COGNITIVE PENETRATION AND THE PERCEPTION/COGNITION DISTINCTION

SERGIO CERMEÑO AÍNSA

UNIVERSITAT AUTÓNOMA DE BARCELONA (UAB)

COGNITIVE SCIENCE AND LANGUAGE (CCiL)

TESIS DOCTORAL

(THESIS PRESENTED BY COMPENDIUM OF PUBLICATIONS)

COGNITIVE PENETRATION AND THE PERCEPTION/COGNITION DISTINCTION

SERGIO CERMEÑO AÍNSA

DIRECTOR

OLGA FERNANDEZ PRAT

COGNITIVE PENETRATION AND THE PERCEPTION/COGNITION DISTINCTION

-INTRODUCTION-

This doctoral thesis is a compendium of published articles. It consists of two papers that address the issue of the cognitive penetrability of perception and two pieces that discuss the case of the perception/cognition distinction. All the papers are related to each other; the relationship between perception and cognition will depend on where we draw the border between them, and drawing such a border will, in turn, be decisive to finding out how they are related. This introduction outlines the main ideas developed in the papers.

The goal of perceptual systems is to allow organisms to respond to environmental relevant stimuli adaptively. Perceptual states provide the most intimate contact with the world. Perception is generally considered to be the most reliable source of information about the external world. Without fear of being wrong, we would say that what we see, hear, smell, taste, or touch corresponds to what is out there. Indeed, perception provides a correspondence with reality much reliable than that provided by any other mental state.

There is a deep sense in which we all know what perception is and how it differs from other mental states, e.g., cognitive states. Looking at an apple and appreciating its redness is different from planning a vacation. Our direct phenomenological acquaintance with objects –the colours, shapes, and sizes that populate our visual experiences– makes the perceptual experiences different from other non-perceptual experiences. Perceptual experiences, therefore, have a particular phenomenal character. This means that objects impinge in our perceptual systems in a way that makes the perceiver experience things in a certain way; there is something like having a perceptual experience. Besides a particular phenomenology, perceptual experiences also have specific representational content. All we perceive is perceived to be a certain way: the car as red, the ice as cold, or the sound as melodious. It is this representational content that determines the truth conditions of perceptual experiences. For many, the content of perceptual states differs from the content of other non-perceptual states because the former is non-conceptual in character.

Along with a pure perceptual aspect, perceptual experiences are also composed of thoughts, beliefs and judgements about the objects of perception. Most of our beliefs about the external world are perceptual beliefs acquired from perceptual experience; I believe that bananas are yellow because of my direct perceptual experience of yellow bananas. In fact, when I see a banana, I cannot avoid judging that object like a banana. It could be said that perceptual experiences (as a whole) are composed of a pure perceptual component and another non-perceptual one. Traditionally, perceptual systems have been seen as a hierarchical structure comprising a series of discrete stages that successively produce increasingly abstract representations. From the information entering the retina to the conceptual recognition of perceptual objects, the signal goes through different levels, each responsible for a particular kind of processing (colour, luminance, contrast, depth, shape, size, and finally, identification and recognition). According to this view, there should be a critical phase where the information processed by other systems does not influence perception. This means that (at least during this uninfected stage) two subjects under the same external and internal conditions will have the same perceptual experience; they will experience the same phenomenological percept with the same content. This is the modular view; perceptual experiences are closed under informational restrictions. Perceptual systems process the information coming from outside without the interruption of central systems (Marr, 1982; Fodor, 1983; Pylyshyn, 1999)[1]. Following this view, it is natural to argue for a joint in nature separating perception from cognition.

But things are probably not so simple. It is uncontroversial whether perception influences cognition –when I perceive a banana in front of me, this disposes me to believe that there is a banana in front of me. Nevertheless, the possibility that information flows in the opposite direction –from cognition to perception– is a matter of controversy. Is what we perceive determined by what we think? The proponents of the cognitive penetrability of perception (henceforth CP) respond yes. The CP hypothesis holds that cognitive states such as beliefs, desires, and possibly other mental states influence perceptual processing in a way that determines subjects´ perceptual experiences (Zeimbekis and Raftopoulos, 2015).

Whether cognition influences perception is one of the most foundational questions that can be asked about what perception is and how it works; if true, its theoretical consequences are considerable. If what we see is determined by what we think, then the epistemic role of perception in justifying beliefs is in question (Siegel, 2017)[2], and our empirical observations will cease to be neutral and will become at the expense of the observer's beliefs. Undoubtedly, these consequences are not very encouraging for an objective theory of science. Furthermore, the existence of CP challenges our current theories on mental architecture, according to which perceptual systems are informationally encapsulated from central systems. These theories have been the installed paradigm in the study of perception for the last decades. For these reasons, the issue has recently received tremendous interest in psychology (Firestone & Scholl, 2016; Lupyan, 2015), neuroscience (Gilbert & Li, 2013; Petro et al., 2014; Newen & Vetter, 2017) and philosophy (Deroy, 2013; Macpherson, 2012; Siegel, 2012; Stokes, 2013).

Crucially, in debates on CP, it is common to differentiate between the early and late stages of a perceptual experience (see Pylyshyn, 1999; Raftopoulos, 2011, 2014). According to Raftopoulos, early vision refers to the pre-attentional stage that includes a feed-forward sweep in which signals are transmitted exclusively bottom-up and a stage at which some kind of local recurrent processing within visual areas is allowed. All this processing lasts about 120-150ms. from stimulus onset and does not involve signals from higher cognitive centres (Raftopoulos, 2014). On the other hand, late vision, the stage after the early vision, is a conceptually modulated stage where top-down processing from cognitive areas is allowed. The conjunction of early and late vision amounts to a whole visual

[1] These different stages are often considered in terms of low-, mid-, and high-level representations. Low-level vision involves the representation of elementary features, such as colour, luminance or contrast. Such processing is linked to the flow of information to the primary visual cortex (V1). The immediate stages beyond V1 (V2–V4) encompass mid-level vision. These areas allow the representation of conjunctions of elementary features and properties such as perceptual grouping, figure-ground organization, depth, and shape perception. Finally, high-level vision reflects the abstraction of the visual input into categorical or semantic representations that enable categorization or identification.

[2] According to Siegel (2017), CP suggests that perception may be epistemically downgraded.

experience. And here is where the debate breaks out. According to the above distinction, there is CP of late vision but not early vision (Raftopoulos, 2011). However, other researchers advocate CP of all perceptual experience, early and late vision (Lupyan, 2015). And others defend that there is neither early nor late vision CP; all the perceptual experience is cognitively impenetrable (Firestone and Scholl, 2016). This is, broadly speaking, the issue addressed in the two first papers here discussed. In Cermeño-Aínsa (2020), I warn about two blocks that prevent solving the CP debate and suggest that seen from other perspectives (cognitive neuroscience and the predictive coding framework), the debate falls on the side of CP supporters of the whole perceptual experience (both, early and late vision). Cermeño-Aínsa (2021a), for its part, delves into the relationship between CP and the predictive coding framework and concludes that whether accepting this framework, not only there is CP of both early and late vision, but also that this cognitive influence on perception is pervasive. I will dig deep into these papers soon.

Strongly related to the CP issue is where perception ends, and cognition begins. Depending on where we put that line, the relationship between them can vary considerably. For example, suppose we endorse a narrow understanding of perception where only the low-level properties (e.g., colour or shape properties) of the perceptual experience are purely perceptual. In that case, perception will be cognitively penetrated only in case that the influence of cognition arrives at these low-level properties. Instead, let us think of perception as a broader class of mental state, a state that includes some kind of conceptual information (e.g., perceptual categorization or identification). Perception will be cognitively penetrated if the influence of high cognition reaches this point. Therefore, drawing a border, if any, between perception and cognition becomes crucial for debates on the CP of perception.

The existence of a perception/cognition boundary not only is crucial for debates on CP, but other philosophical debates have also revived the interest in re-examining the strongly assumed idea that there should be a joint in nature separating perception from cognition. For example, debates on the nature of perceptual content, perception's ability to justify beliefs, the richness of perceptual content, attention's influence on perceptual appearance, or the existence of social perception depend on, and in many cases assume, the existence of such a border. This renewed interest has encouraged theorists to propose some properties that make the difference between perception and cognition. The properties posited differ depending on the theorist; there are, in fact, suggestions for all tastes. For example, the classic idea that perception is modular whereas cognition is not (Fodor, 1983; Pylyshyn, 1999) has recently received new impulses (see Mandelbaum, 2018)[3]. The representational approach: the idea that perception is nonconceptual in content and iconic in format, whereas cognition is conceptual in content and discursive in format (Carey, 2009; Burge, 2010, 2014; Block, 2014; Kulvicki, 2015) has also received much attention. Another way to mark the border is by differentiating how experiences are felt. In this case, cognition, unlike perception, lacks phenomenal character since it is somewhat intentional (Bayne and Montague, 2011). And

[3] I consider this possibility in an unpublished paper currently under review in the journal Philosophical Psychology.

recently, some researchers have considered that, unlike cognition, perception is stimulus-dependent or is under stimulus-control (Beck, 2018; Philips, 2018)[4].

All these laudable attempts have defenders and detractors, but arguably, those who categorically deny the existence of a sharp distinction between perception and cognition are a rare exception[5]. So, with all this in mind, the question of how best to draw the line between perception and cognition becomes crucial since a complete understanding of such a border, if any, is pivotal to many projects in philosophy, psychology and cognitive science. This is, broadly speaking, the issue discussed in the two other papers that make up this thesis. Succinctly, in Cermeño-Aínsa (2021b), I examine the idea that perception and cognition are differentiated by their representational content and format. I offer reasons to think that this is an erroneous idea. In Cermeño-Aínsa (2021c), on the other hand, I consider a most intuitive (and perhaps more compelling) way to draw the perception/cognition border; I discuss the idea that in contrast to cognition, perception is stimulus-dependent. I offer replies to it. So, without further ado, I present a general summary of the ideas presented in the publications that make up this thesis project. I begin with the papers concerning the CP debate.

The cognitive penetrability of perception

The first two papers consider the possibility that perception is cognitively penetrated. In fact, both papers conclude that CP occurs. The first begins by detecting two pitfalls that psychological studies should face elucidating CP's existence. Overcoming these pitfalls is, I argue, an extremely difficult, if not insurmountable, task. So that, I delve into other alternative sources than psychological studies to disentangle these issues. The paper suggests that according to recent cognitive neuroscience findings and consistent with the predictive coding framework, we should conclude that CP occurs. The second paper is a continuation of the previous one, but its conclusions are more radical. It suggests that, according to the thesis suggested by the predictive coding framework, CP is expected to occur not only at all perceptual levels but also pervasively.

Cermeño-Aínsa (2020)

The first paper begins by posing problems for attempts to address the existence of CP. I offer two pitfalls, one definitional and the other methodological, that philosophers and psychologists must address before launching any postulate.

The first pitfall is definitional: the difficulties in defining what counts as cognition (the penetrating), what as perception (the penetrated) and what as cognition penetrating perception blocks the debate. Some think that cognition refers only to propositional

[4] Block (2014) and Burge (2010) have also argued that adaptation and constancy are properties that are persistent in perception but not in cognition.

[5] To my knowledge, only some defenders of the predictive coding framework recognize more or less explicitly that there is not a distinction to be made (Clark, 2013: 10; Hohwy, 2017: 84; Lupyan, 2015: footnote 6; Vetter & Newen, 2014: 69).

attitudes (beliefs and desires), but it can also include other mental states (moods, emotions, types of personality, cognitive styles, expectations, education or learning). Regarding perception, there is the phenomenal experience and the content of such experience; for CP to exist, it is not clear whether cognition should affect one or the other. Furthermore, at least in vision, researchers distinguish between early and late vision (see above); the conjunction of both is a perceptual experience. It is, however, not clear whether CP is the influence of cognition over the late states, or it must also affect the early stages of perception. Finally, the necessary conditions for CP to be relevant are also a matter of debate. For example, it is not clear whether the relationship between the penetrating (cognition) and the penetrated (perception) must be semantical, causal, or rational (for more on the definitional concerns, see Stokes, 2015). Philosophers disagree on defining CP but agree that for CP to exist, there should be some kind of top-down cognitive-perceptual relation that bears relevant philosophical and scientific consequences. For instance, there should challenge the epistemic role of perception in justifying beliefs or questions that our empirical observations are theory-neutral or confront our current theories about mental architecture.

The second pitfall is methodological. Most empirical research on CP comes from psychological studies; indeed, a large body of psychological research establishes that cognitive factors influence perception (http://perception.yale.edu/TopDownPapers.). However, these studies are subject to many different interpretations. I argue that this is because psychological experiments are infested by methodological limitations that prevent the debate from being solved. The point is that these studies do not show that there are top-down effects from cognition towards perception because the influence might be post-perceptual (recognition, conceptualization or memory effects), pre-perceptual (attentional effects), or intra-perceptual (the effects occur inside perception) (see Pylyshyn, 1999; and especially the pitfalls pointed out by Firestone and Scholl, 2016). These pitfalls are insurmountable since such studies cannot appropriately accommodate them. Simply, from subjects´ subjective reports, it is not possible to yield conclusive results; after all, once reported, the percept leaves to be pure perceptual. Furthermore, even assuming that these points can be solved and the post-, pre-, and intra-perceptual effects controlled, there is still an inconsistency. Whether being authentically perceptual requires ruling out the non-perceptual effects over perception, then we are assuming the premise that there should be a part of perception which is cognitively impenetrable. However, this is precisely what we want to elucidate. At this point, impenetrability supporters are, in my view, begging the question; they are trapped into their intuitions because they are assuming what they want to show. In sum, from psychological studies, it is not possible to opt for one option or the other without previously relying on a preestablished intuition. For this reason, I suggest that subjective reports must be combined with other non-subjective sources in order to obtain firmer results.

The rest of the paper is devoted to offering possible solutions to these concerns. Section 3 suggests that widespread top-down processes in the brain avoid the methodological limitations of psychological studies and go in line with the CP thesis. After reviewing the current neuroscientific literature on visual perception, which shows that instead of unidirectionally (from lower to higher brain areas), the information is processed bidirectionally (from lower to higher brain areas and vice versa), I discuss the reasons offered by

Firestone and Scholl (2016) to rule out the neuroscientific approach to unravel these issues. Roughly, they claim that the perspective from neuroscience is unscientific, false and irrelevant. The rest of this section confronts these criticisms (see section 3; pp. 10-12).

Finally, section 4 delves into the novel thesis of predictive coding and its contribution to the CP debate. The predictive coding framework postulates that the brain predicts the incoming sensory information by continually elaborating approximate models of the outside world. In other words, what we see is determined jointly by the current input and the priors established by previous experience, expectations and other contextual factors (Lupyan, 2015: 117). This continuous optimization of the information is done according to Bayesian rules and provides an original and intriguing way to think about perception as an inferential mechanism. The idea is simple: high-level cognitive brain areas send signals (predictions) to incoming low-level ones (prediction errors) to modulate and optimize perceptual processing.

After presenting the predictive coding model in detail (sect. 4.1), I examine its contribution to the CP debate (sect. 4.2). In principle, if perceptual experience results from the minimization of the prediction error, if perceptual experience results from the convergence between top-down projections and bottom-up incoming information, then cognition is involved in perceptual experiences, and therefore CP should be expected. However, finding a solid implication requires clarifying whether Predictive Coding involves actual cognitive states and whether such a relationship includes the CP of perceptual experience, early vision, or both (see Macpherson, 2017).

Since the CP of early vision is the most discussed issue in the current literature, I focus on whether the early vision is CP under the lens of the predictive coding framework (sect. 4.2.1). One can confront these issues in two ways, or by analysing the temporal occurring of predictive and incoming signals and measuring the time lapse between them (see Newen & Vetter, 2017: 29–30; although see Raftopoulos, 2017), or by observing whether the predictive signal reaches the typical processes carried out during the early stages of visual processing. Regarding the first possibility, I show that the temporal strategy does not make sense in the context of predictive coding. According to Raftopoulos (2017), early vision comprises the first 100ms. from stimulus onset, which is the impenetrable part of perception; however, predictive coding suggests that the learned world in our heads is persistently prepared to adjust and be adjusted with the world out there. Accordingly, as soon as the stimulus enters the retina, top-down effects are already underway, thus precluding the possibility that during the first 100ms. the information is exclusively transmitted in a bottom-up direction. Regarding the second possibility, I provide compelling evidence showing that high-level processes influence typical visual properties processed during early vision (see p. 15).

Subsequently, I examine whether the top-down predictions implicate real cognitive states (sect. 4.2.2). Indeed, from the fact that predictive coding posits that high-level processes are crucial to producing perceptual representations, we cannot follow that those high-level processes are real cognitive processes; they can be high with relation to low-level processes but perhaps not high enough to be included as cognitive. This forces us to stipulate an intermediate stage between early vision and high cognition, which belongs to the visual system (perhaps late vision). I confront this possibility by sowing doubts about the existence of an intermediate non-cognitive stage between cognition and early vision; it is unclear whether this stage is perceptual rather than cognitive. Furthermore, I argue that whether these predictions are necessary to guide processing at early stages, then they are crucial to the epistemic status of the agents (a consequence of CP), in which case will count as CP. Finally, I note also that when predictive coding theorists posit that top-down predictions are necessary to have perceptual experiences, they refer to predictions as real cognitive states; predictions convey information from another modality, prior experience, expectations, knowledge or beliefs, which are authentic cognitive processes.

Finally, and with the previous discussion in mind, I address the question of where situate the boundary between perception and cognition (sect. 4.2.3). I consider three possibilities: monism, pluralism or eliminativism (see Philips, 2018). According to monism, there is a unique border between perception and cognition; pluralism claims that there might be multiple ways to mark the border, and for eliminativism, there is no such a border. Predictive coding rejects the monist position, but it is compatible with pluralism and eliminativism. In effect, according to predictive coding, a sharp distinction cannot be sustained. However, the very nature of such a connection is essential to take CP into account. If there is no distinction between perception and cognition, then the very notion of CP becomes meaningless. The point at issue here is that monism is incompatible with predictive coding, and eliminativism is inconsistent with CP, so that only some kind of pluralism may be compatible with both. Consequently, for predictive coding to be consistent with CP, we should consider a shifting border between perception and cognition, an idea compatible with a continuum that lies more or less cognitive and more or less perceptual states. Only in this case, CP makes sense and can connect to predictive coding. In short, the position to be considered here is, perforce, that of pluralism. I suggest then that predictive coding, as a scientific-based theory, can be related to CP only if we are pluralists regarding the perception/cognition border.

To conclude, this paper retrieves many of the issues concerning the cognitive penetrability of perception. Issues about the definitional concerns or methodological difficulties attached to the psychological studies prevent the debate from being solved: no apparent progress is following this path. Now, considering the enormous philosophical and scientific consequences derived from the existence of CP, it is worth raising a possible solution, even if only tentative. I propose incorporating two new perspectives into the debate: cognitive neuroscience and the predictive coding framework, and conclude that when setting our eyes on these information sources, CP is the most plausible view.

Cermeño-Aínsa (2021a)

The abstract of this paper speaks for itself: “In this paper, I discuss the strong thesis of cognitive penetrability (CPs), to wit, that the perceptual states (P) of a subject (S) are pervasively influenced, affected, or caused by cognitive factors (C) as expectations, memories, thoughts, goals, and so on, at all levels of perceptual processing. I argue that following the predictive coding models of perception (PC), the strong thesis of cognitive penetrability is to be expected". In some sense, this paper is devoted to reinforcing the ideas developed in the previous paper, but the ideas provided here are even more substantial. Note that the plan here is to show not only that CP exists at all levels but also that it is inevitable; is pervasive.

I have not found such radical conclusions elsewhere. Typically, defenders of the CP thesis place themselves on the side of the burden of proof: they look for indirect mechanisms or isolated cases in which CP occurs to show that it is a possible phenomenon (Macpherson, 2012; Cecchi, 2018) or defend the CP of only a part of perception but not all perceptual process (Raftopoulos, 2017), or rely on other mental processes (learning or attention) to show that sometimes CP occurs (Cecchi, 2014; Mole, 2015). Proponents of CP, in sum, have been reluctant to abandon the old paradigm thoroughly. The mainstream advocates for non-theorized perceptual processes and has been firmly anchored into philosophical and scientific circles for decades. Thus, the radicality of this paper rests in that it questions the mainstream and situates the burden of proof in no people´s land. Suppose that the theses defended by the predictive coding framework show that CP is an omnipresent phenomenon occurring at all perceptual levels. In that case, the CP critic is forced to argue against the plausibility of the predictive coding framework to avoid its unpleasant consequences. At this very moment, the burden of proof ceases to be on the side of CP's defenders; after all, the traditional view goes from defending their established points of view to attacking the emerging framework and its derived consequences. The paradigm shift is on the table, and the burden of proof is up in the air. This is the primary goal of this paper. Let me sum it up.

I begin the paper defining CP and explaining the postulates of the predictive coding thesis. On the one hand, CP is defined as a genuine cognitive-perceptual relation (being this semantic, rational, causal or internal) that challenges the epistemic role of perception in justifying beliefs, or grants that our empirical observations are theory-ladenness, or confronts our current theories on mental architecture (sect. 2). The thesis of predictive coding, on the other hand, is the idea that the brain produces top-down generative representations that are bottom-up modified by incoming signals (sect. 3). These signals are propagated upwards only as a prediction error signal and subsequently modified by a cascade of top-down processing to reduce global prediction error. Subsequent feedforward-feedback passes refine this process until the entire system settles on the most likely interpretation. The processing is typically thought to be done according to Bayesian rules (Clark, 2013; Hohwy, 2013; Lupyan, 2015; see also Macpherson, 2017, p. 10).

Once introduced the characters, I begin with my argument. I first examine the "all levels claim". In doing so, I first provide evidence showing that there is CP at the very early stages of visual processing. Posteriorly, I address a possible analogy between perception and visual imagery. The idea is as follows: if perception and visual imagery trigger the activation of the same cortical areas, and visual imagery is the product of an endogenous top-down activity that arrives until early visual areas, why not think that some kind of top-down information is elicited when vision occurs exogenously? I leave this possibility open.

Notwithstanding, the core of my argument pivots on elucidating the existence of CP from the predictive coding framework. So, I go to it. Since there are two ways of defining early vision, one functional (Pylyshyn) and the other temporal (Raftopoulos), I address the two possibilities. For the first one, I provide evidence showing that predictive signals modulate the typical functional processes (colour, size or shape) represented during early vision. That is, the pairing between top-down (predictions) and bottom-up (prediction error) processes occur so early that even perceptual organization is subject to descending cognitive effects. Regarding the second possibility, I argue that to the extent that our brains work as a prediction machine that anticipates the events occurring in the environment, the idea of a temporal space during which cognition does not influence perception loses its meaning. Furthermore, studies find top-down predictive activity very quick and influencing the visual system even before that incoming stimulus enters cortical areas (I examine this literature in the paper). This literature is consistent with the idea that if we take the first 100ms. of processing to be early vision, high-level predictive signals reach down as low as this.

In conclusion, if we assume that, as PC suggests, when viewing a stimulus, bottom-up incoming signals and top-down descending signals emerge simultaneously, then at the very moment that the stimulus enters the retina, the brain is already forming predictive mental images to facilitate perception. So, the "*all levels part"* of the strong CP claim is fulfilled.

Finally, I go to the more substantial part of the strong CP claim (sect, 5): that CP is a pervasive phenomenon. Of course, by accepting the all-levels claim, we are only admitting that CP may occur at any level of visual processing; but this is consistent with the idea that CP is a rare and uncommon phenomenon. To argue for the pervasive claim, I focus on Hohwy (2017), who argues that top-down modulation is tied to a variable learning rate in hierarchical Bayesian inference. This means that the difference between the influence of prior knowledge (the prediction or the top-down processing) and the influence of current sensory input (the prediction error or the bottom-up processing) is determined by the deviations from this learning rate. The lower the learning rate, the more top-down modulation and the more prevalent the cognitive influence on perception and, conversely, the higher the learning rate, the less influence of top-down modulation and less prevalence of the cognitive influence on perception. Here are the premises that sustain the pervasive claim:

(1) there is always some uncertainty about the world in sensory input.

(2) such perceptual uncertainty needs to be minimized in order to make sense of the world.

(3) such minimization is mediated and modulated by top-down predictions.

(4) such mediation and modulation count as relevant CP.

The conclusion is that CP is pervasive. The uncertainty of sensory input and the need to minimize it to make sense of the world (premises 1 and 2) is not problematic; everyone can accept it. Not so the statements of premises 3 and 4, which could be challenged. This section is, indeed, devoted to arguing for these questionable premises.

Premise 3, on the one hand, is relatively easy to support. The existence of top-down influences on visual perception is largely corroborated by neuroscientific evidence. All areas of the visual pathway, except for the retina, are subject to top-down influences (see Gilbert and Li, 2013), and these top-down influences constitute a necessary step to perceive the world visually. So, the idea that top-down predictions modulate the minimization of perceptual uncertainty is neuroscientifically supported.

Premise 4, on the other hand, is more difficult to defend. The real cognitive nature of this kind of perceptual modulation may be questioned: does this modulation count as a genuine CP process? To show this is the case, I first consider that cognition is not only circumscribed to doxastic states (such as beliefs or desires), but also to sub-doxastic states (such as moods, emotions, types of personality, cognitive styles, education, learning or expectations). Subsequently, I provide compelling examples where the involvement of both senses of cognition, the strong (e.g., beliefs) and the wake (e.g., emotions), is necessary to minimize the uncertainty of the environment. So, if we take the idea that cognition is not exhausted by propositional attitudes (some non-propositional mental states also count as cognition) and that the influence of these states on perceptual states produces epistemological consequences for subjects, then these non-propositional mental constituents would be compelling cases of CP.

In conclusion, there can be no perception without cognition. Perceptual processes are, according to the predictive coding framework, cognitively penetrated at all levels and pervasively. The conclusions derived from this paper are a formidable starting point to address the queries posited in the second part of this thesis. To wit: whether the strong CP thesis is true, then the line that distinguishes perception from cognition is inexistent (or at least fuzzy). I will go for it.

The perception/cognition distinction

The two other papers that make up this thesis address the fundamental idea of a joint between perception and cognition. In Cermeño-Aínsa (2020), I made this issue explicit when explaining why the CP debate is blocked. I argued that one of the reasons for the blocking is that there is no clear boundary between perception and cognition (see section 4.2.3). Now, if, as I outlined in Cermeño-Aínsa (2020) and thoroughly considered in Cermeño-Aínsa (2021a), CP is a massive phenomenon that affects all the perceptual levels, then such a boundary must be fuzzy or perhaps inexistent. So, more than a real difference in kind, the differences between perception and cognition seem to be moved by intuition. This is, however, contrary to what most people think; it is embedded in the foundations of cognitive science to draw such a boundary. So, reconsidering this issue becomes imperative.

Various debates in philosophy and psychology presuppose that perception and cognition belong to separate categories. Not only debates on the cognitive penetrability of perception; the epistemological role of perception, the richness of perceptual content, or the existence of non-conceptual content usually assume that perception and cognition are part of different categories defining different mental phenomena. Theorists of mind have long been committed to the idea that differences between perception and cognition are differences of kind, and more recently, have speculated for various (and varied) candidates to mark such a distinction. It is now time to attack these queries profoundly.

Of all the options researchers suggest to differentiate perception from cognition, I have focused my research on what I considered the most influential ones[6]. In Cermeño-Aínsa (2021b), I consider that perception and cognition are distinguished by the content and format in which they are represented. I argue that this strategy (the representational strategy) fails. In Cermeño-Aínsa (2021c), I go on to the idea that perception, unlike cognition, is stimulus-dependent. I have also posed problems to this strategy. Let me briefly expose the ideas developed in these papers.

Cermeño-Aínsa (2021b)

One of the most prominent ways to distinguish perception from cognition is by appealing to differences in their type of representation; perception, unlike cognition, outputs nonconceptual and iconic representations. The representational account rests in two independent claims: the content claim (CC), the content of perception is nonconceptual, whereas the content of cognition is conceptual, and the format claim (FC), the format of perception is iconic, whereas the format of cognition is discursive. This paper confronts this view. I argue that the content and format of a mental state, be it perceptual or cognitive, is not exhausted either by content types (nonconceptual/conceptual) or by format types (iconic/discursive).

