaginary worlds in which we appear to fly or shrink and so on, its use is fundamentally the same as other devices that can become incorporated into our lives and allow us to experience things differently. Thus, it represents an addition to human evolutionary history rather than something alien to it. In other words: there is nothing evolutionary atypical in engaging with technological devices, VR devices included. That being the case, it is false that VREs are only possible due to the supposed fallibility of our perceptual systems, an assumption that goes hand in hand with the idea that VREs are illusory.

6. Virtual reality experiences: allusion, not illusion

So far, we have argued that the engagement with VR equipment should not be considered illusory—for, like other technological devices, using VR is better understood as a matter of embodiment. Now we turn to the experiential aspect of VR and advance a novel concept to capture what goes on during VREs. Our goal in this section is to show how VREs can be similar to perceptual experiences without being indistinguishable from them. For this, we coin the concept of *allusion*.

In its common usage, 'allusion' means an indirect and often playful reference to something else—as in 'this tweet alludes to the President's corruption' and 'they are alluding to his lack of morals' etc. In this sense, someone with sufficient contextual information does not need to be explicitly directed to the reference of allusion, for what is being alluded to is implicit but still accessible as if it were explicit. Similarly, in our borrowed meaning of the term, a person who has mastered the relevant sensorimotor skills can act in VR *as if* what they are experiencing is in fact happening outside of VR. More precisely, by 'allusion' we mean the activity to access the virtual environment as if it were non-virtually present. Note, however, that this kind of engagement is not a mistake or a failure of the perceptual system, but a matter of *letting oneself go*. In this sense, the Latin radical of 'allusion'—that is, '*alludere'* from '*ad'* + '*ludere'* (Onions, 1966), captures the spirit of our proposal: letting oneself go is a matter of volitional play rather than being misled or illuded. It is also important to distinguish allusion from a similar phenomenon that is commonly referred to as *pretend play* (e.g. Rucińska, 2016; Rucińska & Gallagher, 2021). Whereas pretend play generally requires imagining a counterfactual situation by engaging with certain aspects of the immediate environment—for instance, a child that plays with wooden blocks as if they were houses and trucks—allusion does not necessarily involve imagining. In fact, what is special about allusion in VR is that the virtual environment is presented as if real (non-virtual) without the need to further enrich it by imagination or belief. In this sense, what allusion and pretend play have in common is pertaining to the larger class of *as-if* mental attitudes. Likewise, allusion should not be confused with other *as-if* states that involve representational and propositional content, such as describing a counterfactual situation and other make-believe states. In this sense, therefore, allusion is a radically embodied attitude.

The volitional element at play in allusion ties in with EEC in an explanation of why we can distinguish VREs from everyday (non-virtual) experiences, thus motivating a rejection of the indistinguishability thesis. Recall our earlier remarks about the onboarding process: to enter a VR, a person must actively manipulate the controls as they wear the HMD—which involves a certain level of mastery. That idea discussed by Hovhannisyan and colleagues (2019) is supported by the enactivist account of cognition and perceptual consciousness as active exploration by an agent of their surroundings. Accordingly, we only entertain VREs because we perform a series of actions that enable the synchronization of our physical actions outside of VR with those of our digital avatar, thus enjoying those experiences as if we were in fact there. So VREs (like other experiences) are not static, but dynamic, and they are brought forth once we voluntarily embody the VR devices. In contrast, if one thinks of perceptual experiences as snapshots in quick succession, comparing genuine everyday "experiences" with graphically realistic VREs would indeed hold that they are indistinguishable. But that argument not only ignores how the process of entering VR unfolds, it also relies on problematic assumptions regarding the nature of experience.

Interestingly, even if one is not committed to a snapshot view of perceptual experiences —that is, even if one is sympathetic towards EEC—one can still arrive at an indistinguishability thesis. We can infer such a view from Simonetta's (2015) discussion regarding augmented reality. In augmented reality, unlike in VR, tridimensional digital objects are superimposed to non-virtual ones and therefore afford certain actions, which are akin to what non-virtual objects afford. Thus, 'these [virtual objects] are indistinguishable from real objects insofar as their affordances are exactly the same as those of real objects.' (Simonetta, 2015, p. 108). This would be the correct verdict insofar as one treats Gibson's theory of affordances as a theory of reactive behavior (Flach & Holden, 1998, for instance, arrive at the same conclusion). Applying Simonetta's considerations to VR would imply that VREs are indistinguishable from actual perception, characterizing a metaphysical realism regarding virtual objects.

