color) does not eliminate an illusory perceptual attribute (e.g., two squares have different colors). They tend to neglect the fact that

a the conflict is not between a belief and a percept, but between two beliefs (and, correspondingly, between two percepts) and
b observers are deprived of interactions with the image that would resolve the conflict between the two sets of beliefs/percepts.

Thus, the illusory attributes typically provide strong ground for the supposedly incorrect belief, which is in conflict with the supposedly correct belief. Not only do these cases not support the notion of modularity, in some examples – when the incorrect belief is one that is supported by memory, and contradicts the physical properties of the image – they even contradict modularity (e.g., Hansen et al. 2006). In contrast to illusory attributes, when a percept does not provide strong ground for a particular belief, i.e., when the perceptual state is ambiguous, then the perceiver's thought can influence perception (e.g., the case of intentionally switching between two states of a bi-stable image). That is to say, in the case of perceptual ambiguity, an observer can engage in the activity of switching between multiple beliefs that could be associated with the image.

« 11 » In sum, the enactivist perspective offers a broader and more inclusive paradigm in which the common-sense view of color perception – with its associated puzzles – remains intelligible. The common-sense view of veridical perception is one based on the match between subjective experiences and objective states of affairs. Once we recognize that "objective" is a shorthand for an infinite possibility of other activities (different ways of interacting with an object of perception), and recognize the "subjective-objective match" as a shorthand for a coherence among those activities (including interaction with other perceivers), we arrive at different conceptions of misperception and individual differences. As I tried to argue, the enactivist view of an illusion might be best characterized in terms of attributes that do not survive transitions across different modes of activity. A sustained illusion, therefore, might be best characterized in terms of a sustained deprivation from activities that would otherwise test/remove the illusion. These new conceptions no longer pose the same paradoxes and unbridgeable gaps as they did within a naïve model of color perception.

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Authors' Response
Is a Weak Notion of Representation not Compatible with a Contextualist and Enactivist Account of Perception?

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> Upshot • We argue that the notion of basic perception could help to develop a general enactivist account of perception, without compromising the compatibility between our approach to this theory and the notion of weak representation. To support this, we elaborate on the contextual and normative aspects of our enactivist proposal, on perception, and on how these aspects may be crucial for understanding misrepresentation and comparability.

« 1 » We respond to the inspiring and challenging comments our article about the enactive account of perception sparked, mainly clarifying the compatibility between that account and a weak notion of representation. Such a notion may help to explore different ways of associating enactivism with related approaches and research proposals. We also focus on the importance of the contextual and normative aspects of our enactive approach to perception, responding to challenging cases related to misrepresentation and comparability.

A radical notion of perception could form the basis for a broader and more flexible enactivism

« 2 » Laura Nascimento and Erik Myin argue that the notion of contentless interaction should be considered to understand color perception. We cannot disagree with this suggestion. Actually, this might be one of the best ways to arrive at a non-circular definition of the notion of contentful representation. However, we find it hard to accept that this idea could ground an argument against our claim that enactivism and a non-objectivist version of representationalism are compatible, as they seem to do. As we try to show, we can account for different features of color perception without dismissing entirely the concept of representation. We do not have to provide a naturalistic definition of that concept within an account of color vision. But if that were necessary, the radical enactivist account defended by Nascimento & Myin would help.

« 3 » The authors further point out that our proposal can be confronted with the hard problem of content, i.e., the challenge of providing a scientifically adequate explanation of how representations occur (§4). We agree that such a problem is crucial if we want to arrive at a general theory of cognition and color perception. Nascimento & Myin characterize basic color perception on the basis of the idea that "organisms tend to show similar perceptual reactions to similar stimuli" (§9). With this characterization, we can account for color perception mainly in terms of how organisms interact with their environments. The notion of contentful representation should be characterized at the non-basic level of human communication, by considering linguistic and cultural interactions between individuals and their environment.