The paper begins by explaining the necessary conditions to be conceptual (in contrast to nonconceptual) and the necessary conditions to be iconic (in contrast to discursive). On the one hand, a mental state is conceptual if it satisfies the Generality Constraint; otherwise, it will be nonconceptual. On the other hand, a mental state is iconic if it satisfies the Iconicity Principle; otherwise, it will be discursive. This is a crucial point since, depending on such constrictions, the rest of the paper will make sense or not[7]. There is another crucial point. Note that even if the content of cognition is both conceptual and nonconceptual, one can still maintain the distinction by arguing that what makes the difference is the exclusively nonconceptual nature of the content of perception. Equally for the format, one can hold that the format of cognition is both discursive and iconic and still maintain the distinction by arguing that what makes the difference is that the format of perception is uniquely iconic. And the same occurs on the opposite side. If the content of cognition is entirely conceptual, then although perception is conceptual and nonconceptual, one can use this to make the distinction. And if the format of cognition is entirely discursive, and the format of perception is both iconic and discursive, one can use this to make the

[6] One substantial and classical attempt to distinguish perception from cognition is by considering that perception, unlike cognition, is modular. Note, however, that the existence of CP advocated in the previous papers leaves the perception/cognition distinction drawn by the modularity of perception in a complicated situation. Indeed, if CP is true, then perceptual systems are not informationally encapsulated; and if perceptual systems are not informationally encapsulated (which is a fundamental requirement to be modular), then it is hard to see how the modular nature of the former can differentiate perception and cognition (see, Stokes and Bergeron, 2015; for different positions see Clarke, 2021). I have addressed these issues in an unpublished paper currently in review in the journal Philosophical Psychology.

[7] The Generality Constraint and the Iconicity Principle are explained in the text (see section 1). Unfortunately, these are not entirely accepted conditions. How we must interpret the Generality Constraint, for example, has been questioned (Clapp & Duhau, 2011), and the value of the Iconicity Principle as well (see Burge, 2018). I do not discuss thoroughly the criticisms made to these restrictions; it would take another paper to do it. Therefore, it should be clear that the conclusions of this paper only hold if we admit these constraints.

distinction. So, to show that the content and the format cannot be good candidates to mark the perception-cognition distinction, one should show that both perception and cognition can share the same contents and formats. With all this in mind, I got down to work.

Let us begin with content. Recall the content claim: the content of perception is nonconceptual, whereas the content of cognition is conceptual. To show that the content claim is false, it must be shown that there is nonconceptual content in cognition (sect. 2.1) and conceptual content in perception (sect, 2.2). The presence of nonconceptual content in cognition can be shown in different ways (see the candidates proposed at the beginning of section 2.1), but I focus on analogue magnitude states. It must be shown that these states are nonconceptual and count as real cognitive states. To see this point clearer, I urge the reader to carefully read this part of the text that will inevitably lead to Beck's (2012) paper; but let me outline a rough characterization here. Analogue magnitude states are primitive representations of spatial, temporal, numerical, and other magnitudes (say, for example, representations of approximate numbers) shared by humans and animals. These estimations or approximations in discriminating certain representations are, therefore, part of a primitive system whose limitations (e.g., the incapacity of representing discriminations of very close numerical estimations) prevent elaborating the corresponding representations. In effect, there is a point where two magnitudes become indiscriminate, and therefore there is no way to recombine their constituents. This lack of recombinability suggests that analogue magnitude representations do not satisfy the Generality Constraint, and therefore are nonconceptual (for criticism, see Halberda, 2016; for replies to this criticism, see section 2.1). Now, count these representations as cognitive states? The answer is yes. In a broad sense of cognitive and in contrast to the perceptual, these states do not depend on the stimulation of any particular sensory modality, so they count as cognitive all the way down.

So far, the objection to the second part of the content claim. The first part: that the content of perception is nonconceptual, may also be disputed. To show that conceptual content may be part of perception, I turn to studies on the ultra-rapid object categorization[8]. Using a rapid serial visual processing task (RSVP), Potter et al. (2014) found that conceptual understanding could be reached when a novel picture is presented as briefly as 13ms from stimulus onset. This evidence suggests that perception might output conceptualized representations (Mandelbaum, 2018), which would leave the content distinction in trouble. At this point, however, we must be strict. Potter et al.´s evidence, in fact, unfolds two possibilities, or perception includes conceptualized representations, or it is the processing developed during this very reduced space of time. The nonconceptualist is forced to opt for the second —what occurs during this very cramped space of time is what counts as genuine perception. Now, what is registered nonconceptually are the intrinsic properties of perceptual experiences, that is, the early levels of visual processing (such as shape or colour), the representations registered at the late levels (e.g., object recognition) are already conceptualized and therefore do not count as perception but as cognition. This corresponds precisely to the traditional view on visual processing, which considers perception hierarchically; perception comprises a

[8] Note that appealing to the Generality Constraint as a requirement for concept possession is, in this part, less relevant since in order to categorize objects, possessing the concepts ascribed to such categories is required. Therefore, if we include conceptual information in perception, perception will satisfy GC; otherwise, it will not.

series of discrete stages that successively produce increasingly abstract representations. However, recent studies in visual perception contradict this view. Studies of temporal dynamics have found overlapping signatures of low- mid- and high-level representations (Groen et al., 2013; Harel et al., 2016), suggesting co-occurring and co-localized visual and categorical processing (Grill-Spector and Kanwisher, 2005; Ramkumar et al., 2016).

Furthermore, if we attend to the spatial frequencies, the studies suggest that object categorization can be achieved at very poor resolutions; the intervention of low-level properties in the consecution of categorical information is thus minimal. So, as CC claims, if the nonconceptual/conceptual distinction coincides with the perception/cognition distinction, then the space corresponding to perception is exceptionally narrow. The responsibility for perception in vision is, in this case, almost insignificant. The remainder of this section is dedicated to explaining why we should expect so much more from perceptual processing.

Following the marked itinerary is now time to examine the FC claim; to wit, the idea that the format of perception is iconic and the format of cognition discursive (sect. 3). Again, for the iconic/discursive format being a good candidate for the perception/cognition distinction it should be shown either that iconicity is a property exclusive of perception or that, though present in cognition, it is pervasive in perception. This section argues against both.

To show the presence of iconic format in cognition, I focus on mental imagery (see sect., 3.1). The phenomenon of mental rotation is quite illustrative; when we mentally rotate a figure, there is a correspondence between the manipulation of the mental representation and the physical rotation of the object (Shepard and Metzler, 1971; Kosslyn et al., 2006) so that there seems to be a pictorial image representation where every part of the mental representation represents some part of the scene represented by the whole representation. Contrary to discursive formats, the representation cannot be decomposed or recombined. Thus, mental imagery satisfies the Iconicity Principle and, therefore, is conveyed in an iconic format. Now, does mental imagery count as a cognitive process? Actually, mental imagery seems to share properties of both perception and cognition. Like perception requires a visual object, but like cognition, it does not require the real presence of such a visual object nor the stimulation of the sense organs. Once arrived at this point, I asked myself about the possibility of including a third kind of mental state between perception and cognition, a mental state composed of mental imagery, episodic memories, imagination or certain forms of multisensory integration. The reason for rejecting this possibility is that there is no essential property in mental imagery suggesting the need to introduce an independent type of mental state; all the properties of mental imagery are found in both perceptual and cognitive processes. Finally, I take these mental states as cognitive not appeal to phenomenological considerations nor to the brain areas implicated in its consecution (which largely coincide with the perceptual areas), but to the sort of processing involved. Whereas paradigmatic perception requires bottom-up processing from external stimuli passing through sense organs, visual imagery does not. Thus, mental imagery cannot be explained in terms of changes occurring within bottom-up processing, but with changes occurring during top-down processes; so, it counts as cognitive.

Finally, the presence of discursive format in perception is, perhaps, the most slippery argument of the paper. Indeed, to show that perception is not exclusively iconic, it is necessary to expand on the previous explanations on the Iconicity Principle. The Iconicity Principle contains in itself two principles, the part principle, that every part of an icon corresponds to parts of what it is represented, and the holistic principle, that parts of icons can represent multiple properties simultaneously (see the text for examples and detailed explanations). So, for satisfying the Iconicity Principle, the two principles derived from it, the part and the holistic principles, must be satisfied. Quilty-Dunn (2020) provides arguments showing that object perception does not obey the part principle nor the holistic principle, thus suggesting the non-iconicity of object perception. Although I explain these arguments in the paper, I prefer to focus on face perception, which is, I think, a more compelling case of non-iconic perception. I begin by noting that there should be an initial perceptual stage, previous to face recognition, that detects faces as faces and not as other kinds of things. Indeed, the condition of prosopagnosia shows cases in which even without failures in the processing of low-level properties (processing of shape, colour or orientation), some subjects mistake the mere face/non-face distinction, and cases in which without failures in the face/non-face distinction subjects still present failures in face recognition. Therefore, this condition shows an intermediary detection stage for processing faces as faces and not as other kinds of things. So, since this intermediary stage represents the property of being a face, and this property cannot represent multiple properties simultaneously, it will not meet the holistic principle (a necessary condition for IP). It follows that face detection cannot be purely iconic, it should have a discursive aspect.

And the argument goes on; does face detection belong to the perceptual or cognitive side of the story? If cognitive, then perception will be confined to the representation of low-level properties. However, this faces a problem with the low-level properties. We should distinguish between general and specific low-level properties. General properties allow representing faces instead of objects (the detection stage). Face detection is, for example, eased by the previous knowledge that the two eyes are positioned above the nose, which is above the mouth. On the other hand, specific properties represent more complex conceptual information associated with faces (the recognition stage). Face recognition is eased by the previous knowledge of some specific features, such as eyes and hair colour, nose size, characteristic freckles, or scars. Face detection must be prior to representing specific properties of the face (what allows detecting faces as pertaining to), but not to the representation of the general properties of faces (what allows detecting faces as faces and not as other things). So, to be purely and entirely iconic, perception must be restricted to general properties since specific properties are already contaminated by the discursive knowledge that we are facing a face and not another thing. In my view, this option decreases too much the scope of perception. By restricting the notion of perception to only the processing of the general low-level properties, the very notion of face perception (as well as to object perception) becomes bad-labelled and trivial. In short, the only we need to incorporate discursivity in perception is to admit the existence of an intermediate stage, posterior to the processing of general low-level features but necessary for object recognition —the mere detection of faces as faces. If this argument is correct, the second part of FC also fails —the perception/cognition border cannot be drawn by differences in the format in which are represented.

In conclusion, the border between perception and cognition cannot be marked by differences in the type of content or the type of format. The representational strategy, as a whole, fails.

Cermeño-Aínsa (2021c)

The last paper that makes up this thesis discusses the strongly intuitive idea that perception, unlike cognition, is stimulus-dependent. In effect, perhaps the most obvious way to mark a border between perception and cognition is by appealing to the notion of stimulus dependence. This is the suggestion made by Beck (2018). The present paper (2021c) examines this view and provide reasons and examples suggesting that even the criterion of stimulus-dependence fails to mark a clearly defined border between perception and cognition.

The paper begins (sect. 2) by outlining the stimulus-dependent criterion suggested by Beck (2018). Roughly, a mental state is perceptual if, necessarily, all veridical occurrences of such mental state are stimulus-dependent; otherwise, it will be cognitive (Beck 2018: 323). This is the simple formulation. Now, to be appropriate to mark the perception/cognition boundary, Beck notes, the stimulus-dependence criterion should accommodate two problematic cases: hallucinations, where perception is stimulus-independent, and demonstrative thoughts, where cognition is stimulus-dependent. Once applied the restrictions invoked by these cases, the final formulation of the criterion is as follows: A mental state is perceptual if, necessarily, all occurrences of all elements of such mental state have the function of being stimulus-dependent; otherwise, it will be cognitive (Beck, 2018: 331). On the one hand, the condition of "having the function of being stimulus-dependent" accommodates the problematical cases of endogenous perceptual hallucinations. Simply, insofar as a perceptual state has the function of representing the occurrences of the environment, the representation of deviant occurrences (exogenous hallucinations and illusions) or even the very absence of the occurrences (endogenous hallucinations) in the environment are, by the functional formulation, tolerated. On the other hand, the condition of "all occurrences of all elements" rules out perceptually grounded demonstrative thoughts. Simply, insofar as these states are composed of an attributive element and a perceptual element, they are only partially stimulus-dependent. So, introducing the clause "all occurrences of all elements" rule out the problematic case of perceptually grounded demonstrative thoughts[9].

So far, Beck´s account. Let us assume that S-D full is the appropriate formulation; perception differs from cognition by having the function of being fully stimulus-dependence. Now, departing from this assumption, I analyse the possible accommodation of other mental states that seem to be halfway between perception and cognition; in particular, amodal completion, which is prima facie perceptual yet stimulus-independent, and visual categorization, which is prima facie cognitive yet stimulus-dependent.

[9] Note that the final formulation allows the presence of some kind of hallucinations but blocks the presence of demonstrative thoughts.

Before proceeding, however, I provide some general difficulties in taking S-D full (sect. 3). First, to accommodate hallucinations, S-D function rests on neuroscientific evidence about perceptual brain mechanisms, and second, to accommodate demonstrative thoughts, S-D full assumes the object-independent theory of demonstrative thoughts. In the first place, it should be noted that the functional definition leans on neurological criteria; the difference between imagistic and perceptual endogenous hallucinations lies in differences in the brain mechanisms deployed. For example, Beck states the Charles Bonnet Syndrome is an instance of perceptual endogenous hallucination since it is correlated with activity in areas of the cortex closely linked to mechanisms of visual perception (Beck 2018: 329). However, a closer examination of this syndrome reveals another reality. Recent evidence shows that more than differences in organizational properties of visual areas, the syndrome is better explained by the disconnections between top-down and bottom-up processing. The issue is that the very distinction between imagistic and perceptual endogenous hallucinations loses sense when we approach the neurological basis of hallucinations. Secondly, appealing to the object-independent theory of demonstrative thoughts (Burge, 2010) is vital for Beck´s account. The object-independent theory of demonstrative thoughts posits that perceptual demonstrative thoughts have, like perceptual states, a demonstrative element but differs from perceptual states in the attributive element. Just as in perceptual states the attributive elements are typically perceptual, in perceptual demonstrative thoughts, the attributive elements are conceptual. In contrast to this view, however, the object-dependent theory of demonstrative thoughts posits that even though conceptual, the attributive elements of perceptual demonstrative thoughts fall on the side of perception. The idea is that in the absence of sensorial input, there is no attribution at all; it is the presence of the input that specifies the full content of the perceptual demonstrative thought, and therefore, the attributives of a perceptual demonstrative thought must be part of perceptual content (Evans, 1982; McDowell, 1984)[10].

The variations of the original formulation of the stimulus-dependent criterion are, therefore, pretty controversial. However, I overlook these difficulties and accept such variations: I assume that S-D full is an appropriate formulation to distinguish perception from cognition. Now, departing from this assumption, I examine how other mental states whose nature (whether perceptual or cognitive) is unsolved accommodate S-D full; particularly, I put under the prism of S-D full amodal completion and visual categorization.

I begin with amodal completion (sect. 4). Amodal completion is the capacity to see objects as having occluded parts; almost all perceptual experiences represent incomplete objects or scenes. Three mental mechanisms can do this job: imagination (Nanay, 2010), perception (Gibson, 1972) or belief (Briscoe, 2011)[11]. For example, when we complete an occluded horse, we employ our previous beliefs; we cannot complete a horse if we have never seen one. However, when we complete a trivial figure (trivial in the sense that it has no particular meaning), we do it through perceptual mechanisms; only specific perceptual rules (or perhaps habits) play this game (for clarity, see the paper examples). Now, when applying S-D full constraints, what remains is that perceptual amodal completion has the function of being fully stimulus-dependent (there is not a conceptual attributive in this sort of completion). In contrast, cognitive

[10] For a recent discussion on these issues, see Crawford (2020).

[11] For the present discussion, belief and imagination mechanisms, although different, are considered both cognitive mechanisms.

amodal completion requires the use of prior conceptual information, and therefore, it is only partially stimulus-dependent; it does not satisfy S-D full. And here arrives the crucial point of the analysis: *in the vast majority of everyday perceptual scenarios, stimuli are completed cognitively*. In effect, perceptual experiences are not usually composed of nonsensical oriented bars, squares, circles or crosses, but rather by more complex stimuli like tools, animals, faces or moving objects. That is, in natural conditions, it is very rare to amodally complete stimuli through only sensory stimulation-driven perception. So, if we take the perceptual side of the amodal completion story as a residual and rare phenomenon only present in labs, in controlled situations and with deliberately designed stimuli, one is tempted to claim that the phenomenon of amodal completion is mostly cognitive and, therefore, according to Beck's logic, stimulus-independent.

Next, I apply Beck's constraints to another widespread mental phenomenon: visual categorization. Visual representations are understood very quickly, conceptual information is effortlessly available in the blink of an eye, almost instantaneously. Recent evidence shows that conceptual understanding can be reached when a novel picture is presented as briefly as 13ms. from stimulus onset (Potter et al., 2014). However, whether visual categorization counts as perceptual or cognitive is a debated issue[12]. Let me then apply the constraints of the stimulus-dependence criterion.

In a first approximation, visual categorization satisfies the simple formulation of S-D since it is causally sustained by proximal stimulation; one cannot visually categorize an object if the object is not visually present. Now, when we apply the functional part of the formulation, we encounter some difficulties in assigning typically perceptual or cognitive brain areas. Indeed, a multiplicity of brain areas is activated during visual categorization (from V1 to Prefrontal Cortex). It is the ventral pathway (which, in fact, encompasses multiple areas) that is responsible for providing meaning to objects. If we grant that this stream is part of a perceptual brain mechanism, then visual categorization could satisfy the constraints imposed by the functional formulation. In the paper, I concede this point. However, overcoming the full part of the S-D full formulation is out of the reach of visual categorization. The reason is similar to that of perceptually grounded demonstrative thoughts; the attributive element of visual categorization is not proximally constrained. So, visual categorization should count, under the prism of the S-D full criterion, as cognitive.

Finally, the discussion on the S-D criterion to differentiate perception and cognition leaves the perceptual part extremely narrow, almost insignificant; it is, in fact, hard to find a mental state whose function is to be fully stimulus-dependent.

Conclusion

[12] While some argue that the conceptual nature of visual categorization involves that it is cognitive (Firestone and Scholl, 2016), others appeal to its swiftness (Grill-Spector and Kanwisher, 2005; Potter et al., 2014) and automaticity (Mandelbaum, 2018) to argue that it is perceptual in nature.

In conclusion, the two first papers (Cermeño-Aínsa, 2020, 2021a) discuss the cognitive penetrability of perception, and advocate a strong view of CP, according to which perceptual processes is pervasively influenced by cognitive factors at all levels of perceptual processing. The two other papers (Cermeño-Aínsa, 2021b, 2021c) discuss the existence of a perception/cognition border, and pleads that at least the representational strategy fails

References

Bayne, T. and Montague, M. (eds.) (2011). *Cognitive phenomenology.* New York and Oxford: Oxford University Press.

Beck, J. (2012). The Generality Constraint and the Structure of Thought, Mind 121/483: 563–600.

Beck, J. (2018). Marking the perception–cognition boundary: The criterion of stimulus-dependence. *Australasian Journal of Philosophy* 96 (2): 319–334

Block, N. (2014). Seeing-as in the light of vision science. *Philosophy and Phenomenological Research* 89 (1): 560–572.

Briscoe, R. (2011). Mental imagery and the varieties of amodal perception. *Pacific Philosophical Quarterly,* 92: 153–173.

Burge, T. (2010). *Origins of Objectivity*. Oxford: Oxford University Press.

Burge, T. (2014). Reply to Block: Adaptation and the upper border of perception. *Philosophy and Phenomenological Research* 89 (3): 573–583.

Burge T. (2018). Iconic Representation: Maps, Pictures, and Perception. In: Wuppuluri S., Doria F. (eds) The Map and the Territory. The Frontiers Collection. Springer, Cham.

Carey, S. (2009). *The origin of concepts*. Oxford: Oxford University Press.

Cecchi, A. S. (2014). Cognitive penetration, perceptual learning, and neural plasticity. *Dialectica,* 68(1), 63–95.

Cecchi, A. (2018). Cognitive penetration of early vision in face perception. Consciousness and Cognition, 63, 254-266.

Cermeño-Aínsa, S. (2020). The cognitive penetrability of perception: A blocked debate and a tentative solution. Consciousness and cognition, 77, 102838.

Cermeño-Aínsa, S. (2021a). Predictive coding and the strong thesis of cognitive penetrability. THEORIA. An International Journal for Theory, History and Foundations of Science, 36(3).

Cermeño-Aínsa, S. (2021b). The perception/cognition distincton: Challenging the representational account. *Consciousness and Cognition*, 95:103216.

Cermeño-Aínsa, S. (2021c). Is Perception Stimulus-Dependent? *Review of Philosophy and Psychology*, 1-20.

Clapp, L. & Duhau, L. (2011). Varieties of the generality constraint. *Manuscrito,* 34, 397-434.

Clark, A. (2013). Whatever next? Predictive brains, situated agents, and the future of cognitive science. *Behavioural and Brain Sciences, 36*(3), 181–204.

Clarke, S. (2021). Cognitive penetration and informational encapsulation: Have we been failing the module? *Philosophical Studies,* 178, 2599–2620.

Crawford, S. (2020). Perceptual Demonstrative Thought: A Property-Dependent Theory. *Topoi, 39*, 439-457.

Deroy, O. (2013). Object-sensitivity versus cognitive penetrability of perception. *Philosophical Studies, 162*, 87–107.

Evans, G. (1982). *The Varieties of Reference.* Oxford: Oxford University Press.

Firestone, C., & Scholl, B. J. (2016). Cognition does not affect perception: Evaluating the evidence for 'top-down' effects. *Behavioural and Brain Sciences*, 39, 1–77.

Fodor, J. A. (1983). *The modularity of mind.* Cambridge, Massachusetts: MIT Press.

Gibson, J. J. (1972). A theory of direct visual perception. In: Royce, J. R., Rozeboom, W. W. (eds) The psychology of knowing, New York, NY: Gordon and Breach, pp. 215–240.

Gilbert, C. D., & Li, W. (2013). Top-down influences on visual processing. *Nature Reviews Neuroscience, 14*, 350–363.

Grill-Spector, K., & Kanwisher, N. (2005). Visual recognition as soon as you know it is there, you know what it is. Psychological Science 16(2), 152–160.

Groen, I.I.A., Ghebreab, S., Prins, H., Lamme, V.A.F. & Scholte, H.S. (2013). From image statistics to scene gist: evoked neural activity reveals transition from low-level natural image structure to scene category. J. Neurosci., 33, 18814-18824.

Halberda, J. (2016). Epistemic limitations and precise estimates in analog magnitude representation. In D. Barner, & A. S. Baron (Eds.), Core knowledge and conceptual change (pp. 171–190). New York: Oxford University Press.

Harel, A., Groen, I. I., Kravitz, D. J., Deouell, L. Y., & Baker, C. I. (2016). The Temporal Dynamics of Scene Processing: A Multifaceted EEG Investigation. *eNeuro*, *3*(5).

Hohwy, J. (2013) *The predictive mind.* Oxford: Oxford University Press.

Hohwy, J. (2017). Priors in perception: Top-down modulation, Bayesian perceptual learning rate, and prediction error minimization. *Consciousness and Cognition, 47*, 75–85.

Kulvicki, J. (2015). Analog representation and the parts principle. *Review of Philosophy and Psychology* 6(1), 165–180.

Kosslyn, S. M., Thompson, W. L., & Ganis, G. (2006*). The Case for Mental Imagery. Oxford: OUP.*

Lupyan, G. (2015). Cognitive penetrability of perception in the age of prediction: Predictive systems are penetrable systems. *Review of Philosophy and Psychology, 6*, 547–569.

Macpherson, F. (2012). Cognitive penetration of colour experience: Rethinking the issue in light of an indirect mechanism. *Philosophy and Phenomenological Research, 84*(1), 24–62.

Macpherson, F. (2017). The relationship between cognitive penetration and predictive coding. *Consciousness and Cognition. 47*, 6–16.

Mandelbaum, E. (2018). Seeing and Conceptualizing: Modularity and the Shallow Contents of Perception. *Philosophy and Phenomenological Research, 97(2), 267–283.*

Marr, D. (1982). *Vision: A Computational Investigation into the Human Representation and Processing of Visual Information*. Cambridge, MA: MIT Press.

McDowell, J. (1994). *Mind and World*. Cambridge, MA: Harvard University Press.

Mole, C. (2015). Attention and cognitive penetration. In J. Zeimbekis & A. Raftopoulos (Eds.), *The cognitive penetrability of perception: New philosophical perspectives* (pp. 218–238). Oxford: Oxford University Press.

Nanay, B. (2010). Perception and Imagination: Amodal perception as mental imagery. Philosophical Studies 150: 239–254

Newen, A., & Vetter, P. (2017). Why cognitive penetration of our perceptual experience is still the most plausible account. *Consciousness and Cognition, 47*, 26–37.

Petro, L. S., Vizioli, L., & Muckli, L. (2014). Contributions of cortical feedback to sensory processing in primary visual cortex. *Frontiers in Psychology*, 5, 1223.

Philips, B. (2019). The Shifting Border Between Perception and Cognition*. Noûs 53 (2): 316–346.*

Potter, M., Wyble, B., Hagmann, C., & McCourt, E. (2014). Detecting meaning in RSVP at 13 ms per picture. *Attention, Perception, & Psychophysics* 76(2), 270–279.

Pylyshyn, Z. W. (1999). Is vision continuous with cognition? The case for cognitive impenetrability of visual perception. *Behavioural and Brain Sciences, 22*, 341–365.

Quilty-Dunn, J. (2020). Perceptual Pluralism. Noûs, 54 (4), 807-838.

Raftopoulos, A. (2011). Late vision: Processes and epistemic status. *Frontiers in Psychology, 2*(382), 1–12.

Raftopoulos, A. (2014). The cognitive impenetrability of the content of early vision is a necessary and sufficient condition for purely nonconceptual content. *Philosophy of Psychology, 27*, 601–620.

Raftopoulos, A. (2017). *Timing time: Why early vision is cognitively impenetrable. Proceedings of the 39th annual conference of the cognitive science society*. Austin, TX: Cognitive Science Society.

Ramkumar, P., Hansen, B.C., Pannasch, S. & Loschky, L.C. (2016). Visual information representation and rapid scene categorization are simultaneous across cortex: an MEG study. Neuroimage, 134, 295-304.

Siegel, S. (2012). Cognitive penetrability and perceptual justification. *Noûs, 46*, 201–222.

Siegel, S. (2017). *The rationality of perception.* Oxford: Oxford University Press.

Shepard, R.N., & Metzler, J. (1971). Mental rotation of three-dimensional objects. Science 171, 701–703.

Stokes, D. (2013). Cognitive penetrability of perception. Philos. *Compass, 8*, 646–663.

Stokes, D. (2015). Towards a consequentialist understanding of cognitive penetration. In A. Raftopoulos and J. Zeimbekis (Eds.), Cognitive effects on perception: New philosophical perspectives.

Stokes, D., & Bergeron, V. (2015). Modular Architectures and Informational Encapsulation: A Dilemma. *European Journal for Philosophy of Science, 5*(3), 315–338.

Vetter, P., & Newen, A. (2014). Varieties of cognitive penetration in visual perception. *Consciousness and Cognition, 27*, 62–75.

Zeimbekis, J. & Raftopoulos, A. (2015). The Cognitive Penetrability of Perception: New philosophical perspectives. Oxford University Press.