There are, however, a few issues with this kind of application of ecological psychology. First, notice that Gibson does not advance his theory of affordances merely as a theory of reactive behavior. In his earlier work, he identifies affordances with *values*, which in turn are defined as 'what things furnish, for good or ill' (Gibson, 1966, p. 285). This points to the notion *of biologically meaningful* relations in the organism-environment dynamics, a point that is explicitly articulated by enactivists. Affordances, therefore, are meaningful because they matter, in a fundamental sense, to the agent. We return to this point in the final section, but it suffices to say for now that this kind of meaning is lacking in VREs.

Moreover, as we have mentioned before, to think of virtual objects as indistinguishable from non-virtual ones is only possible if one abstracts from the onboarding, which is an essential aspect of successful VR use. In fact, Simonetta opens his paper by asking the reader to 'visualize the *ideal scenario* [...] where "augmented" reality and "ordinary" reality are indistinguishable: where there would be full tridimensional alignment, real time interactivity, and *no awareness of the device*' (Simonetta, 2015, p. 96 emphasis added). But a completely transparent device that one can become totally and permanently unaware of is far from being a technological possibility, at least presently.[11] We can grant that it is *logically* possible that a device is so light, and its projections are so realistic (etc.) that the user could never tell whether they are wearing it or not. Then of course VREs would be indistinguishable from actual perception, at least from the point of view of the user. But this logical possibility is just another variety of skeptical scenario, like Putnam's

[11] To put matters into perspective, Sutherland (1965) already envisioned this possibility, which he describes as the 'ultimate display'. In the ultimate display, whatever happens to the avatar also happens in real life. It is not an exaggeration to say that current technology, almost 60 years later, is still far from achieving what Sutherland imagined. Despite many researchers' optimism, olfactory and gustative simulations (see Maggioni et al., 2019; Ranasinghe et al., 2011), for instance, do not capture the rich phenomenology of our senses of smell and taste, and do so often through cumbersome equipment (e.g., electrodes connected to one's tongue) that is hard or even impossible to abstract during use.

(1982) brain in a vat case.[12] In fact, skeptical scenarios presuppose that we can make sense of a cognizant who is secluded from their body and environment—but this is exactly the kind of assumption that EEC rejects on empirical grounds (see Thompson & Cosmelli, 2011). At this point, we suggest an inversion of the burden of proof: our interlocutor must first show that this logical possibility is not a remote one, which means that such a device can be built—and only then it would make sense for an EEC theorist to take on the burden of proof.

Another version of the indistinguishability thesis is put forth by Humberto Maturana (2008). Together with Francisco Varela, Maturana is known for designing the autopoietic theory, which is aimed to distinguish living systems from other complex systems (Maturana & Varela, 1980). The fact that Maturana proposes that virtual and ordinary objects are indistinguishable might be surprising given the close historical and conceptual relationship between autopoiesis and enaction (Di Paolo et al., 2018; Thompson, 2007; see also Ward et al., 2017). But, once more, EEC has the tools to avoid that conclusion, as we will see.

Maturana opens his paper by writing that 'One of the central features of our operation as living systems is that we cannot distinguish in our experience between what we call, in daily life, "perception" and "illusion"' (2008, p. 109). And, based on that, he later suggests that VREs are illusory because

> the distinction between perception and illusion, *or between virtual and non-virtual realities*, pertain to the operation of the observer as a languaging being capable of operation in the distinction of the inside and outside of an organism as he or she beholds it as a totality in a medium (Maturana, 2008, p. 112, emphasis added).