« 4 » Nascimento and Myin dismiss the idea that all cases of perception involve contentful representation (§11). The fact that they mention this thesis in the com-

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mentary of our article is confusing. We do not claim that all perception involves content intrinsically. Rather, we claim that the notion of representation can be necessary to provide simple characterizations regarding natural vision as well as within computational accounts. Basically, according to a weak notion, visual representations can be characterized as associations between descriptions of visual properties, such as colors, and descriptions of objects. Objects of visual perception do not have to be considered as pre-given, external entities, but can be characterized as sets of perceptual qualities. More importantly, the concepts of those properties and objects do not have to be apprehended by the agent to which we assign the representation. Note that this does not imply a fall back to the computationalist information-processing account. We do not argue that the best explanations of visual processes are always computational explanations, but that such explanations might contribute to a broader perspective, which does not have to be inconsistent with enactivism.

« 5 » Although not all perception involves contentful representation inherently, content can be ascribed extrinsically and contextually. We can thus ascribe, from our contexts of research, contentful, representational features to systems that only exhibit basic vision. We acknowledge, of course, that some aspects of the contextualist approach we propose are in a hypothetical stage and need to be explored more carefully. Contextual content ascriptions to perceptual processes could also explain why and how neural activity can be considered representational, from a Bayesian perspective, which represents another issue pointed out by **Nascimento & Myin** (§7). We can thus ascribe contentful, representational features to systems that only exhibit basic vision. In a conceptual and epistemological sense, we may ascribe representational contents to brain states in a plausible manner. Likewise, we may ascribe contents to computational states, a possibility that carries important advantages for computer vision research and research on visual perception in general. We agree with **Nascimento & Myin** that more work is required on this notion of weak and non-contentful representation. But, again, this does not mean that such a notion should be seen as incompatible with the enactive account on vision.

« 6 » The Bayesian perspective is fully compatible with an enactive account of vision. As David Marr points out, the process of vision is related to interpreting what is present in the scene and where (perhaps even when). Our eyes perform saccade movements every time we observe a new scene, and as Alfred Yarbus (1967) stated, eye movements depend on individual brain states; i.e., different priors about a visual scene generate different patterns of eye movements. Put differently, brain states are codetermined by the priors (given by the Bayesian perspective) and our actions in that environment (saccades).

« 7 » **Lars Chittka & Peter Skorupski** remind us about the comparative and ecological aspect of the study of vision, and that small-brained creatures can display behavioral strategies that differ from those of big-brained mammals. For primates, fast categorization obtained by vision at a glance, reported by Simon Thorpe, Denis Fize and Catherine Marlot (1996), and justified in terms of feedforward information processing (Van Rullen & Thorpe 2002), can be understood if the observer has already built representations about the scenes that are categorized (Ramon, Caharel & Rossion 2011; Wichmann et al. 2010; Arcaro et al. 2017). For example, most of the categories present in the inferotemporal cortex (IT) are biased or formed through experience. Non-human primates that never have had the experience of seeing faces (because they were reared in a controlled environment) did not develop the face-selective area in the IT. Moreover, Michael Arcaro et al. (2017) also observed that face-recognizing behavior (not present in primates without that ability) precedes the formation of the face-selective area, reinforcing the relevance of active vision in brain wiring.

« 8 » **Chittka & Skorupski** argue that the structure of the visual system can operate, in a dynamical-system sense, as an actuator to build sophisticated behavioral capacities to compensate for the potential limitations of small-brained insects. The latter is an intriguing case of simple behavior, related to the natural history of the evolution of species' nervous systems, that supports a direct relation between a sensory stimulus and a behavioral response (e.g., color-dependent behavior in insects) to an experience of mediate cognitive behavior. However, sensorimotor factors are not the only determinants of visual perception, according to enactivism, and would be compatible with a set of factors and abilities constituted by what **Chittka & Skorupski** call implicit knowledge (§8). They claim that whether we should pay heed to them in our scientific explanations depends on the task under study. According to our contextualist account of enactive perception, every enactive determinant contributes to the constitution of visual states. Moreover, **Chittka & Skorupski** rightly point to the need to consider active vision as compensating for inherent storage limitations in small brains, where part of a representational capacity should remain outside the brain, but accessible from the environment and detectable by the active sensory scan carried out by insects' eyes, whenever needed.