Consciousness and Cognition 77 (2020) 102838

Contents lists available at ScienceDirect

Consciousness and Cognition

journal homepage: www.elsevier.com/locate/concog

The cognitive penetrability of perception: A blocked debate and a tentative solution

Sergio Cermeño-Aínsa

Departamento de Filosofía, Facultad de Filosofía y Letras, 08193 Cerdanyola del Vallés, Spain

ARTICLE INFO

Keywords:
Cognitive penetrability
Predictive coding
Neuroscience
Visual perception
Top-down effects

ABSTRACT

Despite the extensive body of psychological findings suggesting that cognition influences perception, the debate between defenders and detractors of the cognitive penetrability of perception persists. While detractors demand more strictness in psychological experiments, proponents consider that empirical studies show that cognitive penetrability occurs. These considerations have led some theorists to propose that the debate has reached a dead end. The issue about where perception ends and cognition begins is, I argue, one of the reasons why the debate is cornered. Another reason is the inability of psychological studies to present uncontroversial interpretations of the results obtained. To dive into other kinds of empirical sources is, therefore, required to clarify the debate. In this paper, I explain where the debate is blocked, and suggest that neuroscientific evidence together with the predictive coding account, might decant the discussion on the side of the penetrability thesis.

1. Introduction

The debate on whether cognition can influence perception has two opposing camps. On one side are those who hold that sensorial information is insufficient to determine the hypothesis about the external world. Supporters of this side claim that to perceive the world, the inputs of perception are not enough, information coming from other systems (e.g. background beliefs) is indispensable. On the other side, others maintain that all the necessary information for complete perception is within the perceptual system. Other systems are oblivious to this information, and only once a part of perception has completed its work, global integration of the information with other systems occurs. Crucially, this idea involves a "raw" stage of perception, an un-interpreted image not affected by the subject's beliefs, thus suggesting that at least during this raw stage, every person in every culture sees the same thing when looking at the same stimuli.

Despite the deep intuitions derived from this last view, there exists a considerable amount of recent literature in experimental psychology consistent with the idea that perceptual processes inevitably involve theoretical presuppositions. This view is usually conceptualized as cognitive penetrability of perception (CPP from now on) or as top-down effects on perception.[1] What CPP suggests is that the sharp intuitive distinction between seeing a colour and planning a vacation is, in a certain sense, fictitious, there is not a clear delimitation between what we see and what we intend, think, act or desire. CPP results in three central consequences of interest.

E-mail address: elsergei@hotmail.com.

[1] There is considerable interest in CPP from different disciplines, psychology (Firestone & Scholl, 2016; Hansen et al., 2006; Levin & Banaji, 2006; Lupyan, Thompson-Schill, & Swingley, 2010; Lupyan & Ward, 2013; Lupyan, 2015), neuroscience (Gilbert & Li, 2013; Vetter et al., 2014; Petro, Vizioli, & Muckli, 2014; Newen & Vetter, 2017) and philosophy (Deroy, 2013; Lyons, 2011; Macpherson, 2012; Siegel, 2012; Stokes, 2013). In this paper, the notions of cognitive penetration and top-down effects on perception are used indistinctively. Although the term *top-down* has been used in a huge variety of ways, I focus the term here in reference to the top-down influences of cognitive states into perceptual ones.

https://doi.org/10.1016/j.concog.2019.102838
Received 23 January 2019; Received in revised form 3 October 2019; Accepted 12 October 2019
1053-8100/

First, empirical observation becomes theory-ladenness instead of theory-neutral (see Churchland, 1988). Second, the knowledge acquired through perceptual experience may be epistemically downgraded (Siegel, 2017). And third, perceptual systems will not be informationally encapsulated[2], thus threatening the modular architectures of the mind (Stokes & Bergeron, 2015).

For its theoretical consequences, the debate on CPP has acquired particular interest among the theoreticians of the mind. The large number of psychological experiments interpreted as CPP cases indicate that such alleged cases can be found all over in different and varied tasks, suggesting that top-down influences are not a strange phenomenon. However, for proponents of impenetrability thesis, these psychological experiments do not overcome the necessary conditions to grant the existence of relevant downward processing on perception (Fodor, 1983; Pylyshyn, 1999; Raftopoulos, 2009; Firestone & Scholl, 2016). The debate, I argue, is blocked for two reasons. First, the lack of consensus on what counts as cognition and what as perception makes it hard to establish boundaries between them, which in turn prevents to obtain a clear understanding of what counts as cognition penetrating perception. And second, from psychological experiments, it is not possible to argue for or against the CPP thesis, the subjective nature of the subject's reports block such possibility. I propose to resort to other non-psychological sources to help find a way out of the debate. I argue that cognitive neuroscience and predictive coding have many things to say in these respects. This paper is structured as follows. Section 2 explains the reasons why the debate is blocked. Succinctly, the first reason is that we do not know where perception ends and cognition begins, which in turn makes it difficult to know how they are interrelated and, in consequence, to know what counts as CPP (Section 2.1). The second reason is that when we apply the constraints suggested by impenetrability supporters to psychological studies, what remains is a private and subjective part of perception that it is not possible to attain experimentally, thus preventing to psychological evidence to offer clear clues to opt for either side of the debate (Section 2.2). Sections 3 and 4, point out a tentative solution to these concerns. Section 3 suggests that cognitive neuroscience can provide strong support to the psychological evidence to unravel the questions raised on CPP. However, cognitive neuroscience has still to solve what I have called the temporal and intra-perceptual constraints. Section 4 argues that the emerging predictive coding account of perception can solve these issues. After a detailed description of the PC model (Section 4.1), I examine how some concetions of PC can make all definitions of CPP possible (Section 4.2), first by denying the temporal constraint (Section 4.2.1), second by denying the intra-perceptual constraint (Section 4.2.2), and third by arguing that there is not a sharp boundary between perception and cognition, but a continuum along which lies more or less cognitive and perceptual states, thus also solving the eliminativist concern (Section 4.2.3). Finally, in Section 5, I summarize my view and conclude that the existence of genuine top-down influences on perception is the most plausible account.

2. Why is the debate blocked?

The debate about CPP is stuck because neither philosophical discussion nor the empirical psychological research has provided, so far, the necessary tools to solve it. There are two main reasons why the debate persists. First, the variety of ways in which we can answer the question about where perception ends and cognition begins impedes to elaborate a standard and stipulated definition of what counts as CPP. This, in part, corresponds to the philosophical discussion. And second, the markedly subjective character of the subject's reports in the psychological experiments suggests that what it is under research is perceptual judgment rather than perceptual experience, which makes it challenging to obtain a single and unified interpretation of the results obtained in the experiments. This corresponds to methodological issues in psychological research. I hold that these reasons bar any movement from the possibility of disentangling the questions concerned with CPP without invoking the presence and support of other different sources.

2.1. *The boundary between perception and cognition*

The debate on CPP is blocked from its inception. The conventional belief in philosophy and cognitive science is that there is a clear boundary between perceptual and cognitive systems. Perceptual systems passively wait to be activated by external stimuli, and once activated, they generate perceptual outputs, which are posteriorly retrieved by cognition to produce beliefs, desires, emotions and other mental states. Perceptual and cognitive systems are, accordingly, widely independent from each other. In contrast, current evidence suggests that perception is an active process that continually interacts with cognition in a bi-directional way. What we see is a combination of both bottom-up incoming information and top-down stored knowledge. Here is the dispute. The existence of CPP might change our way of thinking about the mind functioning in general. If the CPP thesis is right, we will be forced to reinterpret the classical picture and reconsider the real meaning of the notions at stake. In this section, I argue that at the centre of the debate is the lack of a clear delimitation on where perception ends, and cognition begins.

To assess the existence of CPP, we should first try to answer the following questions: What counts as cognition? What counts as perception? And in consequence, what might count as cognition penetrating perception? Unfortunately, there is no consensus on how we should respond to these questions. The first question, what counts as cognition, or in our context, *what is doing the penetrating*, would include propositional attitudes like beliefs and desires, but other mental components (supposedly non-reduced to propositional attitudes) like moods, emotions, types of personality, cognitive styles, and education or learning may also count as compelling candidates. If we take the idea that interesting cases of CPP are those that produce epistemological consequences for the subjects,

[2] Notice that the encapsulation thesis is stronger than the impenetrability thesis, since the former includes the influence of other non-cognitive systems (as for example other sense modalities), while the latter is restricted to the influence of cognitive systems. Although sometimes they are used as interchangeable, this is an important distinction, being informationally encapsulated entails to be cognitively impenetrable, but being cognitive impenetrable does not entail to be informationally encapsulated.

then these other non-propositional mental components would be good candidates. For instance, if a negative emotional state (e.g. sadness or fear) influences our perceptual experience (e.g. perceiving hills to be steeper), we are clearly facing an epistemologically relevant issue, and therefore, it would count as a potential case of CPP[3]. In the CPP debate, it is usually assumed that the cognitive aspect is not exhausted by propositional attitudes, at least some non-propositional mental states are also included. In this paper, I will adopt this position.

The second question, what counts as perception, or in our context, *what is penetrated*, is subject to further disagreements. On the one hand, it is not clear whether for CPP to be relevant, cognitive states (beliefs, desires, emotions, etc.) must influence the phenomenological character of the perceptual experience (the experience properly speaking), its semantic content (what is conveyed to the subject by her perceptual experience) or, in fact, both. Indeed, although it is possible to grasp the crucial difference between the content and the phenomenology of ~~a~~ perceptual experience, its causal relationship is an open question[4]. What it is usually accepted is that the propositional aspect of perception (the perceptual judgment), is separated from what it is currently perceived (what it is like for the subject to have an experience), so that cognitive influences over perceptual judgments do not provide support for the CPP thesis since they are both considered to be post-perceptual.

On the other hand, there are also doubts on whether cognitive influence must occur on perceptual experience or early perception (early vision). While perceptual experience refers to the conscious phenomenal state that we typically go into when we perceive the world, early vision is defined functionally as the system that takes signals from the eyes as inputs and produces shape, size and colour representations as output (Pylyshyn, 1999). Thus, when Pylyshyn (1999) claims for cognitive impenetrability of perception he refers to early vision, and not to visual experience[5]. There are, then, two related (although distinct) phenomena that go under the name of CPP, namely, the cognitive penetration of perceptual experience and the cognitive penetration of early vision. Consider, for instance, two subjects (or the same subject in different situations) who have visual experiences with different contents while viewing and focusing their attention in the same part of a distal stimulus under the same external conditions, it is to be expected that the difference in their perceptual experiences must be caused by differences in their cognitive states[6]. This point is important because, being early vision the output of a perceptual encapsulated module, the contents of visual experience are not exhausted by the outputs of early vision, and therefore it makes the cognitive penetrability of perceptual experience compatible with the cognitive impenetrability of early vision So, what counts as CPP will depend crucially on what we understand by cognition and, above all, on what we understand by perception.

What kind of relationship between perception and cognition is, therefore, to be expected? If I decide to close my eyes to experience darkness, my decision (a cognitive process) will influence my perceptual experience. However, this influence does not obviously count as CPP, what my decision changes is the input to perception and not perception per se, what changes is the state of the sensory organ (open vs closed eye). In these widespread cases the cognitive aspect is not directly connected with the perceptual experience, the influence occurs by the mediation of the focus of attention, but regardless of the viewer's cognitive state– it is said that in these kind of cases the cognitive state does not affect the resulting percept in a logically connected way. So, we need further conditions to define CPP, and here controversies arise. For example, Pylyshyn famously suggests the following definition

> if a system is cognitively penetrable then the function it computes is sensitive, in a semantically coherent way, to the organism's goals and beliefs, that is, it can be altered in a way that bears some logical relation to what the person knows (Pylyshyn, 1999: 343).

The semantic condition is required to ensure that the connection between the cognitive system and perceptual system is intelligible and not a mere question of chance. According to Pylyshyn, for early vision to be cognitively impenetrable, either it does not receive top-down signals from cognitive systems, or, if it does, alterations of early vision could not be done in a semantically coherent way. However, there are examples which suggest that semantically coherent condition is not sufficient for CPP. Macpherson (2015a, 2015b) provides the following example

> suppose that Murdo believes that aliens are attacking Earth. This belief causes stress, which induces a migraine. Suppose that whenever Murdo has a migraine, he experiences flashing lights in the top half of his visual field. So, suppose that Murdo visually experiences flashing lights in the sky on account of having his migraine. The content of this experience bears a semantic relation to

[3] Assessing the epistemic consequences provoked by the interaction between non-propositional aspects of the mind (emotions, moods, and so on) and perceptual experiences become an empirical question. What I want to stand out, however, is that to the extent that licit and illicit cases of CPP could be determined by their impact on the subject's epistemic status, at least some non-propositional attitudes may well be included within these cases.

[4] What it is usually discussed is whether the content of an experience is determined (or supervenes) by its phenomenology (for affirmative positions Dretske, 1995; for negative views see Block, 1996 or Speaks, 2009). I will not press this point here because it needs independent discussion.

[5] By distinguishing between early and late vision, he is pointing out that there can be cognitive influences on perceptual experience, but not on early vision. This distinction becomes decisive because it restricts the impenetrable area to a minimal part of perception. Importantly, late vision is not a part of cognition, but a part of perception (Pylyshyn, 1999; Raftopoulos, 2011) and therefore the swap of information between cognition and late vision or between late vision and early vision is allowed, what is not allowed is the influence of cognitive information on early visual information (for discussion see Raftopoulos, 2011).

[6] Note that the idea of focusing attention on the same part of a distal stimulus may be decisive to avoid that cases like bistable images, where the same stimulus can originate different perceptual experiences, contradict this hypothetic case of CPP. In Necker cube image, for example, depending on where subjects focus their attention, they perceive the cube as if looking at it from the top or the bottom. It occurs because the fixated area tends to be seen as closer to the observer (Toppino, 2003). I thank an anonymous reviewer for pressing this point.

the belief that caused it—the belief about the alien attack—but one might want to deny that this is a case of cognitive penetration (MacPherson, 2015: note 9).

Consequently, MacPherson adds some minimal sense of rationality to the semantic criterion. For CPP to occur, the link between cognition and perception must be transferred from a cognitive state so that its content has to be consistent, in a rational sense, with the perceptual state—there must be a non-accidental causal semantic link at each stage of the process.

Stokes (2012), on the other hand, also notes certain difficulties in the semantic criterion, but more than its sufficiency, he doubts about its necessity. He postulates that there can be cases where background cognitive states affect experience in a wholly semantically incoherent way, but produce significant epistemic consequences for the subject (Stokes, 2015. Indeed, perception may be irrationally influenced by cognition, but still to produce epistemic consequences. Siegel (2012), for example, considers a case where Jill believes that Jack is angry at her. Suppose that this belief influences Jill's visual experience such that Jack appears angry with Jill. If Jill takes her visual experience as evidence for her belief that Jack is angry, then she has moved in a circle, her belief that Jack is angry is supported by her belief that Jack is angry. In this case, the belief and the perceptual experience are not rationally related. Indeed, Jill's belief and her perceptual experience might well be inconsistent, although the epistemic consequences are, however, evident (according to Siegel (2017), this is a clear case of epistemic downgrade). These cases encourage Stokes to provide an alternative definition without appealing to normative considerations. He suggests the following definition

> (CP) A perceptual experience E is cognitively penetrated if and only if (1) E is causally dependent upon some cognitive state C and (2) the causal link between E and C is internal and mental (Stokes, 2013: 650).

In this definition clause (1) ensures that the relationship is direct, and clause (2) that it is internal. The causal chain must involve mental states or processes, thus ensuring that instances where intermediate states cause changes in perceptual experience do not count as CPP. Stokes himself, however, doubts about the sufficiency of his definition. He invokes the following example

> Suppose I suffer extreme exam anxiety and I believe that I am about to take an exam. This belief causes, internally, another mental state, namely the pain that accompanies a migraine. This pain further causes, again internally, a series of visual experiences where everything appears in a reddish hue (Stokes, 2013).[7]

Though this scenario satisfies the two clauses, it is not an instance of the relevant cognitive influence. The causal chain from cognitive state to perceptual experience, although internal and mental, follows an exceedingly meandering route. We seem to move in circles, counterexamples of Pylyshyn definition satisfy Stokes definition and vice versa. It encourages to Stokes (2015) to propose a consequentialist approach. Such an approach tries to discern which cases of CPP are relevant based on its consequences for the theory-ladenness of perception,[8] the epistemic role of perception[9] and mental architecture.[10] This proposal has the advantage to unify the criteria to understand CPP, gathering all the criteria suggested in only one, the consequences of the phenomenon.[11] Once specified the consequences of the alleged CPP case, and not before, it could be discerned about whether the relation in question is causal, rational, direct or whatever. Thus, to be an instance of CPP, at least, the following conditions must be fulfilled:

– There should be a cognitive-perceptual relation (being this causal, rational, internal or mental).
– And such relation should challenge the epistemic role of perception in justifying beliefs, or (relatedly) should grant that our empirical observations are theory-ladenness, or should challenge our current theories about mental architecture.

From these definitional disagreements, the essential question about where to put the boundary between perception and cognition arises. If what counts as cognition, as perception and as cognition penetrating perception is not clear, how is it possible to find the

[7] The example is suggested by Macpherson (2012) to re-emphasize the need of the semantic criterion.

[8] That perception is cognitively penetrated means that perception is theory-laden, that perception is theory-laden implies that the distinction between *seeing* and *seeing as* cannot be sustained, and in consequence, as the neutrality of our observation is rejected, the incommensurability of scientific theories emerges as a possibility. In other words, if perceptual observation is theory-laden, then it will not provide a reliable means for rationally choosing between scientific theories (for discussion see Churchland, 1988 and Fodor, 1988).

[9] Perceptual experience provides us with knowledge about the world. However, under circumstances in which cognitive states influence perceptual experience, the subsequent belief formed from this perceptual experience may be epistemically downgraded, so the epistemic role for perception is threatened. In other words, as the causal history of the consequent belief is the product of a circularity, the reason for that very belief may be undermined (for profound discussions about the essential epistemic consequences of this debate see Siegel, 2012, 2017).

[10] Whether perception is cognitively penetrated, then perceptual modules are not informationally encapsulated (in the sense that its processing will not be aliento the processing of other systems). So, by imposing the informational encapsulation as a fundamental requirement for perceptual modularity (Fodor, 1983), it follows that CPP entails that perceptual systems are not modular.

[11] Stokes considers three possibilities. The first is the construction of a definition that describes CPP to subsequently extract the relevant consequences, although there are reasons to be sceptical about the amenability of CPP to this kind of definition. The second, conjunctive consequentialism, says that there will be CPP if and only if there is a cognitive-perceptual relation that implies consequences for theory-ladenness, the epistemic role of perception and mental architecture. Consequences are explicit, but it rules out the possibility that distinct phenomena imply distinct consequences. And third, disjunctive consequentialism, says that there will be CPP if and only if there is a cognitive-perceptual relation that implies consequences for theory-ladenness or the epistemic role of perception or mental architecture. The third option is, according to Stokes, the one that best captures the spirit of consequentialism because it leaves open the possibility that there are distinct phenomena that meet distinct disjunctive conditions (Stokes, 2015).

border between perception and cognition? Although such a distinction has always had a solid footing in philosophy, cognitive science, and folk psychology, there is little agreement on how it should be drawn. In principle, at least in the matter that we are dealing with here, namely, the possibility of a causal influence of higher-level cognitive processes over perceptual processes, we must presuppose at least some kind of distinction. After all, to assess the relationship between two phenomena a minimal differentiability between each phenomenon is to be expected, for the information of a cognitive state (C) influence the information of a perceptual state (P), there should be some visible demarcation between (C) and (P). Whereas impenetrability defenders advocate for a clear-cut division (Pylyshyn, 1999; Raftopoulos, 2009; Firestone & Scholl, 2016), penetrability supporters give up the idea of a sharp division, thus considering the line that divides perception from cognition imprecise and non-fixed (Newen & Vetter, 2017). In the more extreme position are those who deny any real distinction. Relying mainly on the predictive coding framework, these researchers discard the introduction of any boundary simply because in light of Bayesian approaches it is not suitable (Clark, 2013; Lupyan, 2015; Shea, 2015). I will say more about this in later sections. For now, I want to point out that establishing these boundaries is a very difficult thing to do, mainly because we are not sure about what falls on the side of cognition and what on the side of perception, which in turn prevents us from clearly knowing what kind of relationship between perception and cognition should be expected. In sum, the difficulty to uncontrovertibly respond to these questions makes it difficult to draw the line between perception and cognition, which in turn makes difficult to know whether or not cognition influences perception in a suitable and relevant way.

The first hindrance is, then, terminological. As Fred Dretske (2015: 163) points out, *the first step in trying to decide whether perception is modular, whether it is modifiable by cognitive affairs, is to carefully distinguish perception from cognition*. However, at this point, both sides of the debate cling to a different and opposing intuition, while impenetrability supporters maintain that perception and cognition are differentiated, penetrability supporters, claim that they mostly overlap. The debate is then blocked in the initial delimitation of the terms. Only from philosophical (and terminological) discussion alone, it is hard to distinguish perception from cognition, and therefore it is hard to draw the line, if any, between perception and cognition. What philosophical discussion seems to teach us is that to be relevant, CPP cases must have implications for the philosophical consequences cited above; otherwise, CPP becomes a sterile phenomenon. One can think that such a lack of clarity in describing the interplay between perception and cognition may be cleared up by experimental psychological research, perhaps we should leave the map aside and enter the territory. However, as we will see, the psychological territory not only is embedded by definitional concerns, but it is also entangled by methodological limitations that prevent one or another part of the debate from being endorsed. Next, I will argue that from psychological studies, these worries do not fade off.

2.2. Methodological limitations in psychological experiments

Most of the empirical research on CPP has been addressed from psychological grounds. Unfortunately, when we set our eyes on this evidence, the above difficulties in characterizing the components implicated in CPP are not dissolved. In this section, I show that the relation between perception and cognition cannot be unravelled by mere psychological empirical research. Here is the second part of the blockage. The issue is that these findings are often subject to different interpretations, and the reason of such a varied interpretive tendency is, in addition to the definitional difficulties, that psychological experiments are infested by methodological limitations, which in the long run prevent the debate from being solved (for similar arguments see Masrour, Nirshberg, Schon, Leardi, & Barrett, 2015).

Psychological literature on CPP abounds. There is, indeed, a large body of research which purports to establish that cognitive factors influence perception. These researchers claim to have found alleged cases of CPP all over in very different and varied tasks. They consider that actions, desires, needs, values, knowledge, emotions, judgments, moods, fears, and so on, affect perception in different ways.[12] The amount of experiments cited in the literature indicates that alleged cases of CPP occur more often than initially believed. However, for many, these psychological experiments do not overcome the necessary conditions to admit the existence of CPP. Their strategy has been basically to situate the locus of the influence outside perception (post-perceptually or pre-perceptually) or exclusively inside perception (intra-perceptually). None of these cases constitute bona fide top-down influences on perception: (1) effects that target post-perceptual systems, (2) intra-perceptual top-down effects, whose processing do not go beyond the perceptual hierarchy itself, and (3) effects of overt and covert spatial attention on perceptual processing, where shifts of attention merely alter the input to visual processing, not the manner of that processing. (1) Makes sure that the penetrated is authentically perceptual, (2) that the penetration comes from a real cognitive source, and (3) that accidental effects due to shifts in attention, alterations in stimuli or ~~in~~ sense organs are oblivious to the real effect expected for CPP to occur (see Pylyshyn, 1999, 2003). In conclusion, since no real cognitive state outside the module can access the processes within the module, the thesis of cognitive impenetrability must be correct.

Firestone and Scholl (2016) have recently extended these conditions pointing out six pitfalls ignored by psychological studies. Very briefly. 1) There is a general trend in researchers to commit a lack of bias in their observations. 2) It is not always obvious whether cognitive states affect perception or perceptual judgments. 3) There is the possibility that social biases may intrude on perceptual reports contaminating the experiments by demand characteristics. 4) Those researchers which find top-down effects by manipulating stimuli used across experimental conditions rather than the states of the perceiver may owe their effects to low-level differences and not to perceptual differences. 5) It is not always evident whether cognition affects what we see directly, or it does indirectly, perhaps via attentional effect, by changing the input to visual processing but not the processing itself. 6) Many studies which report top-down effects on perception by improvements in visual recognition should distinguish between the two parts of

[12] See Firestone and Scholl (2016) for an extensive literature. See also: http://perception.yale.edu/TopDownPapers.

visual recognition, namely, perception and memory, distinguish "front-end" perception from "back-end" memory is an essential condition to assert CPP. These pitfalls lead them to the conclusion that empirical evidence in favour of the existence of top-down influences on perception is inconclusive and most likely wrong. They contend that no study has yet escaped their pitfalls and therefore that, so far, researchers have still not found top-down influences of cognition onto perception.

There is, however, a crucial distinction between Pylyshyn and F&S accounts. While the former admits the cognitive penetration of perceptual experiences (seen as conscious perceptual experiences) and advocates the cognitive impenetrability of a part of visual perception called early vision (the weak impenetrability claim), the latter argue that all processes forming our visual experiences are cognitively impenetrable (the strong impenetrability claim). Firestone and Scholl make this distinction clear

> whereas many previous discussions defended the modular nature of only a circumscribed (and possibly unconscious) portion of visual processing (e.g., "early vision"; Pylyshyn, 1999), we have the broader aim of evaluating the evidence for top-down effects on what we see as a whole – including visual processing and the conscious percepts it produces (Firestone & Scholl, 2016: 3).

Let me then discuss the inability of psychological research to solve the CPP debate from these two different positions. If we take the strong impenetrability claim, supported by F&S, the debate is in part blocked because from mere psychological experiments it has not been possible to accurately and without controversy discriminate between subjective perceptual experience and perceptual recognition, perceptual memory or perceptual judgment. One reason is that insofar as these theorists argue for the impenetrability claim of our direct phenomenological acquaintance with percepts, it is hard to see how psychological studies can be able to assess this phenomenological part through mere psychological methods. Recall that we have referred to perceptual experience as the conscious state that we typically go into when we perceive the world, or that mental state that makes a peculiar qualitative effect on the experiencing subject, or that mental state with a distinctive phenomenal character that causes the subject to perceptually experience the world, or what it is like to have a certain perceptual experience, or to abbreviate, a percept. However, from psychological methods it can only be evaluated the perceptually-guided behaviour, that is, the previous processes that serve to the formation of a percept (attentional effects), or the posterior processes that convert the percept into a behavioural response (perceptual judgments, memories, and recognition), remaining oblivious to the percept itself. That we cannot perceive what perceivers perceive, that we can only rely on their responses, sounds like a truism, subjective reports about perceptual experience are, uncontrovertibly, good indicators of the existence of percepts, but they are not percepts themselves, and therefore their contents may differ from each other. The moving from the first-person level (the perceptual experience itself) to the third-person one (the perceptual judgement) makes the issue here. So, in the extent that a perceptual experience is what remains once the effects of perceptual judgment, recognition (and categorization) and memories are rescinded, it is hard to see how psychological approaches, based on subject' reports, can teach us anything about the cognitive influence on the phenomenal private aspect of the perceptual experience (the percept). After all, impenetrability supporters can always argue that the effects observed in the experiments match more with effects on perceptual judgments, memories and so on than with effects on a real perceptual experience.

Researchers, however, have tried to bridge the gap between percepts and perceptual memories, perceptual judgments and perceptual recognition by designing ingenious experiments. One possible strategy to avoid the effects of memory is, for example, to present the stimulus during the response phase. Famously, Levin and Banaji (2006) studied, using an adjustment methodology, how social categories such as race can affect the perception of the lightness of faces. These studies show that matching behaviour is influenced by labels indicating the typical facial features of races. Particularly, they found that faces labelled as black (or showing typical black facial features) are matched to darker patches than faces that are identical in luminance but labelled as white (or showing typical white facial features), suggesting that social categories influence perceptual experiences. This strategy cancels the effects of memory, however, the aforementioned gap between percepts and perceptual judgments remains open. Impenetrability defenders can still argue that we can have different perceptual experiences, but not be able to distinguish them. Although subjects adjust colours by judging the phenomenal character of what they see in an on-line manner, nothing prevents us from thinking that subjects are judging as identical, experiences not perceived as identical. Perceptual judgments and perceptual experiences do not necessarily coincide (for a similar reasoning see Masrour et al., 2015: 6).[13]

Similarly, and also using adjustment methodologies, when researchers show that subject's knowledge of typical colours (e.g. that bananas are yellow) influence the perceived colour (Hansen, Olkkonen, Walter, & Gegenfurtner, 2006; Olkonnen et al., 2008), they are assessing the effects of knowledge on subject's reports about what they are seeing, but not on their subjective experience. Subjects can adjust the colour depending on their belief that bananas are yellow, and not because they perceive the grey bananas as yellow. So, impenetrability supporters can still interpret these results as a post-perceptual effect; perhaps subjects are interpreting differently the same perceptual experience. All these experiments may show a judgment problem for two reasons, on the one hand, because observers judge colours in situations of uncertainty (non-accurate conditions), and on the other hand, and in part because of such uncertainty the selected colour category seems to be biased by anchored categories and not by real changes in perceptual experiences (see Zeimbekis, 2013). Thus, even controlling the effect of memory, these studies cannot rule out the judgment interpretation in their

[13] The study of Levin and Banaji (2006), has been challenged by Firestone and Scholl (2015) in another interesting way. They show that the effect persists even when we blur out faces, thus cancelling race information. They conclude that the effect can be explained as low-level differences instead of differences in the perceived race. Note also that the effect can be explained intra-modularly. Whether perceptual learning is included as a part of the perceptual module, the representations of facial features and their association with a specific colour will be a purely intra-modular issue (see Masrour, 2015: 8–9). My intention here has been to show that, in addition to F&S's low-level explanation, and a possible intra-perceptual explanation, the post-perceptual explanation would still be maintained.

conclusions.