[12] This is similar to Chalmers's (2005, 2022) take on that matter. Although here is not the place to offer a systematic review of Chalmer's claims, we should mention that he advances a form of metaphysical realism about virtual objects which he calls 'simulation realism'. Simulation realism applied to VR is the view that virtual objects are as real as material ones, and that they are made of a digital material, namely, bits. In his recent book (2022), Chalmers claims that our actual experiences, out of VR, could also be simulations. He argues that we cannot rule out the possibility that we live in a simulation, in a Cartesian-like skeptical scenario as illustrated by the film *The Matrix*. Thus, his rejection of the idea that VR objects are illusory is based on a radical commitment to simulation realism applied also to non-virtual reality. We think that entailing skepticism is a high price to pay for the non-illusory nature of VR, and it falls prey to the false dichotomy indicated above that either VR experiences are real or they are illusory.

What he means here is that only an observer endowed with the appropriate conceptual toolkit (i.e., someone capable of 'languaging') can accurately interpret whether they undergo perceptual or illusory states. The person would have to be an observer of themselves, and only at this interpretative level they would be capable of discerning perception from illusion, for perceptual events would be underdetermined regarding their sources. Maturana draws the conclusion that, at a biologically basic level, we cannot access an external reality (virtual or not) from the claim that the nervous system is an operationally closed network. The concept of *closure* here means that every change within the system is followed by subsequent compensatory states, and it is the active maintenance of closure that distinguishes living beings from other systems. Thus, as a closed network, our nervous system can only be affected by external inputs, which in turn trigger systemic responses, but it never transcends its own borders.[13]

Maturana's move to appeal to interpretation as a way of disambiguation is a peculiar one for two related reasons. First, it carries a flair of intellectualism because it requires an upper level of cognition or meta-cognition (interpretation) to solve a problem that takes place at a lower level (perception). Secondly, and as a consequence of that, this strategy looks strikingly similar to the cognitivist idea that we need internal computational processes to interpret and disambiguate the source of perceptual stimuli. These consequences are clearly undesirable from an EEC perspective.[14]

For our purposes, in order to avoid indistinguishability, it suffices to include environmental exchanges as enabling conditions for the nervous system to establish and develop its own operational closure through sensorimotor coordinations (Barandiaran, 2017; Di Paolo et al., 2017). It follows that 'the nervous system's activity achieves its closure, its large scale coherence, through embodied interaction: i.e. through fine grained coordinations between neurodynamic and sensorimotor correlations' (Barandiaran, 2017,

[13] The looming skepticism and solipsism in this account (see Mingers, 1995) is a complicated matter at the heart of the relation between enactivism and autopoietic theory, and we do not intend to tackle this issue here due to space constraints (see Barandiaran, 2017, for an extensive discussion of this issue).
[14] One possibility is to explore the idea that we are interpreters of ourselves in a non-intellectualist and non-cognitivist fashion (see Di Paolo et al., 2018). This implies a substantial review of what language is.

p. 419). That being the case, operational closure is not closedness from environmental encounters—so, in perceptual events, unlike in illusions, world-involving sensorimotor coordinations unfold normally (Fig. 2). This in turn allows us to avoid Maturana's claim of indistinguishability between perception and illusion. And more importantly, it reiterates our rejection of his assumption that virtual realities are fundamentally illusory. For, in VR, sensorimotor coordinations are not absent or faulty, but have an allusory character, i.e., they take place *as if we were* in a non-virtual environment.

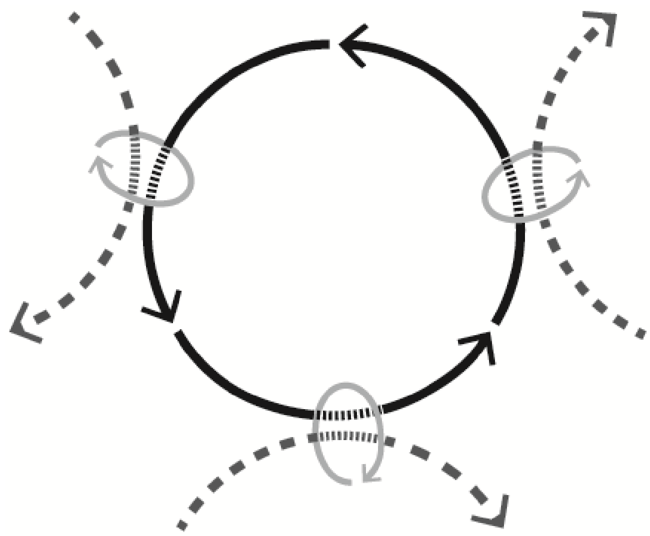

Fig. 2. A diagram representing the organism's operational closure (black), environmental events (dashed grey) and sensorimotor coordinations (grey loops), which are world-involving