« 9 » **Frédéric Alexandre** offers an interesting computational tool to explore how the enactive account of perception could be seen as compatible with a weak notion of representation within the field of computer science. He asks whether objectivism is still present if we build a model of the system that is only constituted by the perceiver and its environment (§14). We would like to recall the distinction between claiming that perceptual properties are objective properties and defending an objective account of perception, i.e., an account that is methodologically and scientifically solid. To avoid misunderstandings, it may be preferable to use the word "scientific" rather than "objective" for the latter case. **Alexandre**'s approach seems objective in this latter sense, even if it may support non-objectivism about color. Accordingly, the enacted reality is not objective, but the result of a perceiver and its environment. Then he asks whether the notion of weak representation is still pertinent in an account based on the notion of systemic representation, which is key in his proposal (§15). According to our characterization, weak perceptual representations are associations between different descriptions that refer to perceptual properties and objects. A systemic representation of neural states, for example, could be seen as a type of weak representation, if it is not associated

with objectivist assumptions. Thus, the notion of weak representation does not need to be replaced by the notion of systemic representation.

« 10 » Can our proposal be helpful in relation to the problems of misrepresentation and comparability, as well as the characterization of the commonsense assumptions that ground them (§16)? Regarding misrepresentation, an aspect highlighted by **Alexandre** deserves scrutiny with respect to enactivism, i.e., how important the internal brain mechanisms acting on the primary sensory signal are for building illusions (§8). If all perceptual processes were understood as cases of misrepresentation, as he claims, then nothing could be considered to be veridical perception. We need a clearly defined notion of veridical perception in order to apply it to different research areas focused on vision and perception in general, as well as to make sense of our assumptions about perception. The example of colored shadows considered by **Valérie Bonnardel** supports the trajectory toward a clear definition of misrepresentation and shows the importance of this notion for vision science. In cases of colored shadows, the sensory information is not modified and the illusion arises from the human visual system.

Emphasizing the contextual and normative features of our version of perceptual enactivism

« 11 » **Davood Gozli** characterizes illusory properties as those that do "not survive a transition from one activity to another, *presuming that such a transition would not remove a veridically perceived attribute*" (§6). Veridical perception is crucial. He proposes to view it as coherence among the infinite possible activities available to an agent in order for her to interact with her environment (§11). Coherence dictates the norm on the basis of which we may evaluate other perceptual contexts. In this sense, veridical perceptual states are identified in relation to normative contexts. As we argue, such contexts include enactive conditions of determination. And on this basis, illusions are perceptual anomalies according to a certain context. Considering the example of Kanizsa's triangle pointed out by **Gozli** (§7), we would argue that a transition from one activity to another also implies a transition from one perceptual context to another. When a particular illusion does not survive a transition between possible activities, contextual changes occur that may involve differences regarding sensorimotor activity, physical features accessible to the observer and normative constraints. Covering a portion of Kanizsa's triangle involves these types of changes. The anomaly may reside in a feature attributed from one of the contexts in the transition to another, by, e.g., stating that the visual perception is not coherent with the definition of a triangle based on the concept of an edge. Such a definition involves crucial normative aspects that permit an assessment of the visual experience.

« 12 » **Bonnardel** emphasizes that the case of the cube considered in our article is not simply a case of misrepresentation, but elicits a misrepresentation mechanism that would allow veridical perception in a lived world (§2). The latter argument does not oppose our proposal on misrepresentation. Actually, it supports our ideas about the contextual features of an enactive theory of perception. According to certain contexts, an observable setting can be considered illusory, while according to other contexts, it can be considered to be eliciting a mechanism that allows veridical perception. **Bonnardel** criticizes then our claim that the idiosyncratic aspects of perceptual enactivism are counterintuitive (§5). The example of Daltonism that she proposes appears very challenging to the idea that two individuals cannot have the same visual experience, if we consider the differences between trichromats and color-blind dichromatic persons. However, we do not claim that incomparability is counterintuitive in general, but that it is counterintuitive with respect to ordinary communication. Hence the difficulty of identifying differences between trichromats and dichromats on the basis of language and behavior. This does not mean, as she argues, that linguistic features are not necessary for a theory of perception (§6). A complete enactivist account of perception should involve explanations of how our concepts about perceptual properties, such as colors, are learned and used. Considering the main principles of this theory, such explanations might help us understand the behavioral coupling between observers and their environments that gives rise to what we call color perception.

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