Other studies try to attack these concerns by manipulating the influences prior to the occurring of perceptual experience, that is, by manipulating the subject' attention or changing the input to perception. For example, attention (a voluntary or involuntary process) can enhance perceived objects making them clearer (Carrasco, Ling, & Read, 2004) or more finely detailed (Gobell & Carrasco, 2005). This strategy seems to avoid the gap between percepts and perceptual judgments, without asking for subjects about what are they perceiving, it is reasonable to think that by augmenting attention, some perceptual properties are also augmented. But, does this lead to CPP? Impenetrability supporters correctly argue that these effects do not correspond to intentional changes on what we see, but to changes in what or how we attend, and therefore attentional effects act as a mediators between intentions and perceptions, thus cancelling the influence of cognition onto perception (Pylyshyn, 1999; Firestone & Scholl, 2016; for alternative views see Lupyan, 2017).

Concerning perceptual recognition, there is compelling evidence showing that basic categorical information (particularly, the basic-level of categorization) may be processed intra-perceptually (Potter, Wyble, Hagmann, & McCourt, 2014). The reason is that basic categorization may occur so strikingly fast (only 13 ms. after stimulus onset), that the existence of feedback influences of high cognitive systems on perceptual processes is unlikely. These results might cancel many of the alleged cases of conceptual or categorical influences on perception since some categorical forms might already be inserted in perceptual processing as outputs (see Mandelbaum, 2017).[14] For example, Lupyan and Ward (2013) showed that hearing the right word can make visible something that is otherwise invisible. This, apparently, cross-modal effect—a determined sound counts as a clue for seeing something—they conclude, is produced by the categorical information inserted in the auditory clue, and therefore language affects perception. Though the effect might also be explained as an attentional shift, since hearing the right word change our visual attention (perhaps automatically) to the object represented by the heard word, Lupyan and Ward ruled out attentional effects in their second experiment. But, even ruling out the attentional explanation, these results can still be explained as intra-perceptual effects—whether basic-level semantic information is embedded inside the perceptual module, then visual representations are not penetrable by factors outside of vision since everything occurs inside visual processing. Similarly, investigating semantic influences in amodal completion, Vrins, de Wit, and van Lier (2009) showed that amodal completion is inseparable from general object interpretation, during which object semantics may dominate. But again, the impenetrability supporter can always argue that the effects of categorization on amodal completion occur inside perception (intra-perceptually) and therefore, there is not space for CPP. So, the point is that to the extent that object categorization is achieved so fast, categorical influence on perception cannot be considered a case of CPP, since categories can already be a part of perception. This, therefore, cancels the results obtained by many psychological studies that try to show that categories penetrate perception.

Of course, it is not my aim here to explore in extent the enormous literature allegedly showing CPP, but to advert about a general concern that might be common to all these studies, to wit, that when we apply the counsels suggested by F&S what remains is an aspect of perception which subjective and private nature prevents these studies from provide conclusive evidence. Some researchers (see the commentaries to Firestone and Scholl) claim to have found well-conducted psychological experiments of top-down effects that gets out F&S pitfalls, but, in the long run, the success of this experiments will depend on where to situate the line between perception and cognition (see the first blockage). It seems that there may always be an impenetrability response to these effects. At this point, one can argue that impenetrability supporters construe their constrictions (the guidelines suggested by F&S) from the previous condition that there should be something as an immutable *pure perception* (for criticism of this notion see Churchland, Ramachandran, & Sejnowski, 1994). In effect, that the penetrated should be authentically and exclusively perceptual means that, at least in certain stages, it is not cognitively affected, since in such case would cease to be authentically perceptual. This is important because in the extent that they are assuming that there is a critical phase in perceptual hierarchy where perception is pure perception, becomes a hard mission to find cases of CPP (at least in such a phase). At this point, it seems that impenetrability supporters are begging the question; they assume the existence of what they want to show. If there is such a thing as pure perception, mere psychological methods cannot apprehend it. After applying the counsels of Firestone and Scholl, the perceptual part that remains is one that experimental psychology cannot address since what remains is the private subjective aspect of perceptual experience.

If my arguments are correct, they indicate that what it is like to have a certain perceptual experience is not something that is within reach of the methods used by psychological studies. With this conclusion I am not underestimating the value of these investigations nor denying or affirming the existence of CPP, what I am suggesting is that on these issues psychological experiments are, due in part to their subjective character, inconclusive. The strong impenetrability claim cannot, therefore, be ruled out from mere psychological studies. My suggestion in this paper is that subjective reports must be combined with other non-subjective sources in order to obtain firmer results.

Ruling out the weak claim by psychological methods is even harder. For Pylyshyn, in discussions on CPP, the term perception takes a narrower meaning than usual, not only it is constrained above by post-perceptual effects (perceptual judgment or perceptual

[14] The idea to incorporate some categorical forms (basic-level categories) into perception is elaborated in Fodoŕs (1983) seminal work about the cognitive encapsulation of perception (pp. 86–98). Recently, Mandelbaum (2017) has adopted this position by providing interesting empirical research. Particularly, the research of Potter et al. (2013), who show that we can categorize objects as soon as 13ms. From stimulus onset (very far from the 120–150 ms. stimulus onset proposed by Raftopoulos). Mandelbaum argues that 13ms. is just too short a time to allow for top-down connections to take hold, thus concluding that perception outputs conceptualized representations in a feedforward way. Importantly, this position is at odds with views that posit that the output of perception is solely non-conceptual, and also retrieves the idea that the border between perception and cognition is to be characterized by perception being modular and cognition not being so.

memories), and below by pre-perceptual effects (attentional effects or alterations in sense organs), but in addition, this part of perception, he claims, is inaccessible to consciousness (Pylyshyn, 1999; see also Raftopoulos, 2009). This means that in Pylyshyn's case, the impenetrable part of perception is not the conscious perceptual experience, but a narrow stage of perception in charge of the structural organization of objects. For Raftopoulos such constriction goes still further. As Pylyshyn does, he advocates a clear distinction between late vision and early vision, where only early vision is cognitively unaffected (Raftopoulos, 2009, 2014), but unlike Pylyshyn, Raftopoulos understands early vision as a temporal stage that comprises roughly the first 120–150 ms. after stimulus onset. Thus, Raftopoulos admits the cognitive penetrability of a considerable part of perception (late vision) but denies the cognitive penetrability of a very minimal part (the first 120–150 ms. after stimulus onset). One can think that perceptual processes within this narrow time frame produce states with such poor content that they cannot, strictly speaking, be called perceptual states (Newen & Vetter, 2017: 30), but Raftopoulos claims that however minimal, this part counts as a rich structure that delivers complex representations of stimuli and retrieves from the visual scene an extensive range of information (Raftopoulos, 2017). However, if this is the cognitively impenetrable part of perception, how can we assess, from subject's conscious reports of what they are seeing, that such organizational, unconscious and minimal part of perception is or not affected by cognitive factors? It is hard to see how from the subject's conscious reports, researchers may be able to draw solid conclusions about the unconscious and covered states occurring inside the subject's mind (perhaps even the subject itself might be unable to discern them) without introducing a minimal dose of speculation.

In conclusion, from psychological studies, it is not possible to opt for one option or the other without previously relying on a pre-established intuition. If one believes, for example, that there is a clear and sharp delimitation between "appreciating the redness of an apple" and the knowledge that "that is a red apple", then our interpretation of psychological experiments will be biased in that direction, in such case the knowledge that "that is a red apple" do not interfere in the phenomenal experience, "the appreciation of the redness of the apple". In contrast, if one believes that the knowledge that "that is an apple" interfere with the phenomenal character of "the appreciation of the redness of the apple", then our interpretation of the experiments will be biased according to such interference. It seems, therefore, that psychological evidence does not lead to solid conclusions.

These are, then, the crucial challenges that participants in the CPP debate must overcome. To sum things up, the lack of clarity about what counts as perception and what as cognition impedes to find out when perception ends and cognition begins, what in turn impedes to obtain a clear notion of what counts as CPP. Setting aside this concern, but perhaps with an intuitive idea of what it is at stake, when researchers investigate the phenomenon of CPP psychologically, they find that typical cognitive representational states (beliefs, desires, moods and so on) affect visual experiences, that is, they find that perception is largely penetrated by cognition. However, impenetrability supporters have identified several pitfalls that psychological studies usually have not taken into account, pitfalls that, I have argued, cannot be appropriately accommodated by such studies. The debate is therefore at this point cornered.

My goal hereinafter is to suggest other sources to help solve the debate. Concretely, I put my eye on the evidence from cognitive neuroscience and the novel suggestions offered by the predictive coding framework. From cognitive neuroscience we have a more accurate and objective approach than that offered by experimental psychology, rather than reporting judgments about their perceptual experiences, subject' responses are assessed by decoding the neural mechanisms underlying to different tasks. And from predictive coding, a new insight about the relationship between perception and cognition is proposed.

3. Re-entrant neural pathways in visual processing

My conclusion in the last section was that the empirical approach to the debate on CPP has to draw on data from sources other than purely psychological studies to offer something more positive to the debate. I have also pointed out an additional problem—that the conceptual dispute about how perception and cognition have to be outlined is trapped on intuitive considerations that leave still more blurred the debate. In the course of this section, I provide neuroscientific reasons to show that feedback cognitive influences on visual neural processing in the brain may be decisive to clear up many questions on CPP. Let me first introduce two clarifications. First, from the fact that some brain areas are functionally specialised to some predominant functions, it does not follow that they have clear-cut functional boundaries; the contents of other brain areas can still determine their contents (Gilbert & Li, 2013). Second, a complex mind needs a complex brain, brain complexity demands brain plasticity, and such plasticity requires the existence of top-down processes to be functionally and anatomically feasible; an exclusively bottom-up brain would be metabolically expensive and anatomically infeasible (Sterling & Laughlin, 2015). I then argue that the existence of top-down processes in the brain not only avoids some methodological limitations attached to psychological data but also seems to be in line with the CPP theses.

Traditionally, the visual system has been seen as a hierarchical structure working approximately like this: visual information is, at the neuronal level, connected to the brain via ganglion cells in the retina, those ganglion cells send axons to the lateral geniculate nucleus (LGN) of the thalamus, which in turn synapse with the primary visual cortex (V1), located at the pole of the occipital cortex. From V1, the information bifurcates in two streams, the ventral and the dorsal (Ungerleider & Mishkin, 1982; Goodale & Humphrey, 2008). The ventral stream projects ventro-laterally toward the inferior and lateral temporal cortex, passing through areas V2 and V4, while dorsal stream projects dorso-posteriorly toward the posterior parietal cortex and prefrontal cortex, passing through areas V3 and MT (motion-sensitive area). Although both systems process the same visual stimuli, the information is transformed differently within each stream, while the ventral stream conveys and generates information about objects and features by transforming it into visual representations (i.e., perceptual experiences), the dorsal stream transforms visual information into outputs useful for motor behaviour and the control of action (Norman, 2002: 84-85). Importantly, this means that the neuroanatomical hierarchy also corresponds to a functional hierarchy (different neurons respond to different types of stimuli in their receptive fields).

Researchers, however, have found that this picture of the visual system is incomplete. In contrast with the classical view, which is perfectly compatible with the modular and impenetrable account of perceptual systems, the most recent findings point towards a reverse process, where higher-order cognitive influences interact with information coming from the retina. Indeed, visual pathways operate bi-directionally, exerting widespread top-down influences on all the brain areas. As Gilbert and Li (2013) show:

> All areas of the visual pathway, except for the retina, are subject to top-down influences, including early cortical stages of visual processing such as the primary visual cortex and the lateral geniculate nucleus, and all areas along the dorsal and ventral visual cortical pathways. Each area contains an association field of potential interactions, and expresses a subset of these interactions to execute different functions.
> The source of top-down influences can be widespread, either by direct connections from different cortical areas or by a cascade of inputs originating from many more areas. In effect, a large part of the cerebral cortex can exert influences over individual neurons within a particular area, with multiple descending inputs interacting with intrinsic cortical connections. As such, each neuron is a microcosm of the brain as a whole, with synapses carrying information originating from far flung brain regions (Gilbert & Li, 2013: 350)[15].

In effect, vision is largely interconnected in a top-down manner; it is estimated that each brain area is connected to 66% of the rest of the brain, indicating that cortical brain areas are much more heavily interconnected than previously thought (Markov et al., 2013). It is also estimated that only 10% of the synapses incoming to primary visual cortex are originated in the thalamus, which brings sensory information from the retina, the remaining 90% of these synapses are originated in the cortex itself (Peters, 2002: 184), suggesting that the role of high cognitive levels of processing should be more relevant in the earliest cortical stages of sensory processing than traditionally was believed. We know about numerous examples of feedback projections to the visual cortex. Just to give some examples, we know that the last part of the ventral stream, the inferior temporal cortex (IT), receives signals from prefrontal cortex (PFC) (Tomita, Ohbayashi, Nakahara, Hasegawa, & Miyashita, 1999), which in turn sends re-entrant signals directly to V1 (Rockland & Van Hoesen, 1994) or through the paths TEO—V4—V1 or TEO—V4—V2—V1 (Rockland, Saleem, & Tanaka, 1994). Something similar occurs in dorsal stream, prefrontal cortex projects to FEF (Gerbella, Belmalih, Borra, Rozzi, & Luppino, 2010) and from there the information is sent to the lateral intraparietal area LIP, where it is projected to MT/MST (Stanton, Bruce, & Goldberg, 1995), and finally redirected toward V1 also in different ways, via V2—V1, or via V3—V1 or directly to V1 (Bullier, 2001; Rockland & Van Hoesen, 1994). In sum, these feedback connections are widespread throughout the brain, either directly between distant cortical areas or by a cascade of descending signals passing through many areas (Gilbert & Li, 2013).

The existence of descending projections in visual processing is, in principle, not debated. What it is under debate is the distinct functional roles of these projections. We know that certain functional specialization in the brain exists, but we also know that each brain area is highly interconnected to other areas so that it seems unlikely a strict specialization in the sense of being alien to the information processed by other areas (Newen & Vetter, 2017: 29). This point is crucial because various visual phenomena can be only explained if feedback projections from distinct brain areas more or less distant from each other are taken into account. For example, Wyatte, Jilk, and O'Reilly (2014) show that object recognition requires more than feedforward processing (as traditionally was thought). They show that, independently of attentional processes, early local recurrent feedback plays a functionally distinctive role in stimulus disambiguation, since it facilitates object recognition well before the onset of any attentional influences. The idea is that ongoing brain activity must be combined with new incoming sensory information to guide perception coherently via recurrent processing mechanisms. But not only early local recurrent feedback, also long-distance feedback projections to area V1, although not sufficiently understood, may have implications for multisensory integration, spatial awareness, and visual consciousness (Clavagnier, Falchier, & Kennedy, 2004) as well as other higher cognitive functions (Markov et al., 2013; Dehaene & Changeux, 2011; Muckli, 2010). All this suggests that the direction of information flow matters and the functional role of many perceptual processes most likely depends to a large extent on it.

Given the present evidence, one might suggest that neurological findings can provide robust evidence to show that cognition and perception are integrated and overlapped at all levels. In fact, to the extent that neuroanatomy tells us that the only substrates of visual processing free of descending pathways are in the retina, such integration, in principle, should be expected. Of course, these line of thought leaves little room for a real distinction between vision and cognition—at this level of description such distinction is simply no possible (Rolfs & Dambacher, 2016). It is reasonable, however, to infer that although it is hard to see where perception ends and cognition begins only by looking at neurons, everything we understand about cognition and perception at psychological level should have their correlations at brain level. Being distinguishable at the psychological level does not mean being functional and anatomically separable and independent. In the same way, we can distinguish emotion from cognition at the psychological level, although neurologically they can hardly be accounted for separately. The key question is whether, from the fact that all the brain is massively interconnected (feedforward, feedback and horizontally), can we infer that cognition and perception are intertwined and mutually affected at all levels? If we respond yes, then these psychological labels (perception and cognition) have only sense taken together. This idea becomes strengthened if, ultimately, neurological evidence shows that the ingredients usually labelled as perceptual can only be (neurologically) explained in consonance with other ingredients usually labelled as cognitive. The neuroscientific approach, at least to date, seems to confirm that this is precisely the case. The impenetrability supporter should expect to find some visual brain areas neuro-anatomically and functionally isolated, where none top-down effects should occur, but so far, neurological

[15] Importantly, Gilbert and Li (2013) do not limit top-down influences to attention, usually excluded by strong impenetrability supporters as a real top-down effect on perception, but to a much broader range of functional roles, including perceptual task, object expectation, scene segmentation, efference copy, working memory, and the encoding and recall of learned information.

evidence does not satisfy this, no part in the brain seems to be free from re-entrant pathways. Of course, how the neuroscientific approach will contribute to the prevailing arguments of feedforward and feedback projections in vision is still open, but, in its current state, it can provide many clues about how to understand the intriguing relation between seeing and thinking. In sum, neurological evidence might be determinant to clarify the convoluted philosophical and psychological questions accumulated during the last years in the CPP debate.

Neuroscientific approach, however, might be contaminated by a certain type of drawbacks that makes it, for some, unconvincing. Firestone and Scholl (2016) for example, have recently stressed that these descending neural pathways have not implications for CPP. In his target article (2016) neuroscientific approach is not discussed in deep (see Section 2.2), they just state that other critiques have been extensively elaborated elsewhere (they quote Raftopoulos, 2001), and maintain that in its current state of development neuroscience cannot help to discern clearly about these issues (F&S, 2016: 4). As a reply, just in the responses to their target paper, several authors emphasize that overlooking the relevance of this evidence is inappropriate and untenable neglect. In consequence, F&S feel compelled to respond in more detail, and in response to their critics, they elaborate a broader argumentation. In essence, they claim that the perspective from neuroscience is unscientific, false and irrelevant. Let me discuss these critical ideas.

First, unscientific. They claim that to the extent that top-down effects do not occur all the time, and according to current neuroscientific studies re-entrant pathways are the norm rather than the exception, they ask, how can we explain the independence of perception from cognition in some particular instances? F&S's complaint goes in the following direction:

> whenever there is an apparent top-down effect of cognition on perception, descending pathways get all of the credit. But whenever there isn't such an effect, nobody seems concerned, because that can apparently be accommodated just as easily (p. 56).

To show this, F&S appeal to perceptual illusions, in particular to the illusion of motion in static figures, where the illusion persists even knowing about the illusion. How does this happen? They ask. How is it possible that, given the overwhelming prevalence of descending pathways and interconnected networks in the brain, seeing is insulated from thinking in these particular instances? These cases are not mediated by high-level descending pathways, since even knowing about the illusion, we perceive movement, and therefore it can be explained exclusively in a low-level fashion. Against this, one should notice that other competing explanations of perceptual illusions can be provided. Muckli, Kohler, Kriegeskorte, and Singer (2005), for example, provide a top-down explanation of the motion illusion. They suggest that V1 is part of the network that represents the illusory path of apparent motion, and the activation in V1 can be explained either by lateral interactions within V1 or by feedback mechanisms from higher visual areas, specifically the motion-sensitive human MT/V5 complex (Muckli et al., 2005: 1501). This means that in real and illusory motion, the same neurological patterns are implicated, our brain connects the relevant pathways for motion even in the absence of motion.[16] This, however, does not explain why our prior knowledge about the static figure cannot interfere with our current misleading view about the moving figure. That is, it does not explain why, even knowing about it, the illusion persists. A possible answer is that in illusory motion, the brain solves a problem by completing the illusory scene with the best guesses. The idea is that the brain *infers* the existence of an illusory motion that leads to the perception of an apparent motion, that is, an apparent motion induces an internal model of motion, during which sensory predictions of the illusory motion causes feedback connections from MT/V5 to V1 (Edwards, Vetter, McGruer, Petro, & Muckli, 2017). The best guesses are, in these cases, constructed at relatively early processing stages, though the high-level belief is part of the visual experience (motion in this case), the ambiguity is solved at the lower stages, so it prevails a misperception So, when we perceive motion illusions the erroneous V5 to V1 connection becomes the best guess, thus inducing an erroneous internal model of motion. The persistence of visual illusions only indicates the incapability of high-level knowledge to dominate low-level visual processing in these circumstances, but this does not mean that seeing is insulated from thinking, only that in these exceptional scenarios the conflict between what we know (cognition) and what we see (perception) is inappropriately solved. Indeed, whether we can to distinguish between real and illusory motion is because we know in advance what images drawn on a paper are static, the illusion is an illusion only because, at least in these cases, our knowledge of the world prevails, even without being able to correct what we see. So, low-level domination does not entail that high-level knowledge does not influence or contribute to lower-level processing (see Ogilvie and Carruthers, 2016). Despite these alternative explanations F&S insist,

> Apparently, these rhapsodic accounts of the complete flexibility of perception are no obstacle to the thousands of visual phenomena that aren't affected by what we know, believe, remember, and so forth, (p. 56).

As far as I know, however, the most interesting (and perhaps unique) cases against CPP come from perceptual illusions. In relation with Muller-Lyer illusion, for example, (the paradigmatic case used by impenetrability defenders) where knowing about the illusion, again, does not lessen the effect of the illusion, other non-exclusively bottom-up explanations also compete (see for example Churchland, 1988; McCauley & Henrich, 2006; Prinz, 2006; Howe & Purves, 2005; Lupyan, 2015). Indeed, the involvement of the parietal and occipito-temporal cortices during the occurrence of the Müller-Lyer illusion seem to suggest that higher cognitive processes are likely to be involved (Weidner & Fink, 2007; Mancini, Bolognini, Bricolo, & Vallar, 2011). In addition, one can also object that visual illusions, although very interesting phenomena, should not be used to establish generalizations. Reasonably, researchers are more prone to offer generalizations from the perception of natural scenes than from perception of illusory, im-

[16] Of course, whether MT/V5 connection with V1 must be considered a top-down cognitive effect on perception is far for clear, after all, these areas take part of the visual system, the effects occur within the visual system and, therefore it can be considered an intra-perceptual effect. Consequently, these types of connections are not a substantial proof of CPP.

poverished, ambiguous and naturally inexistent visual stimuli.[17] After all, from the fact that high-level knowledge cannot dominate low-level processing in some perceptual illusions, it cannot be inferred that high-level knowledge cannot dominate low-level processing in other types of circumstances. This point has been correctly pointed out by Newen and Vetter:

> This must at least presuppose that visual illusions are the standard cases of perception but in fact the contrary seems to be the case: if visual illusions are the rare exceptions of our everyday visual experiences, we must be careful to generalize from the exceptional cases to the standard cases without any further evidence. (Newen & Vetter, 2017: 28).

In sum, from the fact that the illusion persists even knowing about it, does not follow that in these cases perception works alone, perceptual processes can dominate cognitive processes in the creation of the visual percept, but mastering the situation does not mean playing alone. What perceptual illusions show is that in uncertain, ambiguous and bad observational conditions the perceptual situation can be completed at low-levels processing, which means, at most, that the perceptual experience cannot, in these cases, be guided by previous knowledge. However, from here, we cannot infer that *all* perceptual experiences are cognitively encapsulated.[18] Thus, what neuroscientific research teaches us is that perceptual brain does not work isolated, a minimum access from other high-cognitive brain processes seem to be necessary to perceive the world. Neuroscience is doing its scientific job.

Second, neuroscientific reasons for CPP are, F&S claim, false. This is because the primary visual area (V1) is the only cortical area where space is represented at a fine resolution. So, for cognition exerts influence over perception it must affect V1 space representation in a sufficiently fine resolution, but re-entrant pathways have a much coarser resolution,[19] the upshot is that perception is not altered by cognition, at least, at the level of detailed perceptual experience. Thus, although cognition can modulate processes (such as attention) affecting a large part of the visual field, it cannot target a small part of the visual scene while leaving other parts unchanged (Gur, 2016: 34).

A quick response to this is that even being true, this reasoning license us to claim that visual perception is reduced to the operations carried out by that part of the cortical brain delimited by V1, and specifically to only that mechanism that is involved in the experience of fine-resolution spatial details. *Visual perception* is generally considered a broader term. On the other hand, although V1 is one of the most studied areas in the brain, so far, only up to 40% of its processing variance during natural vision can be explained, so V1 unexplained processes may, in the future, change our mind about how visual system works (Newen and Vetter, 2017: 29). Moreover, several researchers have examined V1 without feedforward activation, finding activity *even in the absence of retinal information.* This pattern, in fact, has been widely observed among different phenomena, such as in visual occlusion (Smith & Muckli, 2010), perceptual illusion (Kok & de Lange, 2014), blindness (Amedi, Floel, Knecht, Zohary, & Cohen, 2004), blindfolded (Vetter, Smith, & Muckli, 2014), sleeping (Horikawa, Tamaki, Miyawaki, & Kamitani, 2013), in working memory, (Harrison & Tong, 2009), imagery (Albers, Kok, Toni, Dijkerman, & de Lange, 2013) or expectation (Kok, Failing, & de Lange, 2014). For example, Vetter et al. (2014) presented sounds from naturalistic environments (people talking at a party, traffic noise from a street scene and bird singing from a forest scene) to blindfolded human participants. Participants were thus scanned without visual information entering the brain, just only non-retinal information. They showed that different natural sounds elicited distinct neural activity patterns in early visual cortex, V1 included, in the absence of visual stimulation (p. 1259). So, if neural activity patterns in early visual cortex are distinct depending on the semantic content sounds, then the specific content of the sound information must be transferred top-down to V1 from other parts of the brain, suggesting the existence of top-down internal generation of mental content. In the same vein, but avoiding the difficulty of using different sense modalities, Bannert and Bartels (2013) found that the yellow colour of a grey banana is represented in the neural activity patterns of V1 even when participants actually see a grey banana. That is, even if the feedforward information to the visual system is achromatic grey, the typically associated colour information of an object is communicated all the way down along the visual hierarchy to V1. These researchers conclude that our knowledge of their typical colour influences the perception of these so-called colour diagnostic objects, referred to as memory colour (p. 2268).[20] In sum, what it is showing is that V1 neurons respond adaptively to different functional states of the brain (Gilbert & Li, 2013), and not only to fine resolution details.

So, that perception often traffics in fine-grained details does not mean that all perception works like this. We perceive mostly in coarse resolution, independently of the details, which allows, for example, to rapidly identify stimuli as objects even when we have never seen them before. Crucially, many theoretical models assume that the visual system combines the information carried by different spatial frequencies following a coarse-to-fine sequence (Hochstein & Ahissar, 2002; Bar, 2003). Low spatial frequencies (LSF) are concerned with the coarse information, whereas high spatial frequencies (HSF) deal with the fine details of the scene. According to this models, rapid visual perception is not purely feedforward; it is also strongly mediated by top-down influences from

[17] Perhaps not by chance, the illusions based in real pictures, contrary to what happens in Muller-Lyer illusion (or the illusory motion of static figures), are quickly eliminated by our previous knowledge about how the world is (see Lupyan, 2015: 558-560).

[18] Note also that due to the plastic condition of the brain, intensive training during perceptual learning may elicit cognitive influences which later produce neural reorganization in the visual system, thus cancelling, in the long run, the illusory effects (e.g., Churchland, 1988; Cecchi, 2014).