7. Concluding remarks

We have argued that the use of VR equipment is a matter of embodiment and that VREs can be understood as a matter of allusion. The main reason for the first claim is that the embodiment of cultural items is one of the marks of behaviorally modern humans—therefore, the eventual incorporation of VR equipment into our lives must not be seen as alien to our evolutionary history. These are also the reasons we presented to reconsider the commonplace assumption that VREs are illusory, for the traditional conception of illusion as mistaken percepts—which arises from the cognitivist model of the mind—is challenged by an enactive-ecological understanding of our cognitive processes. Illusions are here conceived as failed attempts to perceive in evolutionarily atypical conditions. Two final considerations are in order.

First, if VREs are not illusory, but rather a matter of allusion enabled by the embodiment of VR devices, it follows that studies using VR equipment attain ecological validity (when they are, of course, conducted in accordance with other good research practices). For, if it were the case that VREs are illusory, not much about cognition proper, if anything, would follow from what cognitive scientists observe about their subjects in virtual environments. But because allusion involves acting as if what happens in VR takes place in real life, one's motoric responses and behavior more generally are analogous to one's engagement in real life. More precisely, we can study how one *would* act if the scenarios encountered in VR were real. One such case is Regia-Corte et al. (2013) finding that detection of the affordance for standing upright on a slanted surface in VR tightly correlates with perception in similar, non-virtual circumstances. Crucially, the analogy between perception in virtual and non-virtual environments does not depend on imagining that things are thus-and-so or on mistakenly believing they are, for it is allusory: it depends on acting *as if* they are. This kind of analogy is what grants ecological validity to studies that use VR. We believe that making this clear may help researchers in designing experiments with VR in the future.

That brings us to our second point: even though cognition "in the wild" can be studied by analogy to VR engagements, given the similarities between cognition and VREs, there remains a difference in kind between them. Recall that EEC takes cognition to be in strong continuity with biological processes (as we saw in section 3). This means that biological systems evolved to be able to actively explore their environments as a means to facilitate their self-sustainment. Cognition, therefore, takes place as the organism explores environmental encounters that are meaningful (either positively or negatively) for its viability as a living system, what enactivists call sense-making. Plausibly, sense-making does not take place during VREs, and if it does, it is only as a matter of allusion. For instance: even though one can grab and explore a virtual orange, one that exhibits a certain virtual texture and even displays realistic haptic feedback, in a way that it closely resembles an actual orange, *the virtual one does not afford nourishment*. One can act *as if* the virtual orange is nutritious, but it will not quench one's thirst on a summer day.

More generally, our biological needs, such as nutrition, rest and thermoregulation, cannot be met in VR—only in real life. Maybe one can *simulate* satisfying them virtually while biologically relevant events happen *outside* of VR. Maybe, in the future, technological advancements will allow us to simulate, by allusion, the experience of eating at a Michelin 3 stars restaurant while the nutrients are delivered directly to the user's digestive tract. But even in that scenario, nutrition would not be happening in VR, as the person's digestive system processes the received nutrients, which are obviously not virtual. Maybe one day we will be able to wear a VR suit that allows, for instance, for thermoregulation in sync with what happens inside the virtual environment. One enters a cold environment in VR and a thermostat lowers the temperature of one's actual, non-virtual environment. Then one's body compensates for the loss of temperature by increasing its metabolic heat production. But it is the user's actual body that is being thermoregulated. Similarly, to think of another example, if one undergoes the simulation of resting in VR (say, the HMD screen dims down simulating closed palpebrae), one is not thereby resting unless one actually falls asleep. However, if our most fundamental biological needs could one day be satisfied *within* virtual environments, then the very distinction between virtual and non-virtual would become meaningless. Currently, this possibility is nothing but science fiction.

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