[19] This is mainly because re-entrant pathways redirected to V1 from non-visual areas go through multiple areas before reaching V1; that is, do not exist a direct physical route to V1.

[20] This is a clear example of how the neuroscientific approach may complete the psychological approach. While the effect found by psychologists (e.g. Hansen et al., 2006; Olkonnen et al., 2008) about the influence of subjecťs knowledge of typical colours (e.g. that bananas are yellow) over the perceived colour, can be explained as a post-perceptual effect (what it is assessed is subjecťs perceptual judgements rather than subjecťs percepts), when the brain areas implicated are evaluated, the effect can be explained as the match between descending and ascending information occurring in V1. Thus, confirming psychological results.

high-level areas to lower-level areas (Bullier, 2001; Bar, 2003; Bar et al., 2006; Kveraga, Ghuman, & Bar, 2007; Peyrin et al., 2010). So, LSF information may rapidly reach high-order areas, enabling coarse initial parsing of the visual scene, which can then be sent back through feedback connections into lower-level visual areas to guide a finer analysis based on HSF (Kauffmann et al., 2017). Thus, LSF produces a first increase of activity in prefrontal and temporo-parietal areas, followed by enhanced responses to HSF in primary visual cortex (Peyrin et al., 2010). Therefore, even if specific cells in V1 are specialised in the processing of fine details we cannot conclude that these cells operate in isolation from other cells located in high-level areas that convey coarse information.[21]

Finally, according to F&S, neuroscience is irrelevant to these issues. This is because there exists an insurmountable gap in the level of explanation. They claim that as well as cognition and perception are determined by electrical patterns and chemical activity in the brain, they are also "governed" by the movement and interaction of protons and electrons but this does not entail that seeing and thinking are essentially subatomic phenomena nor that we should study subatomic structures to understand how our behaviour works (p. 57).

Indeed, how neural circuits lead to perception, thought and behaviour, is a delicate issue. Perhaps, a tentative solution is to consider that the intermediate levels between behaviour and subatomic structures can be informative enough to provide an acceptable and reliable physical explanation to understand mental phenomena. It is, of course, hard to see how a subatomic explanation can directly accommodate visual perception, but it is acceptable to line it up with the activation of brain areas, population of neurons and even individual neurons via computer languages and operational systems by decoupling the hardware from the software (Carandini, 2012; Bickle, 2006; see also Churchland, 1989 for a neuro-computational perspective).[22] Although further investigation at multiple levels is needed, the search for linkages between features across the levels might explain behavioural data by the dynamics of interactions at the lower and intermediate levels. Once this achieved, we might in principle to intervene directly at any level to generate behavioural effects, or to observe changes in the other levels.[23] So, though subatomic structures are, clearly, not the most informative way to assess the perception/cognition relationship, the informational interchange between groups of neurons or brain areas, which corresponds to hierarchical functional roles, can plausibly contribute to the generation of interesting hypothesis about how perceptual and cognitive systems are interrelated. In sum, from the fact that the relation between seeing and thinking cannot be understood from subatomic particles since it is not the appropriate level of description, it is not suitable to infer that it cannot be understood from neurons, groups of neurons, brain areas or brain connectivity either. Similarly, subatomic particles do not have many things to say about the dynamics of hallucinations, but brain activity can help to offer a good explanation of it. After all, the correspondence between brain activity and functional mental roles is not in question.

Given the considerable neuroscientific evidence that processing in the visual brain is active, parallel distributed and exquisitely sensitive to context would be wise to take neurological data seriously –the brain may be a large and limpid window to look out the mind functions. Neuroscientific approach teaches us that rather than parts working isolated all brain regions subserve multiple and varied functions. So, those neural descending pathways might count as a way to reinforce psychological data, to endorse the existence of top-down effects on visual perception. However, this would be a too hurried claim. The mere existence of re-entrant pathways does not entail that there are not encapsulated modules in the brain, the impenetrability supporter can still offer replies to this evidence. For example, whether these descending pathways are activated once perceptual system has essentially finished its job, then CPP does not obviously follow, or whether those descending pathways, instead of coming from cognitive areas, occur inside perception, during the time interval in which perceptual processing is in action, then those cues do not entail CPP. So, though there seems not to be a demarcated area in perceptual systems informationally encapsulated from other non-perceptual areas, the neuroscientific approach still has problems to be solved.

These concerns are solved in the next section, which is in part devoted to connecting the neuroscientific evidence with the raising view that our brains predict the incoming sensory information. Empirical data seem to be in line with predictive coding models, and such models postulate a unified account of perception, cognition, and action, where perception is the process that matches the incoming signals with a cascade of top-down predictions.

[21] Empirical evidence suggests that these cells are not static. For example, the constant and repetitive stimulation of V1 neurons during a learning session produces an improvement in the detection of targets, which means that the effect of learning produces anatomical neural changes in V1, which in turn suggests that neural activity in V1 may be subject to top-down influences (Pourtois, Rauss, Vuilleumier, & Schwartz, 2008; Bartolucci & Smith, 2011).

[22] Of course, this does not solve the question of how these levels of description can understand each other, but perhaps, to the extent that the higher levels of organization may be linked with the next level down, such understanding is potentially possible. For example, an illustration of the different levels of organization from higher levels to lower levels and their scientific discipline associated may go as follows: behaviour (psychology)–information processing (cognitive science)–neural systems and neural regions (computational neuroscience)–neural networks (functional neuroanatomy)–neurons (cellular neuroscience)–synapses and intra-neuronal molecular pathways (molecular neuroscience). These levels of explanation can be overlapped along the hierarchy in order to provide a complete understanding of the mind/brain functioning at all levels (see Bickle, 2006: Fig. 1).

[23] Indeed, several models have provided interesting ways to establish a link between the activity of neurons in different brain areas and specific behaviours (for a review see Nienborg, Cohen, & Cumming, 2012). Many philosophers (and cognitive scientists) might dissent with such arguments, (this kind of reductionism it is not to everyone's liking), I think, however, that these models are worth serious attention. In some sense, the explanatory gap between levels of organization arises because we cannot stop ourselves thinking about the mind-brain relation in a dualist way (Papineau, 2011).

4. Predictive coding account: How predictive coding leads us to CPP

The idea behind predictive coding hypothesis (PC hereinafter) is that our brains predict the incoming sensory information. We constantly confront with a vast richness of stimuli that must be processed adequately to facilitate appropriate reactions. Optimizing this information is crucial for the correct functioning of the system, and an adequate way to optimize this processing effort might be by predicting the incoming sensory information from previous experience with the aim of process it efficiently and minimize the impact of novel or surprising stimuli. If PC is correct, our brains are continually generating models of the world based on context and information from memory to predict sensory input. The basic idea is that the human brain is fundamentally a hypothesis generator.[24]

PC is an emerging, rich, comprehensive, and widely discussed account about how our minds work. In recent years, it has been supported by scientists and philosophers concerning a wide variety of functions: perception, motor activity, cognition, attention or consciousness.[25] Roughly, the PC hypothesis states that top-down predictions facilitate perceptual processing by reducing the need to reconstruct the environment via exhaustive bottom-up analysis of incoming sensory information (Panichello, Cheung, & Bar, 2013, 4). Does this mean that PC account of perception is a proof that CPP occurs? Are PC and CPP implicated with each other? Can PC teach us something about the relationship between perception and cognition? Some researchers advocate for a strong relation, by stating that perceptual systems are penetrable to the extent that such penetration minimizes global prediction error (Lupyan, 2015: 550; see also Clark, 2013: 10). This means that CPP occurs because PC occurs, but this strong relation contrasts with other possibilities, when both are dissected, the existence of such a strong relationship is not clear at all. I start this section by providing a more detailed description of the PC model by reviewing some empirical findings that holds the plausibility of the model (Section 4.1). Subsequently, I examine how some conceptions of PC can make all definitions of CPP possible (Section 4.2), particularly, I argue for the inadequacy of temporal strategy from PC account (Section 4.2.1), I provide arguments for the involvement of real cognitive processes in PC (Section 4.2.2), and finally, I suggest that the more interesting relationship between perception and cognition, in concordance with PC and consistent with CPP is that of a continuum along which lies more or less cognitive and perceptual states (Section 4.2.3). If these arguments are strong enough, the conclusion is that PC entails the existence of CPP (perhaps pervasive CPP) at all perceptual levels.

4.1. The predictive coding model

In order to generate an appropriate reaction to the incoming sensory signals, the brain has to be able to gather low-level properties in a perceptual grouped stimulus. The brain has to distinguish, for example, a 2-dimensional figure from a 3-dimensional one, or a rough texture from a smooth one. But the brain also has to solve complex situations; it has to distinguish a real bear from a suggestive bear-resembling toy, or an angry from a cheerful face. Perception has to be faced with apparently simple situations but also with complex ones. According to tradition, this is attained upwardly, the brain first analyses and groups the low-level properties of the stimulus and only later the stimulus is identified. PC thesis, conversely, suggests that in simple and complex perceptual situations the same mechanisms are involved, in both the brain deals with the uncertainty of the environment by implementing or realizing (approximate) Bayesian reasoning. The result is an estimation of the sensorial stimuli by correcting certain kind of error. It is said that the brain continually makes a model of the outer world according to Bayesian principles to predict the incoming sensory information. In other words, what we see is determined jointly by the current input and the priors established by previous experience, expectations and other contextual factors (Lupyan, 2015: 117). This means that perception, as an inferential process, can only know an approximation (more or less robust) of how the world is. Bayesian inference provides a useful and interesting way to think about perception by providing a simple mechanism –high-level cognitive brain areas send signals to low-level ones to modulate its processing. The implication of these statements in the relationship between cognition and perception seems obvious, if we can predict the incoming sensory information, then such information should be modulated by background knowledge stored in memory, and therefore there is no way that perception works independently from other mental processes.

PC is not a unified framework; there is significant disagreement over the extent of what can be explained (Sims, 2016). The range of such explanation goes from some neurocognitive functions (minimal account) to all the biological self-organization (ambitious account). As the scope of the theory is, however, not especially relevant for our purposes, I assume here that whether the relation between PC and CPP is that of implication, the minimal predictive account would be enough to assert the existence of CPP. The reason why these divergences are exposed is to highlight the increasingly influential position that PC is acquiring in recent years. My intention in this part is to ensure the plausibility of PC to guarantee that the subsequent dissertation on its relationship with CPP makes some sense. What exactly is the minimal version of PC?

In its minimal version PC account states that the brain produces top-down generative representations of the world that are predictions of how the world is. Those representations are modified bottom-up by incoming signals, which are propagated upwards only as a prediction error signal, and subsequently modified by a cascade of top-down processing, and perhaps sideways by other

[24] These insights go back at least until Helmholtźs notion of unconscious inference. It is sustained that unconscious inferences mediate visual perception and, therefore that perception draws on the same cognitive mechanisms as ordinary reasoning and scientific inference do (Helmholtz, 1867/1910, 3: 28–29). In a similar vein, Gregory (1980) treats perception as a hypothesis testing.

[25] See for example Rao and Ballard (1999); Brown, Friston, and Bestamnn (2011); Chaumon, Kveraga, Barrett, and Bar (2013); Clark (2013); Friston (2005, 2009); Gilbert and Sigman (2007); Hohwy (2007, 2012); Jehee and Ballard (2009); Kveraga et al. (2007); Panichello et al. (2013); Summerfield et al. (2006, 2008); Summerfield and Egner (2009); Rauss, Schwartz, and Pourtois (2011); Vetter and Newen (2014).

sensory modalities, to reduce global prediction error. Subsequent feedforward-feedback passes refine this process until the entire system settles on the most likely interpretation. The processing is typically thought to be done according to Bayesian rules (Clark, 2013; Hohwy, 2013; Lupyan, 2015; see also Macpherson, 2017: 10).

Researchers have successfully assessed the idea that the brain contains a model of the environment with which helps to infer what it is perceived. For example, Rao and Ballard (1999) provide a robust mathematical framework showing how hierarchical PC approach to perception describes how the sensory cortex extracts information from noisy stimuli. In this model of visual processing feedback connections from higher-order visual cortical areas to lower-order ones carry predictions of lower-level neural activities, whereas the feedforward connections carry the residual errors between the predictions and the actual lower-level activities. Hohwy et al. (2008) have shown that many aspects of the binocular rivalry phenomenon may be explained and unified by the predictive coding model. Panichello et al. (2013) have proposed that predictions enable rapid generation of conscious percepts and bias the contents of awareness in situations of uncertainty (for a review see Clark, 2013). The PC account may also explain a great deal of psychophysical and neurophysiological data, for example, predictive feedback can account for biphasic responses in the lateral geniculate nucleus (Jehee & Ballard, 2009), PC along with biased-competition can simulate a wide range of V1 response properties, as orientation tuning, size tuning, spatial frequency tuning, temporal frequency tuning, cross-orientation suppression and surround suppression (Spratling, 2010, 2011, 2012a,b), it can explain gain modulation as is observed when a retinal receptive field is modulated by eye position (De Meyer and Spratling, 2011, 2013), the contour integration (Spratling, 2013, 2014), the modulation of neural response due to attention (Spratling, 2014), fMRI data related to stimulus expectation (Smith & Muckli, 2010), mismatch negativity (Wacongne et al., 2012), habituation (Ramaswami, 2014) or the saliency of visual stimuli (Spratling, 2012b). Exploring more scrupulously these literature goes beyond the scope of this paper, but increasingly, researchers find that from this attractive point of view a unified account of action, perception and cognition is possible.[26]

In sum, PC account is not a fully accepted but a very plausible vision about how the mind/brain works. Recent disputes are, in fact, more about the scope of the thesis rather than its plausibility. Given its simplicity, elegance and explanatory scope, it seems that PC thesis is here to stay, we can be more precise in the mechanisms that underlie the process, but everything suggests that something must be right in the claim that our brains predict the incoming sensory stimulation.[27] So, bearing all this in mind, let me see what minimal PC account teaches us about the relationship between perception and cognition, in other words, how PC leads to CPP.

4.2. How predictive coding leads to CPP

Does the PC thesis show a clear way to see how cognition could directly affect perception? The first explicit attempts to engage CPP from PC appear in Hohwy (2013: Chapter 6) and Lupyan (2015). The developed idea is that PC can solve all the surrounding CPP controversies by defending that lower-level processes are constrained by higher-level knowledge to minimize global prediction error. As PC posits that our brains are continually generating models of the world through active inference, which are top-down projected to obtain a perceptual experience, CPP, in principle, should be expected. However, to find a solid implication requires clarify both, whether PC involves, never involves or sometimes involves real cognitive states, and whether such a relationship includes the cognitive penetrability of perceptual experience, early vision or both (Macpherson, 2015a: 581–582). We have already seen the two different conceptions of CPP, whether affecting to perceptual experience or early vision, and we have also remarked that CPP of early vision includes the possibility of constraining even more that conception by introducing the temporal criteria, according to which only the 100–120 ms. after stimulus presentation counts as CPP. With regard to PC rather than the scope of the thesis, (I have already argued that a minimal PC account where are involved, at most, some perceptual processes would be in principle enough to assert the plausibility of CPP), what interests us is the kind of states implicated in the process, particularly, if these states are real cognitive states, and in that case what kind of relationship between perception and cognition the theory predicts. With these constraints, the crucial question becomes more precise: What instances of CPP can be solved by what instances of PC?

Macpherson's (2017) has already done this job, and her dissection will serve to drive my discussion. She offers different conceptions of PC and compares each of them with the three different definitions of CPP treated: perceptual experience, early perception (Phylyshyn's functional definition) and early perception (Raftopoulos's 100 ms. definition). She appreciates three kinds of possible connections: 1) PC entails CCP, 2) PC is compatible with, but does not entail CPP, and 3) PC is incompatible with CPP (Macpherson, 2017: 10). Those cases where PC do not involve cognitive processes or those cases where PC does not contemplate the perception/cognition distinction cannot entail nor being compatible with CPP. The first because to be cognitively penetrated perception must be affected by real cognitive states, and the second because for there to be CPP, such a distinction must be established. So, for PC being

[26] Of course, the thesis has also been questioned. In addition to the divergences with its explanatory scope, it is possible to find in the most recent literature a relevant dispute in PC account, the so-called dark room problem. To be exact, such a dispute concern mainly to the more radical version sustained by Friston and colleges, the free energy principle, the minimal approaches are not affected (see Friston, Thornton, & Clark, 2012; Froese & Ikegami, 2013; Sims, 2017).

[27] PC is also consistent with other sense modalities, audition (Wacongne et al. (2011, 2012), taste (Gardner & Fontanini, 2014; Kusumoto-Yoshida, Liu, Chen, Fontanini, & Bonci, 2015), smell (Howard, Gottfried, Tobler, & Kahnt, 2015) and touch (Naeije et al., 2016; Shergill et al., 2013). PC also seeks for an explanation of higher-level cognitive processes like theory of mind (Koster-Hale & Saxe, 2013), mirror neurons (Kilner, Friston, & Frith, 2007), attention (Feldman & Friston, 2010), emotion (Seth, 2013), aesthetics (de Cruys & Wagemans, 2011), self-awareness (Apps & Tsakiris, 2014), consciousness (Seth, Suzuki, & Critchley, 2011), and language (Lupyan & Clark, 2015). And it has also proved to be useful in explaining many symptoms associated to syndromes like schizophrenia (Fletcher & Frith, 2009; Lalanne, van Assche, & Giersch, 2010), psychosis (Corlett, Honey, & Fletcher, 2016) and autism (Pellicano & Burr, 2012; Lawson, Rees, & Friston, 2014).

consistent or entail CPP, whatever its definition, it must involve real cognitive states and recognize some kind of perception/cognition distinction, otherwise, CPP cannot be a consequence of PC. MacPherson concludes that perceptual experience, as well as early vision (defined functionally), entail or at least in some cases are consistent with CPP, not so the 100 ms. definition suggested by Raftopoulos, which must still be addressed empirically. The denial of the early vision is not worth contemplating. In sum, some versions of PC entail that there are some forms of CPP, some versions of PC are compatible with, but do not entail, some forms of CPP and some forms of PC entail that some forms of CPP do not exist (Macpherson, 2017: 6). These are all the possible options, so from now on I will aim to show,

1- that the penetration of early vision (100 ms definition) does not make sense in the context of the PC framework.
2- that PC framework necessarily involves real cognitive states affecting both perceptual experience and early vision.
3- that rather than deny some kind of perception/cognition distinction, what PC proposes is a continuum along which lies more or less cognitive and more or less perceptual states.

Note that showing the points 1 and 2 the concerns raised by impenetrability supporters for neuroscientific evidence are solved, whether top-down effects occur on par with the incoming signal, and whether the top-down effect is cognitive in nature, then the effect might be an authentic case of CPP. If my arguments are sound enough and the PC thesis is plausible enough, then the minimal account of PC is not only consistent with but also entails the existence of CPP, both early visual and visual experience, and importantly, it brings out an exciting conception about the perception/cognition relationship in line with the neurological and psychological data. In sum, whether PC involves real cognitive states and perception and cognition rests in a continuum along which lies more or less cognitive and more or less perceptual states, then PC entails CPP.

4.2.1. The inadequacy of temporal strategy from PC account

First, the temporal criterion does not make sense in the context of PC. As a reminder: the minimal PC is committed with the idea that the brain produces top-down generative representations (knowledge, assumptions and expectations) about how the world is. It is then assumed that the brain contains a registered model of the world that is continuously being corrected and, in turn, corrects incoming information. Those representations are subsequently modified by incoming signals, which propagate bottom-up only as a prediction error signal. The resulting representations are afterwards corrected by top-down processing or by other sensory modalities to reduce global prediction error. It is said that such processing is done according to Bayesian rules.

These models postulate that perceptual inputs directed by the stored knowledge form a sensory prediction of what we will see in the next step. If that is right, human brains represent models of the world, and with the model in hand the brain extracts the information by continually seeking to lower the prediction error, the information is therefore extracted from sensory energy by predicting the input. So, if such a prediction is what counts as the cognitive process influencing perception, the temporal criterion loses its meaning because prediction precedes, or at least works simultaneously, with perceptual inputs. This indicates that the model must constantly be active and prepared to extract the information based on prior expectations, and therefore such prior expectations are crucial to make sense the perception of the environment. Consequently, if PC entails the prediction or the advance of what we are going to see, and that is just what counts as CPP, then the temporal criterion is out of place.

The early vision impenetrability supporter (100 ms. definition) can argue that it is during the reduction of the global prediction error, during the top-down correction of the bottom-up propagation and not before, when real cognitive processes enter at stake, thus saving the temporal criterion. However, PC seems to suggest that if the learned world in our heads is constantly prepared to be adjusted with the world out there, then re-entrant pathways should be elicited just at the moment the stimulus enters by our retinas, that is, as soon as the stimulus enters by the retina top-down effects are already underway, thus precluding the possibility that during the first 100 ms. the information is exclusively transmitted in a bottom-up direction.

It can, however, be replied that even occurring at the same time, top-down predictions and bottom-up propagation will encounter only once a determined time has elapsed, and therefore impenetrability thesis (100 ms.) can still be consistent. Indeed, one can argue that perhaps it is during that minimal lapse of time that precedes the convergence between the two informational canals that early vision is cognitively unaffected. A natural answer to this is that although not touching each other, if predictive and incoming signals are working online, at the same moment, in the same space of events, and outputting part of the same perceptual experience, then the processes should work overlapped.

One can empirically assess these issues in two ways, or by analysing the temporal occurring of predictive and incoming signals and measure the temporal lapse between them (see Newen & Vetter, 2017: 29–30; although see Raftopoulos, 2017), or by observing whether the predictive signal reaches the typical processes carried out during the alleged impenetrable time interval. Let me consider the second strategy. There are examples of the very early influence of high-level processes over typical visual properties processed during the time interval in which the alleged impenetrability occurs. For example, emotion enhances contrast sensitivity (a typical dimension of early vision) irrespective to attention, and potentiates the effect of attention on contrast sensitivity (Phelps, Ling, & Carrasco, 2006); emotional valence (happiness) of the stimuli can also facilitate the processing of biological motion (Lee & Kim, 2017); top-down influences of prior knowledge affect colour processing, most likely by constraining the inferences that the visual system makes at earliest processing stages during complex natural scenes (Bannert and Bartels, 2013); or prior knowledge and expectations about the world prepare perception by biasing incoming sensory information and influencing early visual responses (Samaha, Boutonnet, & Lupyan, 2016). These examples seem to show that the pairing between top-down and bottom-up processes occur so early that even perceptual organization is subject to descending cognitive effects, thus pointing that our prior knowledge, our goals or even our learned emotional valence may act over the structural organization of the stimuli. After all, it does not sound strange that our prior beliefs make us perceive the stimuli in more vividly, clearly, oriented in different ways or even sized, shaped and coloured differently in different circumstances or different situations. So, being this the case, even the determination of the structural descriptions of objects is subject to be altered by cognitive factors.

To conclude, if previous to whatever perceptual experience our mental models are prepared to exert a direct influence on what we are going to perceive, then the underlying predictive mechanism attached to the model, can be activated just at the moment that the incoming signal enters the retinas. If this argument is correct, the penetration of early vision (100 ms. definition) whose relation with PC depends, according to MacPherson, on empirical matters yet to be developed, should be established. The question now is: are there enough reasons to think that the high-level predictive signal counts as a real cognitive process relevant for the CPP?

4.2.2. How PC shows that real cognitive processes affect perception at all levels

The second point, if PC thesis necessarily involves or not *real* cognitive states, is a disturbing and crucial point for MacPherson. She states:

> The minimal account of predictive coding […] simply states that perceptual representations of the world are produced by high-level processes—high-level in relation to the level of perceptual experiences. The account leaves it open whether those high-level processes include cognitive states (Macpherson, 2017: 11).

Indeed, one can deny the real (or relevant for CPP) cognitive nature of the high-level processes predicted by the theory and, in consequence, to doubt about the guarantees that PC entails CPP. MacPherson (2015a, 2017) insists especially in this point –whether such predictions do not count as real cases of CPP, we cannot make sure that PC entails the CPP of both perceptual experience and early vision. This point introduces us into two questions, the first is about what should count as cognition in the context of CPP, and the second about what kind of cognition is at stake in PC accounts.

I have answered the first question in the first part of this paper by arguing that the part of cognition relevant for CPP should not be limited to propositional attitudes such as beliefs or desires. I have argued that other states, perhaps states non-accessible to consciousness and non-inferentially integrated, may also produce important epistemic consequences for the subject. Indeed, there are multiple examples of cognitive states non-reduced to propositional attitudes (see emotions, moods, fears, types of personality, cognitive styles, education or learning) whose alleged influence on perceptual states may provoke important alterations in the epistemic status of the agents. Sadness, for example, may appear objects or faces less illuminated than happiness, or fear can make sounds seem closer or stronger. It is also important to note that a belief is not only a conscious discursive thought, beliefs may also have a form of knowledge recorded in memory ready to be activated automatically. This kind of belief, perhaps more in line with PC proposal, should count as real cognition since an unconscious belief does not differ in essence and origin from the belief arising from conscious discursivity.

The second question, what kind of cognition is at stake in PC accounts, is the crucial point here. From the mere fact that PC posits that high-level processes are crucial to produce perceptual representations we cannot follow that those high-level processes are real cognitive processes, they can simply be high with relation to low-level processes but perhaps not high enough to be included as cognitive in the sense described above. According to MacPherson, philosophers should still determine if real cognitive states play or not a role in the PC account of perception (Macpherson, 2017: 11–13). In the negative case, one should admit that predictive account of perception may be explained without involvement of the cognitive system. If we respond affirmatively, the cognitive system will be involved, and PC will be at least consistent with CPP. It is hard, however, to see what kind of states can be those higher than perception and lower than cognition, that are not perceptual but do not arrive to be strictly cognitive and whose mission is to perform top-down generative representations. Macpherson (2017: 11), for example, introduces the doxastic/sub-doxastic distinction to delimit what and what does not count as a cognitive state. By cognitive states, she exclusively means doxastic states—states that are accessible to consciousness and inferentially integrated—such as beliefs and desires, but not sub-doxastic information-carrying states that the subject does not have access in principle. This point is highly controversial. Whether cognitive states are or not exhausted by doxastic states will depend on further argumentation, but in principle, a cognitive state needs no to be accessible to consciousness and inferentially integrated to be considered a cognitive state, many alleged cases of CPP do not obey to such strong restriction. As I have mentioned above in the extent that these states, doxastic or sub-doxastic, intervene in the perceptual epistemic situation of the agent, may count as relevant cases of CPP. Note that even denying that sub-doxastic states are cognitive in nature (in the strong sense of cognitive), this yet would count as an instance of non-perceptual states influencing perceptual ones.

Suppose, for instance, that these pre-cognitive and post-perceptual states are part of the states computed during late vision, as a reminder, the stage endorsed by Pylyshyn and Raftopoulos where cognitively driven attention and access consciousness take place, stage that belongs to a perceptual stage instead to a thought-like discursive stage, and a stage which requires access to memory for recognition and categorization of objects. Being this the case, the states involved in prediction might not count as real cognitive states. However, to take this hybrid stage (a bridge between cognition and early vision) as the stage where predictions involved in PC are processed requires further considerations. First, it is not clear that this stage is perceptual instead of cognitive, after all, it can be either the lowest cognitive level or highest perceptual one depending on where we put the boundary between perception and cognition. This middle stage between early vision and high cognition may be, indeed, crucial for the perception/cognition distinction. After all, if we accept that there is pure cognition (high non-perceptual cognition), pure perception (early vision) and a middle stage where the majority of everyday perceptual phenomena are processed, and where cognitive and perceptual processes are intermingled (late vision), then it is reasonable to deny a clear and sharp boundary between perception and cognition, we can distinguish perception and cognition, but not where perception ends and cognition begins. I will address this issue later. And second, even accepting that predictions may be generated only within the visual system (in the late vision stage) the relevant issue is that such predictions may have important consequences for the epistemic status of the agents, and in the extent that CP refers to the impact that cognitive states have for the subject's perceptual epistemology, one of two, or top-down effects from late vision to early vision count as CPP, or late vision should be considered more a cognitive than a perceptual stage.

To my knowledge, the vast majority of PC researchers are convinced that these priors are real cognitive states. Lupyan and Clark (2015), for example, explicitly state that:

> Within the predictive processing framework perception is expected to be penetrable to the extent that such penetration minimizes overall (long-term) prediction error. If information from another modality, prior experience, expectations, knowledge, beliefs, etc., lowers overall prediction error, then this information will be used to guide processing at these lower levels (Lupyan & Clark, 2015: 282).

Although Clark does not usually refer to CPP explicitly, he emphasizes that the sorts of abstract predictions made at higher levels can influence the more spatiotemporally precise predictions at lower levels, and claims that PC approach of perception can only be in consonance with the idea that perception is theory-laden or knowledge-driven (Clark, 2013: 7). It is hard to embrace the idea that perception is theory-laden and do not accept that are real cognitive states which exerts influence on perception. In a similar vein, Lupyan (2015) claims:

> Perceptual systems are penetrable to the extent that such penetration minimizes global prediction error. If allowing information from another modality, prior experience, expectations, knowledge, beliefs, etc., to influence perceptual processing lowers global prediction error, then this information will be used to guide processing at these lower levels. (Lupyan, 2015, p. 547)

Accordingly, to the extent that the perceptual brain works by minimizing global prediction error and high-level cognitive information is critical to achieve it, such information must be part of the perceptual processing. Thus, whether we should expect penetrability whenever we have higher-level information processing making predictions about lower-level information processing, then such high-level information should mostly refer to real cognitive states. Similarly, Hohwy suggests not only that PC architectures must induce CPP of some kind (Hohwy, 2013: 120), but he also specifies that

> from the perspective of a prediction error minimization theory of brain function, top-down modulation of perception by prior belief is inevitable. Specifically, top-down modulation can be individually variable, lead to false perception, and be mediated via high-level belief. However, top-down modulation is also answerable to, and enmeshed with, all sorts of contextual prior expectations, including attention, adaptation, and action (Hohwy, 2017: 84).

He seems to suggest that PC involves pervasive CPP. Indeed, Hohwy (2013) has provided a compelling account of how PC explains the cognitive penetrability of our perceptual experience. The crucial point lies in the notion of uncertainty. The idea is that interesting cases of CPP occur when input is somewhat uncertain, noisy or ambiguous. He writes

> Under relatively noisy and uncertain conditions, the perceptual input may underdetermine perceptual inference and give rise to situations where expectations make perceptions differ without much systematic suppression of prediction error (Hohwy, 2013: 123).

This means that if prior learning and the current input are not sufficiently informative, that is, if there is heightened uncertainty, or we are still learning, or there is noise or ambiguity, then there will be more unconstrained exploration of the prediction error landscape, leading to higher probability of deviations from the learning rate (Hohwy, 2017: 83). In other words, the more uncertainty, the more inaccurate the bottom-up prediction error, and therefore, the more top-down modulation. And accordingly, the greater the top-down modulation, the more probability to find CPP cases[28]. Is to be expected, then, that real high-cognitive processes solve such uncertainty, and the most important, as predictions are made according to Bayesian inferences, there should always be a minimum of uncertainty, and therefore there should always be some kind of cognitive process exerting influence on perception.[29]

It seems that researchers appealing to PC framework not only have shown that top-down expectations play an essential role in perceptual experience, but also that prior beliefs, high-level beliefs, expectations, background knowledge and so on, are nothing else than cognitive states capable of exerting influence on perceptual states. Vetter and Newen (2014: 72), Vance (2015: 661) or O'Callahan et al. (2017, 69–70) also seem to opt for the idea that top-down predictions involve cognitive states guiding perception. It is hard even imagine which kind of high-level processes can be those that are not cognitive states and yet affect perceptual states. In sum, it is highly reasonable to read the PC suggestion in the sense that the background knowledge and expectations, understood as the model of the world embedded in our brains, count as a real cognitive state capable of influence perception.

Once overcome the problems raised by the authenticity of the cognitive part involved in the PC, it seems easy enough to outline how PC can make all CPP definitions possible. Simply, by admitting the involvement of authentic cognitive states in PC, it is

[28] Importantly, although Hohwy seems to be committed with the idea that the most interesting cases of CPP are mostly dependent on the aforementioned conditions, he is cautious about admitting that such conditions are necessary.

[29] Vance and Stokes (2017: 96) have found, however, a case where CPP occurs but it cannot be explained by the uncertainty thesis. Concretely, they find a case where the locus of uncertainty is posterior to the high-level priors, and therefore uncertainty cannot explain why the priors are engaged. Most likely, the uncertainty thesis is not the unique explanation of how CPP occurs, but clearly is one of them. It is admissible to think that when the quality of low-level signal is high (there is low uncertainty), such low-level signal can dominate processing, but when the low-level information is more ambiguous (there is high uncertainty), the high-level knowledge will prevail.

reasonable to consider that perceptual experience is cognitively penetrated because, by promoting some hypothesis and inhibiting others, such perceptual experience is identified with the accurate prediction of how the world appears to us. So, to the extent that this accuracy is generated by a mechanism that depends, to a large degree, on a combination of high-level cognitive processes and low-level perceptual ones, it is feasible to conclude that according to PC the cognitive penetration of our perceptual experience actually occurs. The case for early vision is similar, to the extent that predictions are combined with incoming sensory data to arrive at progressively better guesses about the source of the signal (shape, size or colour representations), the cognitive penetration of early vision must occur. After all, if top-down and bottom-up signals are intertwined with each other to minimize the overall prediction error, there are no reasons to limit this processing to some parts of visual processing but no others, the same process will be sustainable for both, perceptual experience and early vision. The fact that we persist in divide the visual phenomenon in visual experience and early vision, although sometimes useful, does not affect the predictions elicited by the system. Top-down predictions thus reflect what the system expects, given what it already knows about the world and the current context. So, if perception is cognitively influenced in the way predicted by PC, all perception will be, even dividing the perceptual process in all the steps we want.

Finally, we still need to respond to another crucial question: How must we understand the interaction between perception and cognition from the PC framework? Should we continue accepting some kind of sharp border between perception and cognition? After all, if PC denies a perception/cognition distinction, then the very idea of CPP becomes meaningless. This point is explored next.

4.2.3. Predictive coding proposes a continuum along which lies more or less cognitive and perceptual states

Regarding the third point, what it is questioned is our traditional tendency to draw a sharp boundary between believing and perceiving.[30] As I have noted above, there is little agreement as to how such a distinction should be drawn. Let us consider three options: monism, pluralism, and eliminativism. Monism states that there is a unique border between perception and cognition. Pluralism claims that there might be multiple ways to mark the border, each one being tethered to a distinct explanatory goal. And eliminativism pleads for jettison the distinction altogether. PC, by its very nature, rejects the monist position but it is compatible with some form of the pluralist account or the eliminativist one. In effect, according to PC, a sharp distinction cannot be sustained, but the very nature of such a connection is essential to take CPP into account. On the grounds that there is no distinction to be drawn between perception and cognition, the very notion of CPP may become meaningless. The point at issue here is, then, that monism is incompatible with PC, and eliminativism is inconsistent with CPP, so that, only some kind of pluralism may be compatible with both. In consequence for PC being consistent with CPP we should consider a shifting border between perception and cognition, idea compatible with a continuum along which lies more or less cognitive and more or less perceptual states. Only in this case, CPP makes sense and can connect to PC. In short, the position to be considered here is, perforce, that of pluralism.

My suggestion is then that PC, as a scientific-based theory, can be related to CPP only if we are pluralists with respect to the perception/cognition distinction. If one thinks that CPP is inconsistent with the architecture suggested by PC, this is because the idea of CPP contemplated is anchored with the traditional folk understanding of the notions of cognition and perception, or because we are eliminativists with respect to that distinction. Thus, according to PC, instead of a real distinction between perception and cognition, we should consider variable differences in the mixture of top-down and bottom-up influence (Clark, 2013: 10). The idea is that bottom-up and top-down information combine to drive the information processing[31]. So, if we accept the change of mind proposed by PC, the notion of CPP can still be understood as the concurrent interaction between top-down and bottom-up processes. It should be, however, noted that the alignment of the perception/cognition distinction with the bottom-up/top-down signals does not necessarily compromise to impenetrability thesis, there can still be top-down signals coming from inside the perceptual system itself (perhaps signals not enough abstract), and therefore independent from cognition. So, a further condition should be imposed; the top-down signals should come high enough to avoid this problem (their content should include sufficiently abstract conceptions of the world). Being this the case, for a distinctively perceptual process to be immune to cognitive processes, it must be entirely a bottom-up process or being mediated by sufficiently low top-down signals, but without even the minimal intervention of high-level cues.[32]

So, to address the issues about perception/cognition distinction one option might be to put it in terms of top-down and bottom-up signals, where bottom-up signals carry the incoming sensory information, while top-down ones carry predictions. The discrepancy between bottom-up signals and top-down predictions constitutes the prediction error, which is continuously corrected in cycles

[30] To make this distinction philosophers have discerned about typical properties of perception in contraposition with typical properties of cognition, after all, if perception and cognition are distinct mental phenomena there should be some properties of perception that cognition lacks. Block (2018: 4), for example, argues that perception, unlike cognition, is iconic in format and non-conceptual and non-propositional in content. Burge (2010) argues that perception possesses mechanisms of constancy which enable us to perceive the same distal feature across variations in the proximal stimulus, while cognition does not. Block (2014) has also argued that perception has an adaptive nature that cognition lacks. And Beck (2017) has recently suggested that perception, unlike cognition, is stimulus-dependent. These suggestions are, in part, dependent on what we understand by the contents of perceptual representation. Whether we consider that perception represents poor contents (low-level properties) such as colour, shape or motion (see Tye, 1995), or whether rich contents (high-level properties) such as being a tiger (see Peacocke, 1992; Siegel, 2010). The debate on where situate the perception/cognition border is, currently, more than open (for review see Phillips, 2019).

[31] For a more extensive review on the top-down/bottom-up distinction, see Shea (2015). For an interesting reformulation of the distinction in terms of PC, see Rauss and Pourtois (2013).

[32] This situation, however, seems unlikely on the current state of the evidence, at physiological level the confluence of high-level top-down cues with bottom-up ones is ubiquitous in the brain (Gilbert & Li, 2013), thus suggesting that the divide between perception and cognition is, at this level, hard to maintain.

occurring throughout the hierarchy, with the appropriate combination of such signals leading to a perceptual experience. As prediction and error-correction cycles occur concurrently throughout the hierarchy, top-down information influences lower-level estimates and bottom-up information influences higher-level estimates of the input signal (Rao & Ballard, 1999: 80). Being this the case, the predominance of bottom-up processes implies that perception directs cognition, while the predominance of top-down processes indicates that perception is strongly constituted by cognition. Thus, bearing in mind the idea of an appropriate combination of top-down and bottom-up signals, and returning to the perception/cognition distinction, the most suitable picture for PC is that of a continuum along which lies more or less cognitive and more or less perceptual states.

The idea to consider here is then that rather than the denial of the intuitive distinction between perception and cognition in its folk sense, perception and cognition are best accounted as intertwined on a continuum. Some claims of PC theorists, nevertheless, can generate confusion, they seem to advocate a total dissolution of the perception/cognition distinction —they sometimes seem to adopt an eliminativist approach (see Macpherson, 2017: 12). Clark (2013), for example, seems to endorse such a position in the following passages

> These accounts thus appear to dissolve, at the level of the implementing neural machinery, the superficially clean distinction between perception and knowledge/belief. To perceive the world just is to use what you know to explain away the sensory signal across multiple spatial and temporal scales. The process of perception is thus inseparable from rational (broadly Bayesian) processes of belief fixation, and context (top-down) effects are felt at every intermediate level of processing. As thought, sensing, and movement here unfold, we discover no stable or well-specified interface or interfaces between cognition and perception. Believing and perceiving, although conceptually distinct, emerge as deeply mechanically intertwined (Clark, 2013: 10).
>
> All this makes the lines between perception and cognition fuzzy, perhaps even vanishing. In place of any real distinction between perception and belief we now get variable differences in the mixture of top-down and bottom-up influence… (Clark, 2013: 10).

Indeed, the passages may provoke some controversies about the acceptance or not of some kind of perception/cognition distinction. In principle, Clark seems to deny that possibility. However, a less meticulous reading of Clark's passage illuminates other reality[33]. Clark suggests the dissolution of perception/cognition distinction at the level of neural machinery but not conceptually, emphasizing that cognition and perception can still be intertwined. One advantage of this pluralist approach is that it allows to obtain different explanatory roles depending on the different border-markers. So, it is possible to read Clark in other sense, although perception and cognition are constructed in the same physical substratum and work in the same computational resources, they may differ conceptually. As far as I can see, what Clark suggests in these passages is the idea that perception and cognition lie, intertwined, on a continuum.

The idea of the continuity between perception and cognition has been, indeed, endorsed by many of the philosophers interested in the relation between PC and CPP. Hohwy, for example, states that

> This approach to top-down modulation and cognitive penetration seems to carve a reasonable route through penetrability and impenetrability, and is consistent with the idea, noted in recent accounts of prediction error minimization […] that perception and cognition are continuous (Hohwy, 2017: 84).

In the same line, Vetter and Newen (2014) support the idea of continuity by asserting that a clear-cut perception-cognition boundary cannot be maintained (p. 62). They suggest that

> [t]he majority of processing is realized in the many intermediate levels in the hierarchy which send and receive information with different levels of abstraction in either direction, belonging neither to a pure "sensory" nor a pure "cognitive" category (Vetter & Newen, 2014: 69).

This suggests that there is no point in the hierarchy at which the processes stop being perceptual and start being cognitive. "I do not think it is possible to say where perception ends and cognition begins", also says Lupyan (2015: note 6), doubting about the transparency of terms like *post-perceptual*, although he admits that these notions are descriptively and conceptually useful. In sum, if we take for granted the continuity position, where there is not a sharp boundary between perception and cognition and we invert the conventional ordering assumed by folk psychology, adopting a different combination of perceptual and cognitive states instead, as PC suggests, then a more reliable and comprehensive picture of our mind/brain functioning emerges. Such continuity is, I have argued, a forced conclusion from PC. If the brain is continuously generating predictions to facilitate perceptual processing by anticipating objects and scenes, then it seems implausible to isolate the perceptual experience from our previous knowledge. Seeing and thinking should constantly be interacting. In short, there can be a folk sense of what perception and cognition are, there can be some more typical properties (although not exclusive) of one than the other, but these properties cannot strictly mark what counts as perception and what as cognition. In consequence, the acceptance of the PC thesis determines that there is not a sharp boundary between perception and cognition since they are mostly intertwined.

To recap this section: I have argued that instead of our everyday understanding of the mind where perception and cognition seem to be distinct processes, we would do well by connecting (not replacing) the perceptual/conceptual interface with the more specific notions of top-down and bottom-up processes. This provides us not only a better comprehension of the interrelation between perception and cognition but also a novel understanding which, in concordance with PC theses, suggest that CPP is a phenomenon (perhaps pervasive) which occurs in different grades depending largely on the ambiguity of visual stimulation. I have also argued that

[33] MacPherson herself concedes this less radical reading of Clark (Macpherson, 2017: 13).

according to PC and in consistence with CPP, the most solid relationship between perception/cognition interface is that of a continuum along which lies more or less cognitive and perceptual states, where the middle ground includes the majority of our everyday perceptual experiences. This allows us to establish a difference between perception and cognition, necessary for CPP, and in turn maintaining a blurred border between them, necessary for PC.

5. Conclusion

To conclude, I review some of what I have argued. I have presented two reasons why the debate on CPP is blocked. The first reason is philosophical, to wit, the difficulties in drawing the line where perception ends and cognition begins, prevents to elaborate a common and stipulated definition of what counts as CPP. The second is methodological, when we apply the constraints suggested by impenetrability supporters to psychological studies, what remains is a private and subjective part of perception that it is not possible to attain experimentally. Psychological evidence on CPP debate is, therefore, inconclusive.

Considering these concerns, I suggest that empirical evidence from other non-psychological sources can help to disentangle the debate. I have first pointed that cognitive neuroscience shows that re-entrant neural pathways from high-level cognitive processes to low-level perceptual ones is pervasive in the brain, and therefore we should expect some kind of informational flow from cognitive areas to perceptual ones. However, whether these descending pathways are activated once perceptual system has finished its job (the temporal concern) or those descending pathways occur inside perception alien to cognitive areas (the intra-perceptual concern), then CPP does not logically follow. To solve these concerns, I have focused on the predictive coding framework.

According to PC account, our brains are continually generating models of the world based on prior information stored in memory to predict sensory input. I have argued that this view can help to clarify the worries imposed by CPP by solving the concerns raised from a neuroscientific approach. Macpherson (2017) has argued that to be useful to these disputes, PC researchers should empirically account for the alleged impenetrability of the early vision (100 ms. definition), should refer to real cognitive states influencing to perception, and offer a reasonable account for the perception/cognition relationship. To respond to these matters, I have argued that the 100 ms. definition does not make sense in the PC account (thus solving the temporal concern), that PC refers to real cognitive states influencing perceptual states (thus solving the intra-perceptual concern), and that in order to make CPP consistent with PC the relationship between perception and cognition should be that of a continuum along which lies more or less cognitive and perceptual states (thus also solving the eliminativist concern). If these arguments are strong enough, then CPP is a pervasive phenomenon, and the extent in which perception is affected by cognition becomes an empirical issue, most likely dependent on the extent in which our relationship with the environment is immersed in uncertain conditions. I hope my discussion will bring out more clearly what is at stake in debates about CPP and will offer a new and improved way of thinking about these topics in light of neuroscience and PC.

References

Albers, A. M., Kok, P., Toni, I., Dijkerman, H. C., & de Lange, F. P. (2013). Shared representations for working memory and mental imagery in early visual cortex. *Current Biology, 23*(15), 1427–1431.

Amedi, A., Floel, A., Knecht, S., Zohary, E., & Cohen, L. G. (2004). Transcranial magnetic stimulation of the occipital pole interferes with verbal processing in blind subjects. *Nature Neuroscience, 7*, 1266–1270.

Apps, M. A. J., & Tsakiris, M. (2014). The free-energy self: A predictive coding account of self-recognition. *Neuroscience and Biobehavioral Reviews, 41*, 85–97.

Bannert, M. M., & Bartels, A. (2013). Decoding the yellow of a gray banana. *Current Biology, 23*(22), 2268–2272.

Bar, M. (2003). A cortical mechanism for triggering top-down facilitation in visual object recognition. *Journal of Cognitive Neuroscience, 15*, 600–609.

Bar, M., Kassam, K. S., Ghuman, A. S., Boshyan, J., Schmid, A. M., Dale, A. M., ... Rosen, B. (2006). Top-down facilitation of visual recognition. *Proceedings of the National Academy of Sciences USA, 103*(2), 449–454.

Bartolucci, M., & Smith, A. (2011). Attentional modulation in visual cortex is modified during perceptual learning. *Neuropsychologia, 49*, 3898–3907.

Beck, J. (2017). Marking the perception-cognition boundary: The criterion of stimulus-dependence. *Australasian Journal of Philosophy. 96*(2), 319–334.

Bickle, J. (2006). Reducing mind to molecular pathways: Explicating the reductionism implicit in current cellular and molecular neuroscience. *Synthese, 151*, 411–434.

Block, N. (1996). Mental paint and mental latex. In E. Villanueva (Ed.). *Philosophical issues 7*. Atascadero, CA: Ridgeview.

Block, N. (2014). Seeing-as in the light of vision science. *Philosophy and Phenomenological Research, 89*(1), 560–572.

Block, N. (2018). If perception is probabilistic, why does it not seem probabilistic? *Philosophical Transactions of the Royal Society B, 373*, 20170341.

Brown, H., Friston, K., & Bestamnn, S. (2011). Active inference, attention and motor preparation. *Frontiers in Psychology, 2*, 218.

Bullier, J. (2001). Integrated model of visual processing. *Brain Research Reviews, 36*, 96–107.

Burge, T. (2010). *Origins of objectivity*. Oxford: Oxford University Press.

Carandini, M. (2012). From circuits to behavior: A bridge too far? *Nature Neuroscience, 15*, 4.

Carrasco, M., Ling, S., & Read, S. (2004). Attention alters appearance. *Nature Neuroscience, 7*, 308–313.

Cecchi, A. S. (2014). Cognitive penetration, perceptual learning, and neural plasticity. *Dialectica, 68*(1), 63–95.

Chaumon, M., Kveraga, K., Barrett, L. F., & Bar, M. (2013). Visual predictions in the orbitofrontal cortex rely on associative content. *Cerebral Cortex, 24*(11), 2899–2907.

Churchland, P. M. (1988). Perceptual plasticity and theoretical neutrality: A reply to Jerry Fodor. *Philosophy of Science, 55*, 167–187.

Churchland, P. M. (1989). *A neurocomputational perspective: The nature of mind and the structure of science*. MIT Press.

Churchland, P. S., Ramachandran, V. S., & Sejnowski, T. J. (1994). A critique of pure vision. In C. Koch, & J. Davis (Eds.). *Large-scale neuronal theories of the brain* (pp. 23–60). MIT Press.

Clark, A. (2013). Whatever next? Predictive brains, situated agents, and the future of cognitive science. *Behavioural and Brain Sciences, 36*(3), 181–204.

Clavagnier, S., Falchier, A., & Kennedy, H. (2004). Long-distance feedback projections to area V1: Implications for multisensory integration, spatial awareness, and visual consciousness. *Cognitive, Affective, & Behavioral Neuroscience, 4*(2), 117–126.

Corlett, P. R., Honey, G. D., & Fletcher, P. C. (2016). Prediction error, ketamine and psychosis: An updated model. *Journal of Psychopharmacology, 30*(11), 1145–1155.

de Cruys, S. V., & Wagemans, J. (2011). Putting reward in art: A tentative prediction error account of visual art. *i-Perception, 2*, 1035–1062.

De Meyer, K., & Spratling, M. W. (2011). Multiplicative gain modulation arises through unsupervised learning in a predictive coding model of cortical function. *Neural Computation, 23*(6), 1536–1567.

De Meyer, K., & Spratling, M. W. (2013). A model of partial reference frame transforms through pooling of gain-modulated responses. *Cerebral Cortex, 23*(5), 1230–1239.

Dehaene, S., & Changeux, J. P. (2011). Experimental and theoretical approaches to conscious processing. *Neuron, 70*, 200–227.
Deroy, O. (2013). Object-sensitivity versus cognitive penetrability of perception. *Philosophical Studies, 162*, 87–107.
Dretske, F. (1995). *Naturalizing the mind.* Cambridge, MA: MIT Press.
Dretske, F. (2015). Perception versus conception: The Goldilocks Test. In J. Zeimbekis, & A. Raftopoulos (Eds.). *Cognitive effects on perception: New philosophical perspectives*. Oxford: Oxford University Press.
Edwards, G., Vetter, P., McGruer, F., Petro, L. S., & Muckli, L. (2017). Predictive feedback to V1 dynamically updates with sensory input. *Scientific Reports, 7*, 16538.
Feldman, H., & Friston, K. J. (2010). Attention, uncertainty, and free-energy. *Frontiers in Human Neuroscience, 4* Article 215.
Firestone, C., & Scholl, B. J. (2015). Can you experience top-down effects on perception? The case of race categories and perceived lightness. *Psychonomic Bulletin and Review, 22*, 694–700.
Firestone, C., & Scholl, B. J. (2016). Cognition does not affect perception: Evaluating the evidence for 'top-down' effects. *Behavioural and Brain Sciences, 39*, 1–77.
Fletcher, P. C., & Frith, C. D. (2009). Perceiving is believing: A Bayesian approach to explaining the positive symptoms of schizophrenia. *Nature Reviews Neuroscience, 10*, 48–58.
Fodor, J. A. (1983). *The modularity of mind.* Cambridge, Massachusetts: MIT Press.
Fodor, J. A. (1988). A reply to Churchland's "Perceptual plasticity and theoretical neutrality". *Philosophy of Science, 55*(2), 188–198.
Friston, K. (2005). A theory of cortical responses. *Philosophical Transactions of the Royal Society of London B: Biological Sciences, 360*(1456), 815–836.
Friston, K. (2009). The free-energy principle: A rough guide to the brain? *Trends in Cognitive Sciences, 13*(7), 293–301.
Friston, K., Thornton, C., & Clark, A. (2012). Free-energy minimization and the dark-room problem. *Frontiers in Psychology,* 3.
Froese, T., & Ikegami, T. (2013). The brain is not an isolated "black box',' nor is its goal to become one. *Behav. Brain Sci. 36*(03), 213–214.
Gardner, M. P. H., & Fontanini, A. (2014). Encoding and tracking of outcome-specific expectancy in the gustatory cortex of alert rats. *Journal of Neuroscience, 34*(39), 13000–13017.
Gerbella, M., Belmalih, A., Borra, E., Rozzi, S., & Luppino, G. (2010). Cortical connections of the macaque caudal ventrolateral prefrontal areas 45 A and 45B. *Cerebral Cortex, 20*, 141–168.
Gilbert, C. D., & Li, W. (2013). Top-down influences on visual processing. *Nature Reviews Neuroscience, 14*, 350–363.
Gilbert, C. D., & Sigman, M. (2007). Brain states: Top-down influences in sensory processing. *Neuron, 54*(5), 677–696.
Gobell, J., & Carrasco, M. (2005). Attention alters the appearance of spatial frequency and gap size. *Psychological Science, 16*, 644–651.
Goodale, M. A., & Humphrey, G. K. (2008). *Separate visual systems for action and perception.* Blackwell Handbook of Sensation and Perception.
Gregory, R. L. (1980). Perceptions as hypotheses. *Philosophical Transactions of the Royal Society of London B, 290*(1038), 181–197.
Gur, M. (2016). The anatomical and physiological properties of the visual cortex argue against cognitive penetration. *Behavioral and Brain Sciences, 39*, 34.
Hansen, T., Olkkonen, M., Walter, S., & Gegenfurtner, K. R. (2006). Memory modulates color appearance. *Nature Neuroscience, 9*(11), 1367–1368.
Harrison, S. A., & Tong, F. (2009). Decoding reveals the contents of visual working memory in early visual areas. *Nature, 458*(7238), 632–635.
Helmholtz, H.L. (1867/1910). Handbuch der physiologischen Optik. Leipzig: L. Voss. Reprinted, with extensive commentary. In A. Gullstrand, J. von Kries & W. Nagel (Eds.), Handbuch der physiologischen Optik (3rd ed.). Hamburg and Leipzig: L. Voss. ())
Hochstein, S., & Ahissar, M. (2002). View from the top hierarchies and reverse hierarchies in the visual system. *Neuron, 36*, 791–804.
Hohwy, J. (2007). Functional integration and the mind. *Synthese, 159*(3), 315–328.
Hohwy, J. (2012). Attention and conscious perception in the hypothesis testing brain. *Frontiers in Psychology, 3*(96), 1–14.
Hohwy, J. (2013). *The predictive mind.* Oxford: Oxford University Press.
Hohwy, J. (2017). Priors in perception: Top-down modulation, Bayesian perceptual learning rate, and prediction error minimization. *Consciousness and Cognition, 47*, 75–85.
Hohwy, J., Roepstorff, A., & Friston, K. (2008). Predictive coding explains binocular rivalry: An epistemological review. *Cognition, 108*(3), 687–701.
Horikawa, T., Tamaki, M., Miyawaki, Y., & Kamitani, Y. (2013). Neural decoding of visual imagery during sleep. *Science, 340*, 639.
Howard, J. D., Gottfried, J. A., Tobler, P. N., & Kahnt, T. (2015). Identity-specific coding of future rewards in the human orbitofrontal cortex. *Proceedings of the National Academy of Sciences, 112*(16), 5195–5200.
Howe, C. Q., & Purves, D. (2005). The Müller-Lyer illusion explained by the statistics of image–source relationships. *Proceedings of the National Academy of Sciences of the United States of America, 102*(4), 1234–1239.
Jehee, J. F. M., & Ballard, D. H. (2009). Predictive feedback can account for biphasic responses in the lateral geniculate nucleus. *PLoS. Computational Biology, 5*(5), e1000373.
Kauffmann, L., Roux-Sibilon, A., Beffara, B., Mermillod, M., Guyader, N., & Peyrin, C. (2017). How does information from low and high spatial frequencies interact during scene categorization? *Visual Cognition, 25*(9–10), 853–867.
Kilner, J. M., Friston, K. J., & Frith, C. D. (2007). Predictive coding: An account of the mirror neuron system. *Cognitive Processing, 8*(3), 159–166.
Kok, P., & de Lange, F. P. (2014). Shape perception simultaneously up- and down regulates neural activity in the primary visual cortex. *Current Biology, 24*(13), 1531–1535.
Kok, P., Failing, M. F., & de Lange, F. P. (2014). Prior expectations evoke stimulus templates in the primary visual cortex. *J. Cogn. Neurosci. 26*, 1546–1554.
Koster-Hale, J., & Saxe, R. (2013). Theory of mind: A neural prediction problem. *Neuron, 79*(5), 836–848.
Kusumoto-Yoshida, I., Liu, H., Chen, B. T., Fontanini, A., & Bonci, A. (2015). Central role for the insular cortex in mediating conditioned responses to anticipatory cues. *Proceedings of the National Academy of Sciences, 112*(4), 1190–1195.
Kveraga, K., Ghuman, A., & Bar, M. (2007). Top-down predictions in the cognitive brain. *Brain and Cognition, 65*, 145–168.
Lalanne, L., van Assche, M., & Giersch, A. (2010). When predictive mechanisms go wrong: Disordered visual synchrony thresholds in schizophrenia. *Schizophrenia Bulletin, 38*(3), 506–513.
Lawson, R. P., Rees, G., & Friston, K. J. (2014). An aberrant precision account of autism. *Frontiers in Human Neuroscience, 8*(302).
Lee, H., & Kim, J. (2017). Facilitating effects of emotion on the perception of biological motion: Evidence for a happiness superiority effect. *Perception, 46*(6), 679–697.
Levin, D., & Banaji, M. (2006). Distortions in the perceived lightness of faces: The role of race categories. *Journal of Experimental Psychology: General, 135*, 501–512.
Lupyan, G. (2015). Cognitive penetrability of perception in the age of prediction: Predictive systems are penetrable systems. *Review of Philosophy and Psychology, 6*, 547–569.
Lupyan, G. (2017). Changing what you see by changing what you know: The role of attention. *Frontiers in Psychology, 8*, 553.
Lupyan, G., & Clark, A. (2015). Words and the world: Predictive coding and the language-perception-cognition interface. *Current Directions in Psychological Science, 24*(4), 279–284.
Lupyan, G., Thompson-Schill, S. L., & Swingley, D. (2010). Conceptual penetration of visual processing. *Psychological Science, 21*(5), 682–691.
Lupyan, G., & Ward, E. J. (2013). Language can boost otherwise unseen objects into visual awareness. *Proceedings of the National Academy of Sciences USA, 110*(35), 14196–14201.
Lyons, J. (2011). Circularity, reliability, and the cognitive penetrability of perception. *Philosophical Issues, 21*, 289–311.
Macpherson, F. (2012). Cognitive penetration of colour experience: Rethinking the issue in light of an indirect mechanism. *Philosophy and Phenomenological Research, 84*(1), 24–62.
Macpherson, F. (2015b). Cognitive penetration and predictive coding: A commentary on Lupyan. *Review of Philosophy and Psychology, 6*(4), 571–584.
Macpherson, F. (2015a). Cognitive penetration and nonconceptual content. In J. Zeimbekis, & A. Raftopoulos (Eds.). *Cognitive effects on perception: New philosophical perspectives*. Oxford: Oxford University Press.
Macpherson, F. (2017). The relationship between cognitive penetration and predictive coding. *Consciousness and Cognition. 47*, 6–16.
Mancini, F., Bolognini, N., Bricolo, E., & Vallar, G. (2011). Cross-modal processing in the occipitotemporal cortex: A TMS Study of the Müller-Lyer illusion. *J. Cogn. Neurosci. 23*, 1987–1997.
Mandelbaum, E. (2017). Seeing and conceptualizing: Modularity and the shallow contents of perception. *Philosophy and Phenomenological Research*. https://doi.org/10.

1111/phpr.12368.
Markov, N. T., Ercsey-Ravasz, M., Van Essen, D. C., Knoblauch, K., Toroczkai, Z., & Kennedy, H. (2013). Cortical high-density counterstream architectures. *Science, 342*.
Masrour, F., Nirshberg, G., Schon, M., Leardi, J., & Barrett, E. (2015). Revisiting the empirical case against perceptual modularity. *Frontiers in Psychology, 6*, 1676.
McCauley, R. N., & Henrich, J. (2006). Susceptibility to the Muller-Lyer Illusion, theory-neutral observation, and the diachronic penetrability of the visual input system. *Philosophical Psychology, 19*(1), 79–101.
Muckli, L. (2010). What are we missing here? Brain imaging evidence for higher cognitive functions in primary visual cortex V1. *International Journal of Imaging Systems and Technology, 20*, 131–139.
Muckli, L., Kohler, A., Kriegeskorte, N., & Singer, W. (2005). Primary visual cortex activity along the apparent-motion trace reflects illusory perception. *PLoS Biology, 3*(8).
Naeije, G., Vaulet, T., Wens, V., Marty, B., Goldman, S., & De Tiège, X. (2016). Multilevel cortical processing of somatosensory novelty: A magnetoencephalography study. *Frontiers in Human Neuroscience, 10*, 259.
Newen, A., & Vetter, P. (2017). Why cognitive penetration of our perceptual experience is still the most plausible account. *Consciousness and Cognition, 47*, 26–37.
Nienborg, H., Cohen, M. R., & Cumming, B. G. (2012). Decision-related activity in sensory neurons: Correlations among neurons and with behavior. *Annual Review of Neuroscience, 35*, 463–483.
Norman, J. (2002). Two visual systems and two theories of perception: An attempt to reconcile the constructivist and ecological approaches. *Behavioral and Brain Sciences, 25*, 73–144.
O'Callaghan, C., Kveraga, K., Shine, J. M., Adams, R. B., & Bar, M. (2017). Predictions penetrate perception: Converging insights from brain, behaviour and disorder. *Consciousness and Cognition, 47*, 63–74.
Ogilvie, R., & Carruthers, P. (2016). Opening up vision: The case against encapsulation. *Review of Philosophy and Psychology, 7*, 721–742.
Olkkonen, M., Hansen, T., & Gegenfurtner, K. R. (2008). Color appearance of familiar objects: Effects of object shape, texture, and illumination changes. *Journal of Vision, 8*(5), 1–16.
Panichello, M. F., Cheung, O. S., & Bar, M. (2013). Predictive feedback and conscious visual experience. *Frontiers in Psychology, 3*(620), 1–8.
Papineau, D. (2011). What exactly is the explanatory gap? *Philosophia, 39*, 5–19.
Peacocke, C. (1992). *A study of concepts.* Cambridge, MA: MIT Press.
Pellicano, E., & Burr, D. (2012). When the world becomes 'too real': A Bayesian explanation of autistic perception. *Trends in Cognitive Sciences, 16*, 504–510.
Peters, A. (2002). Examining neocortical circuits: Some background and facts. *Journal of Neurocytology, 31*, 183–193.
Petro, L. S., Vizioli, L., & Muckli, L. (2014). Contributions of cortical feedback to sensory processing in primary visual cortex. *Frontiers in Psychology, 5*, 1223.
Peyrin, C., Michel, C. M., Schwartz, S., Thut, G., Seghier, M., Landis, T., ... Vuilleumier, P. (2010). The neural substrates and timing of top–down processes during coarse-to-fine categorization of visual scenes: A combined fMRI and ERP study. *Journal of Cognitive Neuroscience, 22*(12), 2768–2780.
Phelps, E. A., Ling, S., & Carrasco, M. (2006). Emotion facilitates perception and potentiates the perceptual benefits of attention. *Psychological Science, 17*(4), 292–299.
Phillips, B. (2019). The shifting border between perception and cognition. *Noûs, 53*(2), 316–346.
Potter, M., Wyble, B., Hagmann, C., & McCourt, E. (2014). Detecting meaning in RSVP at 13 ms per picture. *Attention, Perception & Psychophysics, 76*(2), 270–279.
Pourtois, G., Rauss, K. S., Vuilleumier, P., & Schwartz, S. (2008). Effects of perceptual learning on primary visual cortex activity in humans. *Vision Research, 48*(1), 55–62.
Prinz, J. (2006). Is the mind really modular? In R. Stainton (Ed.). *Contemporary debates in cognitive science* (pp. 22–36). Oxford: Blackwell.
Pylyshyn, Z. W. (1999). Is vision continuous with cognition? The case for cognitive impenetrability of visual perception. *Behavioral and Brain Sciences, 22*, 341–365.
Pylyshyn, Z. W. (2003). *Seeing and visualizing: It's not what you think.* The MIT Press.
Raftopoulos, A. (2001). Reentrant neural pathways and the theory-ladenness of perception. *Philosophy of Science, 3*(September), 187–199.
Raftopoulos, A. (2009). *Perception and cognition: How do psychology and the cognitive sciences inform philosophy.* Cambrigde, MA: MIT Press.
Raftopoulos, A. (2011). Late vision: Processes and epistemic status. *Frontiers in Psychology, 2*(382), 1–12.
Raftopoulos, A. (2014). The cognitive impenetrability of the content of early vision is a necessary and sufficient condition for purely nonconceptual content. *Philosophy of Psychology, 27*, 601–620.
Raftopoulos, A. (2017). *Timing time: Why early vision is cognitively impenetrable. Proceedings of the 39th annual conference of the cognitive science society*. Austin, TX: Cognitive Science Society.
Ramaswami, M. (2014). Network plasticity inadaptive filtering and behavioural habituation. *Neuron, 82*(6), 1216–1229.
Rao, R. P. N., & Ballard, D. H. (1999). Predictive coding in the visual cortex: A functional interpretation of some extra-classical receptive-field effects. *Nature Neuroscience, 2*(1), 79–87.
Rauss, K., & Pourtois, G. (2013). What is bottom-up and what is top-down in predictive coding? *Frontiers in Psychology, 4*, Art. 276.
Rauss, K., Schwartz, S., & Pourtois, G. (2011). Top-down effects on early visual processing in humans: A predictive coding framework. *Neuroscience and Bio-behavioral Reviews, 35*(5), 1237–1253.
Rockland, K. S., Saleem, K. S., & Tanaka, K. (1994). Divergent feedback connections from areas V4 and TEO in the macaque. *Visual Neuroscience, 11*, 579–600.
Rockland, K. S., & Van Hoesen, G. W. (1994). Direct temporal-occipital feedback connections to striate cortex (V1) in the macaque monkey. *Cerebral Cortex, 4*, 300–313.
Rolfs, M., & Dambacher, M. (2016). What draws the line between perception and cognition? *Behavioral & Brain Sciences, 39*, 46–47.
Samaha, J., Boutonnet, B., & Lupyan, G. (2016). How prior knowledge prepares perception: Prestimulus oscillations carry perceptual expectations and influence early visual responses. *bioRxiv*.
Seth, A. K. (2013). Interoceptive inference, emotion, and the embodied self. *Trends in Cognitive Sciences, 17*(11), 656–663.
Seth, A. K., Suzuki, K., & Critchley, H. D. (2011). An interoceptive predictive coding model of conscious presence. *Frontiers in Psychology, 2*(395).
Shea, N. (2015). Distinguishing top-down from bottom-up effects. In D. Stokes, M. Matthen, & S. Biggs (Eds.). *Perception and its modalities* (pp. 73–91). Oxford University Press.
Shergill, S. S., White, T. P., Joyce, D. W., Bays, P. M., Wolpert, D. M., & Frith, C. D. (2013). Modulation of somatosensory processing by action. *Neuroimage, 70*, 356–362.
Siegel, S. (2010). *The contents of visual experience.* New York: Oxford University Press.
Siegel, S. (2012). Cognitive penetrability and perceptual justification. *Noûs, 46*, 201–222.
Siegel, S. (2017). *The rationality of perception.* Oxford: Oxford University Press.
Sims, A. (2016). A problem of scope for the free energy principle as a theory of cognition. *Philosophical Psychology, 29*, 967–980.
Sims, A. (2017). The problems with prediction – The dark room problem and the scope dispute. In T. Metzinger, & W. Wiese (Vol. Eds.), *Philosophy and predictive processing: 23*. Frankfurt am Main: MIND Group.
Smith, F. W., & Muckli, L. (2010). Nonstimulated early visual areas carry information about surrounding context. *Proceedings of the National Academy of Sciences USA, 107*, 20099–20103.
Speaks, J. (2009). Transparency, intentionalism, and the nature of perceptual content. *Philosophy and Phenomenological Research, 79*(3), 539–573.
Spratling, M. W. (2010). Predictive coding as a model of response properties in cortical area V1. *Journal of Neuroscience, 30*(9), 3531–3543.
Spratling, M. W. (2011). A single functional model accounts for the distinct properties of suppression in cortical area V1. *Vision Research, 51*(6), 563–576.
Spratling, M. W. (2012b). Predictive coding as a model of the V1 saliency map hypothesis. *Neural Networks, 26*, 7–28.
Spratling, M. W. (2012a). Predictive coding accounts for V1 response properties recorded using reverse correlation. *Biological Cybernetics, 106*(1), 37–49.
Spratling, M. W. (2013). Image segmentation using as parse coding model of cortical area V1. *IEEE Transactions on Image Processing, 22*(4), 1631–1643.
Spratling, M. W. (2014). A single functional model of drivers and modulators in cortex. *Journal of Computational Neuroscience, 36*(1), 97–118.
Stanton, G. B., Bruce, C. J., & Goldberg, M. E. (1995). Topography of projections to posterior cortical areas from the macaque frontal eye fields. *The Journal of*

Comparative Neurology, 353, 291–305.
Sterling, P., & Laughlin, S. (2015). *Principles of neural design.* MIT Press.
Stokes, D. (2012). Perceiving and desiring: A new look at the cognitive penetrability of experience. *Philosophical Studies, 158*(3), 479–492.
Stokes, D. (2013). Cognitive penetrability of perception. Philos. *Compass, 8*, 646–663.
Stokes, D., & Bergeron, V. (2015). Modular Architectures and Informational Encapsulation: A Dilemma. *European Journal for Philosophy of Science, 5*(3), 315–338.
Stokes, D. (2015). Towards a consequentialist understanding of cognitive penetration. In A. Raftopoulos and J. Zeimbekis (Eds.), Cognitive effects on perception: New philosophical perspectives.
Summerfield, C., & Egner, T. (2009). Expectation (and attention) in visual cognition. *Trends in Cognition Science, 13*, 403–409.
Summerfield, C., Egner, T., Greene, M., Koechlin, E., Mangels, J., & Hirsch, J. (2006). Predictive codes for forthcoming perception in the frontal cortex. *Science, 314*, 1311–1314.
Summerfield, C., Trittschuh, E. H., Monti, J. M., Mesulam, M. M., & Egner, T. (2008). Neural repetition suppression reflects fulfilled perceptual expectations. *Nature Neuroscience, 11*(9), 1004–1006.
Tomita, H., Ohbayashi, M., Nakahara, K., Hasegawa, I., & Miyashita, Y. (1999). Top-down signal from prefrontal cortex in executive control of memory retrieval. *Nature, 401*, 699–703.
Toppino, T. C. (2003). Reversible-figure perception: Mechanisms of intentional control. *Percept. Psychophys. 65*, 1285–1295.
Tye, M. (1995). *Ten problems of consciousness.* Cambridge, MA: MIT Press.
Ungerleider, L. G., & Mishkin, M. (1982). Two cortical visual systems. In D. J. Ingle, M. A. Goodale, & R. J. W. Mansfield (Eds.). *Analysis of visual behavior* (pp. 549–586). Cambridge, MA: MIT Press.
Vance, J. (2015). Cognitive penetration and the tribunal of experience. *Review of Philosophy and Psychology, 6*(4), 641–663.
Vance, J., & Stokes, D. (2017). Noise, uncertainty, and interest: Predictive coding and cognitive penetration. *Consciousness and Cognition, 47*, 86–98.
Vetter, P., & Newen, A. (2014). Varieties of cognitive penetration in visual perception. *Consciousness and Cognition, 27*, 62–75.
Vetter, P., Smith, F. W., & Muckli, L. (2014). Decoding sound and imagery content in early visual cortex. *Current Biology, 24*, 1256–1262.
Vrins, S., de Wit, T. C. J., & van Lier, R. (2009). Bricks, butter, and slices of cucumber: Investigating semantic influences in amodal completion. *Perception, 38*(1), 17–29.
Wacongne, C., Changeux, J. P., & Dehaene, S. (2012). A neuronal model of predictive coding accounting for the mismatch negativity. *Journal of Neuroscience, 32*, 3665–3678.
Wacongne, C., Labyt, E., van Wassenhove, V., Bekinschtein, T., Naccache, L., & Dehaene, S. (2011). Evidence for a hierarchy of predictions and prediction errors in human cortex. *Proceedings of the National Academy of Sciences, 108*(51), 20754–20759.
Weidner, R., & Fink, G. R. (2007). The neural mechanisms underlying the Muller-Lyer illusion and its interaction with visuospatial judgments. *Cerebral Cortex, 17*, 878–884.
Wyatte, D., Jilk, D. J., & O'Reilly, R. C. (2014). Early recurrent feedback facilitates visual object recognition under challenging conditions. *Frontiers in Psychology, 5*, 674.
Zeimbekis, J. (2013). Color and cognitive penetrability. *Philosophical Studies, 165*, 167–175.

Theoria, 2021, 36(3), 341-360
https://doi.org/10.1387/theoria.21949

THEORIA

ISSN 0495-4548 – eISSN 2171-679X

Predictive coding and the strong thesis of cognitive penetrability

(La codificación predictiva y la tesis fuerte de la penetrabilidad cognitiva)

Sergio Cermeño-Aínsa*
Universidad Autónoma de Barcelona

ABSTRACT: In this paper, I discuss the strong thesis of cognitive penetrability (CPs), to wit, that the perceptual states (P) of a subject (S) are *pervasively* influenced, affected, or caused by cognitive factors (C) as expectations, memories, thoughts, goals, and so on, *at all levels* of perceptual processing. I argue that following the predictive coding models of perception (PC), the strong thesis of cognitive penetrability is to be expected.

KEYWORDS: cognitive penetrability; predictive coding; top-down effects; early vision.

RESUMEN: *En este artículo discuto la tesis fuerte de la penetrabilidad cognitiva (CP), a saber, que los estados perceptivos (P) de un sujeto (S) están siempre influidos, afectados o causados por factores cognitivos (C) como expectativas, recuerdos, pensamientos, metas, etc., a todos los niveles del procesamiento perceptivo. Sostengo que asumiendo los modelos de codificación predictiva de la percepción (PC), la tesis fuerte de la penetrabilidad cognitiva es lo más esperable.*

PALABRAS CLAVE: penetrabilidad cognitiva; codificación predictiva; efectos top-down; visión temprana.

* ***Correspondence to:*** Sergio Cermeño-Aínsa. Escuela de Doctorado de la UAB. Programa de Doctorado en Ciencia Cognitiva y Lenguaje. Universidad Autónoma de Barcelona (08193 Cerdanyola del Vallès-Barcelona) – elsergei@hotmail.com – https://orcid.org/0000-0002-9598-8386

How to cite: Cermeño-Aínsa, Sergio (2021). «Predictive coding and the strong thesis of cognitive penetrability»; *Theoria. An International Journal for Theory, History and Foundations of Science,* 36(3), 341-360. (https://doi.org/10.1387/theoria.21949).

Received: 2020-08-11; Final version: 2021-03-18.

ISSN 0495-4548 - eISSN 2171-679X

1. *Introduction*

Traditional accounts of perception hold that all the information necessary to determine a perceptual experience is localized within the perceptual system, other non-perceptual systems are alien to this information, and only once perception has completed its work is this information integrated with other higher systems. Despite the strong intuitions derived from this view, there exists a considerable body of recent literature in experimental psychology and cognitive neuroscience consistent with the idea that perceptual processes inevitably involve theoretical presuppositions. This is the general idea defended by supporters of cognitive penetrability (CP), in short, that information from cognitive systems (e.g., thinking, remembering, or desiring) is indispensable for perceiving the world. What is ultimately suggested is that the intuitive distinction between seeing and thinking is, in a sense, fictitious —there is no clear delimitation between what we perceive and what we intend, think, or desire.

Such a lack of differentiation could, however, render the CP phenomenon meaningless, after all, for information of a cognitive state (C) to influence the information of a perceptual state (P), there should be a minimal distinction between (C) and (P). The debate might, at this point, be at a dead end. To keep the debate alive, some researchers have proposed to discard the folk understanding of perception and cognition and appeal to differences in the roles of bottom-up and top-down effects. For example, in characterizing a psychological process (for example, a perceptual process), we can ask how much the process is driven by incoming information from external stimuli, and how much it is affected by prior representations already in place before the stimulus was encountered. The cognitive penetrability debate can, thus, be recaptured by asking about the extent of top-down and bottom-up influences on a perceptual process (see Shea, 2015). If we accept this step, what brain science teaches us is that top-down processing is widespread in the brain (Gilbert and Li, 2013). A perceptual experience thus becomes the product of the appropriate combination of both, bottom-up incoming sensory information and top-down stored knowledge. This results in a novel picture of the perception/cognition relationship, where perception is seen as the constant interaction between the information entering our retinas, and our background knowledge registered (trough learning and memory) as a model of the world. This new approach provides an interesting and integrated view of how these aspects of the mind are related.

However, there is a sense in which perception, understood as pure perception, resists being removed; it can still be seen as the source and cause of perceptual judgments, or as the more intimate and confidential connection with the objects in the world, or even as the spontaneous acquisition of some kind of experiential given knowledge. In this paper, I argue that the classic idea of perception as a form of natural given knowledge becomes blurry and increasingly moves away from the empirical evidence. This recent evidence challenges our more profound intuitions, showing why we should abandon the sharp distinction between perception and cognition hidden in our folk psychology and embrace the idea that perception and cognition are rather intertwined, inseparable, and all along working together. There are several reasons to think in this way. First, because on the basis of psychological studies it is not possible to isolate anything that deserves to be called pure perception, since even if it existed, it would always be contaminated by perceptual judgement, perceptual memory or perceptual recognition, thus becoming inaccessible to psychological methodologies (see Masrour *et al.,* 2015; Cermeño-Aínsa, 2020). Second, because although psychological studies do not conclusively solve the debate on the perception/cognition relationship, they may not be necessary either —the intertwined view might still be supported by neurological evidence (Cecchi, 2018; although see Firestone and Scholl, 2016). And third, because the recent predictive processing framework (PC), the idea that the brain continually constructs predictions about the world, not only fits perfectly with the view delivered by such empirical discoveries, but also with the idea that perception cannot be isolated from cognition (Clark, 2013; Hohwy, 2013; see MacPherson, 2017 for a discussion about the relationship between PC and CP). What these reasons show, is that if we avoid postulating inaccessible substances or mediums between us and the world, however intuitive and intimate they may seem, and we pay attention to the most recent neurological findings and the tenets postulated by PC, then the traditional view cannot stand any longer.

In this paper, I argue for the strong thesis of cognitive penetrability (CPs). CPs is, in fact, doubly strong, since argues that, first, all visual processing, also early vision, is cognitively penetrated (the all-levels claim), and second, that this occurs pervasively (the pervasiveness claim). Section 2 presents some controversies around what is usually understood by CP, putting emphasis on the cognitive penetration of early vision, traditionally (and functionally) defined by Pylyshyn (1999, 2003) and recently (temporally) redefined by Raftopoulos (2009, 2014, 2017). I introduce, in section 3, a brief exposition of the predictive coding framework (PC). Section 4, argues for the all-levels claim. I first offer compelling evidence for very early top-down effects on perception, and subsequently, I focus on evidence from PC. I argue that the top-down predictive signal reaches the typical processes carried out during early vision and that the temporal criterion proposed by Raftopoulos is therefore out of place. Finally, in section 5, I argue for the pervasiveness claim. I propose that from PC we should expect CP not only at all levels but also pervasively. To the extent that sensory input is always uncertain, such uncertainty has to be minimized, and such minimization is mediated and modulated by top-down predictions, I argue that CP must be a ubiquitous phenomenon. Section 6, summarizes my view.

2. *What is cognitive penetration?*

The general idea behind the cognitive penetrability of perception (CP) is the influence of mental states like beliefs, intentions, or desires over sensory perception in some relevant way.[1] There are two distinct phenomena that go under the name of CP. The first is the CP of early vision. Early vision is defined functionally as the part of the visual system that takes signals from the eyes as inputs and produces shape, size, and colour representations as output (Pylyshyn, 1999).[2] The other is the CP of perceptual experience. Perceptual experi-

[1] In general, relevant cases of CP are those that produce epistemological consequences for the subjects. More specifically, are those that have consequences for the theory-ladenness of empirical observation, the epistemic role of perception, or (modular) architectures of the mind (see Stokes, 2015).

[2] Importantly, Raftopoulos differentiates early and late vision by focusing on neuroscientific work, particularly, on the timing of neural processes in the visual system. Early vision is a *pre-attentional stage of vision which includes a feed forward sweep (FFS) in which signals are transmitted bottom-up and which*

https://doi.org/10.1387/theoria.21949

ence refers to the conscious phenomenal state that we typically go into when we perceive the world. The difference between early vision and visual experience is that the contents of visual experience are not exhausted by the contents of early vision so that the cognitive penetrability of perceptual experience is compatible with the cognitive impenetrability of early vision. In this paper, I will refer mostly to early vision.

As expected, philosophers disagree on how to define CP. For example, Pylyshyn (1999), who restricts CP to early vision, considers a system to be cognitively penetrable when

> the function it computes is sensitive, in a semantically coherent way, to the organism's goals and beliefs, that is, it can be altered in a way that bears some logical relation to what the person knows. (Pylyshyn, 1999, p. 343)

This definition highlights the need for an intelligible link between the content of the cognitive state and the content of early vision, but neglects the type of causal relation between these contents (Stokes, 2013, 650; MacPherson, 2017, p. 10). MacPherson (2015), for example, provides the following case where the semantic condition is not sufficient for CP:

> [S]uppose that Murdo believes that aliens are attacking Earth. This belief causes stress, which induces a migraine. Suppose that whenever Murdo has a migraine, he experiences flashing lights in the top half of his visual field. So, suppose that Murdo visually experiences flashing lights in the sky on account of having his migraine. The content of this experience bears a semantic relation to the belief that caused it—the belief about the alien attack—but one might want to deny that this is a case of cognitive penetration. (MacPherson, 2015, footnote 9)

These cases show the insufficiency of the semantic criterion, because even existing a semantic connection between the content of a cognitive state and the content of the perceptual experience, this is an accidental connection. Consequently, for CP to occur, the link between cognition and perception must be transferred from a cognitive state, so that its content has to be consistent, in a minimal rational sense, with the perceptual state, but there must also be a non-accidental causal semantic link at each stage of the process.

Consider now the following contrafactual formulation based in the necessary (and taken together sufficient) conditions for CP to occur: perception will be cognitively penetrable if it is possible for two subjects, or one subject at different times, to have different perceptual experience when the visual scene, the perceptual conditions, the spatial attention and the sensory organs, remain fixed (adapted from MacPherson, 2012, p. 29). It is to be expected that, maintaining a rational non-accidental connection between the cognitive and the perceptual states, the difference in their perceptual experiences must be caused

---

lasts, in visual areas, for about 100 ms, and a stage at which lateral and recurrent connections allow recurrent processing (LRP). *This sort of recurrent processing, which starts at about 80-100 ms, is restricted within visual areas and does not involve signals from higher cognitive centers* (Raftopoulos, 2014, 3). Late vision is, on the other hand, a stage modulated by attention in which visual processing and cognitive effects coexist. It is a *hybrid stage of vision/thought in which perception and cognition are intermingled* (Raftopoulos, 2011, 11). According to Raftopoulos early vision is cognitively impenetrable, whereas late vision is not.

by differences in their cognitive states.[3] A direct problem to these definitions is that focus on perceptual experience rather than early vision, so even meeting all these conditions, it is possible the CP of perceptual experience but not of early vision. Furthermore, the requirement of keeping the internal state of the sensory system fixed is in practice not very credible, the visual system needs to continually adapt, so demanding internal function to be fixed is an idealization that prevents the system to produce its internal changes.

Stokes (2013), on the other hand, downplays the semantic criterion and focuses his definition on the causal link. Indeed, he appreciates certain difficulties in the semantic criterion, but more than its sufficiency (as MacPherson does) he has doubts about its necessity. He postulates that there can be cases where background cognitive states affect the perceptual experience in a wholly semantically incoherent way, but nonetheless count as a real CP case (see Stokes, 2015, pp. 78-80). This possibility encourages Stokes to provide an alternative definition without appealing to normative considerations. He suggests the following definition

> a perceptual experience E is cognitively penetrable if and only if (1) E is causally dependent on some cognitive state C, and (2) the causal link between E and C is internal and mental. (Stokes, 2013, 650)

Clause (1) ensures that the relationship is direct, and clause (2) that it is internal. The causal chain must involve mental states or processes, thus ensuring that instances where intermediate states cause changes in perceptual experience do not count as CP. Stokes himself, however, doubts about the sufficiency of his own definition. Consider the following example: "Suppose I suffer extreme exam anxiety and I believe that I am about to take an exam. This belief causes, internally, another mental state, namely the pain that accompanies a migraine. This pain further causes, again internally, a series of visual experiences where everything appears in a reddish hue" (Stokes, 2013, 650).[4] Both causal conditions are satisfied, but clearly, this is not a case of CP.

Finally, Stokes proposes a consequentialist understanding of CP (Stokes, 2015). According to this proposal, a definition of CP should be constrained by its consequences, so it will be successful just in case that it describes a phenomenon that has implications, says Stokes, for the theory-ladenness of perceptual observation, or for the epistemic role of perception, or for the modular theories of mental architecture. Thus, to be an instance of CP, at least, the following conditions must be fulfilled:

— There should be a genuine cognitive-perceptual relation (being this semantic, rational, causal, internal or whatever).
— And such relation should challenge the epistemic role of perception in justifying beliefs, or should grant that our empirical observations are theory-ladenness, or should challenge our current theories on mental architecture.

[3] Siegel (2012) provides a similar formulation: "If visual experience is cognitively penetrable, then it is nomologically possible for two subjects (or for one subject in different counterfactual circumstances, or at different times) to have visual experiences with different contents while seeing and attending to the same distal stimuli under the same external conditions, as a result of differences in other cognitive (including affective) states" (Siegel 2012, 205-206).

[4] The example is an adaptation of MacPherson (2012, 26), and it is originally used for emphasizing the necessity of the semantic criterion.

https://doi.org/10.1387/theoria.21949

These conditions move away from the discussions on the type of link expected between perception and cognition but emphasize both, the intervention of genuinely cognitive states during perceptual processing, as well as the implications of such an intervention for the theory-ladenness of perception or the epistemic role of perception or mental architecture. I think this better captures the essence of what CP must be, and can serve as an operational formulation. Yet, I insist, there is no consensus in the application of such definitions (mainly regarding the type of connection that would be expected between perception and cognition), like many other mental phenomena, finding a non-debatable definition becomes a very hard mission (for more profound and detailed discussions on the definitional concerns see Stokes, 2013, 2015; Macpherson, 2012, 2015).

Thus, setting aside the definitional controversies, a crucial aspect for this paper is to situate the locus and the scope of the CP phenomenon. For example, considering Raftopoulos or Pylyshyn accounts, being early vision the output of a perceptual encapsulated module, the contents of visual experience are not exhausted by the outputs of early vision, and therefore the cognitive penetrability of perceptual experience is compatible with the cognitive impenetrability of early vision (Raftopoulos, 2011). It is, therefore, possible to appreciate three different theses as to whether CP involves all, none, or only some parts of perceptual states. I call the strong cognitive penetrability thesis (CPs) the following statement:

> (CPs) The perceptual states (P) of a subject (S) are pervasively influenced, affected, or caused by cognitive factors (C) as expectations, memories, thoughts, goals, and so on, at all levels of perceptual processing.

To put it differently, there can be no perceptual states without minimal influence of cognitive states at all perceptual levels.[5] Note that CPs is doubly strong. On the one hand, it entails the influence of cognitive factors at all levels of the visual process (*the all-levels claim*), and on the other, it postulates that CP is a pervasive phenomenon (*the pervasive claim*). Regarding the first claim, CPs is strong in contrast to the weak penetrability thesis (CPw), which holds that only a part (late vision but not early vision) of the perceptual states of a subject is influenced by cognitive factors, an idea defended by Pylyshyn (1999) and more recently by Raftopoulos (2009, 2014). CPs is also opposite to the total impenetrability supporters, who hold that the perceptual states of a subject are not influenced by cognitive factors at any level, that is, that all the processes forming our perceptual experience are encapsulated from cognition, idea recently advocated by Firestone and Scholl (2016). CPs supports, then, that perception is cognitively penetrated at all levels, cognition affects perception at early and late levels of visual processing. Since I defend the CPs thesis, all my efforts will be concentrated on diminishing CPw, which I think is the unique redoubt that remains to impenetrability supporters. Finally, and regarding the second claim, CPs states that cognition always and systematically influences perception, there cannot be perceptual

[5] In this paper, I focus preferably on vision, mainly because it is a very well-studied field that provides very rich empirical data, but also because it is usually considered that all we can say about vision may be extended to other sense modalities. The process of vision or visual perception begins with the computation of a physical stimulus from the retina and finishes with the generation of a conscious or unconscious perceptual experience.

states without a minimal influence of cognitive states. This is a very radical claim, there are in fact many proponents of the existence of CP, but few argue that CP is a pervasive phenomenon. As we will see pervasiveness arises as a natural consequence of embracing the predictive coding account of perception.

3. *The predictive coding account of perception*

The idea behind PC is that the brain produces top-down generative models or representations of the world that constitute predictions of how the world is (Rao and Ballard, 1999; Lee and Mumford, 2003; Hohwy, 2013; Clark, 2013; Friston, 2010). It is said that *these top-down predictions facilitate perceptual processing by reducing the need to reconstruct the environment via exhaustive bottom-up analysis of incoming sensory information* (Panichello *et al.,* 2013, 4). Accordingly, the perceptual system relies on representations of prior probabilities to adjust the incoming sensory inputs to the representations stored in memory. Perceiving the world consists, therefore, in constantly elaborating estimations about how the world is, or more succinctly, perceiving the world is to balance the neuronal wiring configured in the brain with the cues arriving from the environment.

The brain is, therefore, constantly active. Cognitive and sensory systems work altogether interactively and concurrently, lower visual brain areas do not merely filter or extract environmental information, but participate as much as necessary along with the higher-levels in order to predict the incoming sensory stimulus. So, visual representations do not progress in a merely bottom-up serial fashion but occur interactively in constant feedforward and feedback loops that involve at the same time the entire hierarchical circuit in the visual system. According to this perspective rather than waiting to be activated by external influences, the brain is constantly generating expectations and predictions about the immediate future. To put simply, brains are essentially prediction machines (Clark, 2013).

The minimal version of PC[6] is committed with the idea that the brain produces top-down generative representations that are bottom-up modified by incoming signals, these signals are propagated upwards only as a prediction error signal, and subsequently modified by a cascade of top-down processing, and perhaps sideways by other sensory modalities, to reduce global prediction error. Subsequent feedforward-feedback passes refine this process until the entire system settles on the most likely interpretation. The processing is typically thought to be done according to Bayesian rules (Clark, 2013; Hohwy, 2013; Lupyan, 2015; see also Macpherson, 2017, p. 10).

PC accounts of perception are sustained by a good number of instances. Rao and Ballard (1999), for example, provide a robust mathematical framework showing how hierarchical PC approach to perception describes how the sensory cortex extracts information from noisy stimuli. In this model of visual processing feedback connections from higher-order visual cortical areas to lower-order ones carry predictions of lower-level neural activi-

[6] I say minimal because PC is not a unified framework, there is significant disagreement on the explanatory scope of the theory. The range of such an explanation goes from some neurocognitive functions to all the biological self-organization (Sims, 2017, 4). I am referring here to the minimal version.

ties, whereas the feedforward connections carry the residual errors between the predictions and the actual lower-level activities. Hohwy *et al.* (2008) have shown that many aspects of the binocular rivalry phenomenon may be explained and unified by the predictive coding model. Panichello *et al.* (2013) have proposed that predictions enable rapid generation of conscious percepts and bias the contents of awareness in situations of uncertainty (for a review see Clark, 2013). Exploring this literature more scrupulously is beyond the scope of this paper, but increasingly, researchers find that from this attractive point of view a unified account of action, perception and cognition is possible.[7]

One can easily argue that this revolutionary idea runs in favour of CP: after all, once perception is understood as an inferential predictive process, perceptual systems are penetrable to the extent that such penetration minimizes global prediction error. If the information from non-perceptual systems (prior experience, expectations, knowledge, beliefs, etc.) influence perceptual processing by lowering global prediction error, then this information will be used to guide processing at lower levels (Lupyan, 2015). However, the relationship between PC and CP is currently under pressure: some theorists raise doubts about the real cognitive character of predictions (MacPherson, 2017, pp. 11-13), others doubt whether these predictions really affects the earlier states of perceptual processing (Raftopoulos, 2017, 975), others argue that in its current state of development PC cannot uncontrovertibly explain some interesting cases of CP (Vance and Stokes, 2017), and others argue that PC suffers from unsolvable difficulties such as the so-called dark room problem (Sun and Firestone, 2020).[8]

Summarizing, the PC account is not a fully accepted but a very plausible vision about how the mind/brain works. Recent disputes are, in fact, more about the scope of the thesis rather than its plausibility. Given its simplicity, elegance and explanatory scope, it seems that PC thesis is here to stay, we can be more precise in the mechanisms that underlie the process, but everything suggests that something must be right in the claim that our brains predict the incoming sensory stimulation. So, bearing all this in mind, let me analyse what the PC account teaches us about the relationship between perception and cognition, and more precisely, how PC leads to CPs.

[7] PC is also consistent with other sense modalities, audition (Wacongne *et al.* (2012), taste (Gardner & Fontanini, 2014), smell (Howard, Gottfried, Tobler, & Kahnt, 2015) and touch (Naeije *et al.,* 2016), as well as with other mental phenomena like theory of mind (Koster-Hale & Saxe, 2013), mirror neurons (Kilner, Friston, & Frith, 2007), attention (Feldman & Friston, 2010), emotion (Seth, 2013), aesthetics (Cruys & Wagemans, 2011), self-awareness (Apps & Tsakiris, 2014), consciousness (Seth, Suzuki, & Critchley, 2011), and language (Lupyan & Clark, 2015). And it has also proved to be useful in explaining many symptoms associated to syndromes like schizophrenia (Fletcher & Frith, 2009; Lalanne, van Assche, & Giersch, 2010), psychosis (Corlett, Honey, & Fletcher, 2016) and autism (Pellicano & Burr, 2012).

[8] The dark-room problem can be formulated as follows: if perception, action, and cognition are driven by the error minimization then why do not cognitive creatures act to minimize stimuli in general? Why cognitive creatures do not take up position in the nearest “dark room” and never move again? For some interesting responses to this concern see Friston, Thornton & Clark (2012) and Cruys, Friston & Clark (2020).

4. *From predictive coding to the all-levels claim*

In section 2, I noted that there is a fundamental difference between the CP of perceptual experience and the CP of early vision. It may be the case that perceptual experience is cognitively penetrated while early vision is not. It is, in fact, very hard to determine what exactly a perceptual experience is, but what seems evident is that early vision is a perceptual process that leads to perceptual experience, that is, early vision is part of perceptual experience. There is a good number of examples showing the CP of perceptual experience (e.g., Levin & Banaji, 2006; Balcetis & Dunning, 2010; Stefanucci *et al.,* 2012 to cite just a few; see however Firestone and Scholl, 2016), but whether there is CP of early vision is currently in the core of the debate. In this section, I assume the CP of perceptual experience, and review some evidence arguing that from PC the CP of early vision is to be expected (for further details see Vetter & Newen, 2014, and specially Newen & Vetter, 2017).

Cognitive scientists and neuroscientists have indeed put forward evidence for very early top-down effects on perception. For example, there is evidence showing top-down processing from motion area V5 to primary visual cortex V1 during motion perception (Silvanto, *et al.,* 2005; Vetter *et al.,* 2015), or top-down processing from the frontal eye fields (FEF), a higher-level area in frontal cortex involved in motor planning of eye movements, to V5 (Silvanto, *et al.,* 2006; Morishima *et al.,* 2009), and very early processing of object recognition (Drewes *et al.,* 2016).[9] Prominently, Potter *et al.* (2014) registered ultra-rapid object categorization as fast as 13ms. from stimulus onset, so far from the time interval suggested by Raftopoulos for early vision.

Following another line of thought, an analogy can be made between perception and mental imagery. There is strong evidence supporting the idea that visual imagery and visual perception share the same mechanisms and cortical regions (Kosslyn *et al.,* 2006; Reddy *et al.,* 2010). When one visually imagines an object, a kind of endogenous conceptual content is top-down elicited to construct a blurred visual representation of such object (including, of course, the low-level properties of the imagined visual stimulus). These top-down signals trigger activity within the early visual system. So, if such top-down signals can be elicited through imagination (endogenously) to produce representations within the visual system, why can't those same signals influence bottom-up processing in cases where vision occurs exogenously? In short, if visual imagery involves top-down activity over early visual brain areas, then there are no reasons to think that the same effects cannot be triggered during actual visual perception. I think that this line of thought may provide an excellent empirical contribution in support of the CP of early vision (see Ogilvie and Carruthers, 2015, pp. 728-730).[10]

In my view, all the above evidence is enough to accept the all-levels claim. However, in this paper I focus on evidence from PC. Since early vision is defined both functionally (by

[9] For a more subtle description of these studies see Newen and Vetter (2017), for discussion see Raftopoulos (2017), and for further evidence of CP of early vision see O'Callaghan *et al.* (2017).

[10] Interestingly, Cecchi (2018) has also provided solid reasons and compelling examples to demonstrate that neural reorganization in the visual system is genuinely produced by CP. Other studies show that emotion enhances contrast sensitivity irrespective to attention, and potentiates the effect of attention on contrast sensitivity (Phelps, Ling, & Carrasco, 2006), and others that emotional valence (e.g., happiness) of the stimuli can also facilitate the processing of biological motion (Lee & Kim, 2017),

Pylyshyn) and temporally (by Raftopoulos), it becomes pertinent to address these two possibilities. So, from PC one should empirically assess the CP of early vision in two ways, or by observing whether the top-down predictive signal reaches the typical processes carried out during early vision, or by analysing the temporal occurring of predictive and incoming signals and measure the temporal lapse between them.

Let me point out a number of examples of the first possibility. Top-down influences of prior knowledge affect colour processing (a typical dimension of early vision), most likely by constraining the inferences that the visual, system makes at earliest processing stages during complex natural scenes (Bannert and Bartels, 2013). Prior knowledge and expectations about the world also prepare perception by biasing incoming sensory information and influencing early visual responses (Samaha, Boutonnet, & Lupyan, 2016). Shape perception (the grouping of local elements such as edges and lines into coherent shapes) is also modulated by predictive feedback, enhancing or reducing the activity in V1 depending on whether or not the predictive feedback meets with congruent bottom-up input (Kok and de Lange, 2014). Along with biased-competition, PC can also simulate a wide range of V1 response properties, including orientation tuning, size tuning, spatial frequency tuning, temporal frequency tuning, cross-orientation suppression and surround suppression (Spratling, 2010, 2011, 2012). Predictive signals can explain gain modulation as is observed when a retinal receptive field is modulated by eye position (De Meyer and Spratling, 2011, 2013), enhance the perceived contrast (Han and VanRullen, 2016), modulate contour integration (Spratling, 2013, 2014), or improve the detection of apparent motion (Vetter *et al.,* 2012). These examples show that the pairing between top-down and bottom-up processes occur so early that even perceptual organization is subject to descending cognitive effects, thus showing that our prior knowledge, our goals or expectations may act over the structural organization of the stimuli. After all, it does not sound strange that our prior beliefs make us perceive the stimuli more vividly, more clearly, oriented in different ways or even sized, shaped and coloured differently in different circumstances or different situations. So, this being the case, even the determination of the structural descriptions of objects is subject to be altered by cognitive factors. So, regarding its functional definition, when viewing early vision as the system that produces shape, size and colour as representations, there exist compelling evidence showing that predictive feedbacks directly affect these functional (psychophysical) representations. Thus, we can conclude on the basis of predictive feedbacks that there is no room for the impenetrability of early vision (as defined functionally).

Let me now evaluate things from the point of view of the temporal criterion. The minimal version of PC postulates that perceptual inputs driven by stored knowledge form a sensory prediction of what we will see in the next time step. If that is right, human brains are representational models of the world, and with the model in hand, the brain extracts the information by continually seeking to reduce the prediction error. The information is extracted from sensory energy by predicting the input. Consequently, if such a prediction counts as the cognitive process influencing perception, the idea of a temporal space during which cognition does not influence perception loses its meaning because prediction precedes, or at least runs simultaneously, with the early stages of perception. As the model is constantly active in our brains, and our brains are prepared all the time to extract the information based on prior expectations, then such prior expectations (and not just sensory input) help us make sense of our environments. In sum, if PC involves the prediction or the advance of what we are going to see, and that is just what counts as CP, then the temporal criterion is, in principle, out of place.

Predictive processes must therefore be carried out within the period of time considered by Raftopoulos for early vision. For example, there are studies suggesting that directed spatial attention produced by the effects of feature salience enhance responses in the lateral geniculate nucleus (LGN), indicating that activity in the LGN can be altered by top-down attentional goals (Poltoratski *et al.,* 2017; Ling *et al.,* 2015; Jehee and Ballard, 2009). In these cases, the incoming signal, the exclusively bottom-up processing, does not alone go beyond the subcortical structures (LGN), which means that when the stimulus enters the cerebral cortex, predictive recurrent processing is not only underway, but it has already reached V1, the gateway of the visual cortex. Taking into account that incoming signals arrive at LGN before reaching V1 and arrive at V1 at 40-60ms. from stimulus onset (Nowak and Bullier, 1997), the predictive signal must be top-down transmitted at least as fast as this. In sum, prior knowledge stored in our heads may influence the visual system even before that incoming stimulus enters cortical areas. Other studies reveal similar results. For example, analysing the influence of prior experience on face perception, Gamond, *et al.* (2011) found that prior knowledge links with incoming current sensory input as fast as 65 ms. from stimulus onset. Analysing the transfer of predictive signals across saccades in an apparent motion paradigm, Vetter, Edwards and Muckli (2012) found that the detection advantage of predictable targets is detectable as early as 50-100 ms. after saccade offset, thus showing very early latencies of predictive feedbacks. Although the temporal profile of the process in which predictive signals shape the incoming sensory stimuli has to be more deeply addressed, all this literature is consistent with the idea that if we take the first 100 ms. of processing to be early vision, high-level predictive signals reach down as low as this.

In conclusion, if we assume that, as PC suggests, when viewing a stimulus, bottom-up incoming signals and top-down descending signals emerge simultaneously, then at the very moment that the stimulus enters the retina, the brain is already forming predictive mental images to facilitate perception.[11] Since these predictive codes use sensory inputs and stored knowledge to form a sensory prediction trough their constant interaction, there will not be room for static and passive bottom-up processing. Indeed, the dynamic character of our mental life, interacting with the dynamic character of the world, means that priors may drive or alter how a subsequent image is visually processed. After all, if we are immersed in a changing world with a changing mind, it is conceivable that our perceptual states are the product of a variable rate of previous belief and incoming sensory inputs. Simply put, mostly (though perhaps not exclusively) unconsciously, we predict the incoming sensory stimuli in order to make sense of the spatio-temporal sequentiality of the environment. In the same way, we consistently predict the next causal link in a sequence of events in, for ex-

[11] As expected, if bottom-up and top-down signals start their respective paths at the same time, at some intermediate point in the hierarchy the signals must encounter one another. The encounter of the ascendant and descendant signals produces the prediction error minimization and perhaps originates the conscious experience through the interaction between stimulus-driven and cognitive-driven attention (although this last point is highly speculative). The key point is that bottom-up signals never work alone (for a similar view see Clark, 2019).

ample, the trajectory of moving objects, the behaviour of people in certain circumstances, or whatever.[12]

Of course, careful consideration of how to interpret the PC framework in the CP debate is needed (see MacPherson, 2017). However, given the initial evidence and the fact that the model is supported by a number of well-conducted studies, it is sensible to predict that CP occurs even at the earliest levels of perceptual processing. The core idea is that CP is a form of prediction and prediction is a form of CP, that prediction permeates the entire visual hierarchy, influencing all levels of processing, thus suggesting that the *all-levels claim* proposed by CPs is the most suitable account.

5. *From predictive coding to the pervasive claim*

What about the pervasive claim? By admitting the all-levels claim, we are only admitting that CP may occur at any level of visual processing, but this is consistent with the idea that CP is a very rare and uncommon phenomenon. The pervasiveness of CP is undoubtedly what makes it really strong.[13] To account for the pervasiveness claim—that perception is always, and not rarely, determined by cognition—I resort to Hohwy (2017). Hohwy presents an account that ties top-down modulation to a variable learning rate in hierarchical Bayesian inference. The learning rate refers to the difference between the influence of prior knowledge (the prediction or the top-down processing) and the influence of current

12 Surprisingly, what this picture seems to suggest is that visual perception is a process in which visual imagination is involved to some extent. This is because both perception and imagination share the endogenous top-down generation of their own sensory input. Perception and imagination are therefore not separate processes— perceivers are imaginers too (for discussion see Kirchhoff, 2018). Perceiving is then understood as an inferred fantasy about what lies behind the veil of input (Paton *et al.,* 2013, 222), or as a process of controlled hallucination (Clark 2013, 25).

13 It should be noted that hidden in the idea of the pervasiveness of CP there is incrusted a potential dissolution of the perception/cognition boundary. In effect, this point is currently under pressure (for review see Phillips, 2019), and it could certainly be an inevitable consequence of the pervasive claim. After all, if perception is always determined by cognition, it is hard to find the point where perception ends and cognition begins. Let us consider three options of drawing such a distinction. First, there is a clear and sharp distinction between perception and cognition (monism). Second, there are multiple and blurry ways to distinguish perception and cognition (pluralism). And third, there is no distinction at all (eliminativism). PC, by its very nature, rejects the monist position but it is compatible with pluralism or eliminativism. CP, on the other hand, requires a minimal perception/cognition distinction, that is, rejects eliminativism but it is compatible with monism and pluralism. The point at issue here is, then, that monism is incompatible with PC, and eliminativism is incompatible with CP, so that only some kind of pluralism may be compatible with both. In consequence, for PC being compatible with CP we should consider a non-fixed distinction between perception and cognition, an idea compatible with a continuum along which lies more or less cognitive and more or less perceptual states (Newen and Vetter, 2017). Only in this case is CP intelligible and able to connect to PC. So, the position to be considered is, perforce, that of pluralism. My suggestion is then that PC, as a scientifically based theory, can be related to CP only if we are pluralists with respect to the perception/cognition distinction—to be more precise, with the idea that perception and cognition lie on a continuum along which there can be more or less cognitive and more or less perceptual states.

sensory input (the prediction error or the bottom-up processing) in perceptual processing. CP is in this case conceived in terms of prediction error minimization deviations from this rate. What emerges here is a picture in which CP is determined by the learning rate. The lower the learning rate, the more top-down modulation and the more prevalent the cognitive influence on perception (high CP). And conversely, the higher the learning rate, the less influence of top-down beliefs (the more certain that the prior hypothesis is correct) and therefore the less prevalence of the cognitive influence on perception (low CP). So, assuming that to perceptually construct the world we need to infer the causes of sensory inputs, and considering that the construction of such perceptual inference is continually regulated by a variable rate of uncertainty, it follows that top-down modulation of perception by prior belief is inevitable (Hohwy, 2017, p. 84).[14] CP is therefore ubiquitous, although the extent in which perception is modulated by prior beliefs is, of course, variable. The more uncertainty, the more inaccurate the bottom-up prediction error, the greater top-down modulation, and the more prominent the influence of cognition on perception. In contrast, the less uncertainty, the more accurate the bottom-up prediction error, and therefore, the less top-down modulation and less prominent the influence of cognition on perception. It is then to be expected that such uncertainty (whether high or low) is solved by high-cognitive processes, and the most important, as our predictions are done according to Bayesian inferences, there should always be a minimum of uncertainty, and therefore, there should always be some kind of cognitive process exerting influence on perception.

The argument for the pervasiveness of CP relies, therefore, on the truth of the following assumptions:

(1) there is always some uncertainty about the world in sensory input.
(2) such perceptual uncertainty needs to be minimized in order to make sense the world.
(3) such a minimization is mediated and modulated by top-down predictions.
(4) such mediation and modulation count as relevant CP.

Hardly anyone denies (1) and (2), these assumptions are relatively unproblematic. That sensory information alone underdetermines perceptual integrations, and such underdetermination requires the contribution of further information to perceptual integrations is here assumed (although see Orlandi, 2015). However, (3) and (4) are far from being commonly accepted. Whether perceptual uncertainty is widespread and mediated by top-down predictions (3) and whether the nature of these predictions is cognitive and consequently counts as relevant to CP (4), are of course the key questions.

There exists compelling neuroscientific evidence to accept (3). I have assumed that PC reveals an essential part of the perceptual mind functioning, basically that the mere bottom-up information is insufficient to make sense the world. This is indeed corroborated by neuroscientific research, which reveals that all areas of the visual pathway, except for the retina, are subject to top-down influences, and most importantly, also reveals that these

[14] This is related to the idea that perceptual inference is the process by which incoming sensory data is assimilated into a prior model of the world, which ultimately means that no level of neuronal processing hierarchies can be a priori excluded from the perceptual process (see Kiefer, 2017). I thank an anonymous reviewer for bringing this point.

top-down influences constitute a necessary step to visually perceive the world. The predictions elicited from high-level information to lower-level activity becomes relevant to consummate the functional properties of these areas (Gilbert and Li, 2013).[15] Therefore, premise (3), that the minimization of perceptual uncertainty is modulated by top-down predictions, is neuroscientifically supported.

Assessing the truth of (4) is more complicated. By accepting (3) we are admitting not only that top-down predictions occur, but also that they are pervasive, yet are these predictions really cognitive in nature? After all, predictions are high in relation to early vision, but are enough high to count as cognitive? Of course, everything depends on what we understand by cognition, or better, on whether the notion of cognition considered by CP and PC are equivalent. At this point, one can consider a strong and a weak sense of cognition. The strong sense refers only to doxastic states, that is, propositional attitudes like beliefs or desires that are accessible to consciousness and inferentially integrated, the weak notion refers also to non-doxastic states like moods, emotions, types of personality, cognitive styles, education, learning or expectations, which are in principle non-accessible to subject's consciousness. I do not see any particular obstacles in accommodating predictions to both the strong and the weak sense. Simply stated, if PC is on the right track, the prediction will sit variably high in the hierarchy depending on the uncertainty or ambiguity of stimuli. For example, the belief that my friend is upset with me can make me perceive my friend's facial features as particularly irritated, or the desire to see shooting stars can cause motion in static stars. These are cases where belief and desire (strong cognition) modulate perception. One can argue that cases where uncertainty is solved by high-level beliefs are perhaps scarce, in normal situations we perceptually reconstruct the world without the need of employing high-level beliefs (in the doxastic sense). If we take the weak sense of cognition, however, cases are not so scarce, moods, emotions, types of personality, cognitive styles, education, learning, or expectations, mostly unconscious, commonly influence perception. For example, when tracking a particular face in a crowded classroom, the expectation that the next stimulus is a face will be strengthened (we will tend to see a noisy non-face stimulus as a face), or a negative emotional state (e.g. sadness or fear) may also influence our perceptual experience (e.g. perceiving hills to be steeper or colors as darker), or types of personality, cognitive styles and moods can make us perceive stimuli in more vividly, clearly, oriented in different ways or even sized, shaped and colored differently in different circumstances or different situations. The critic may object that in the weak sense the prediction is not high-level enough to capture the essence of CP, but a cognitive state need not be accessible to consciousness and inferentially integrated to be considered a cognitive state, and many alleged cases of CP do not adhere to such a strong restriction. So, if we take the idea that cognition is not exhausted by propositional attitudes (some non-propositional mental states also count as cognition) and that the influence of these states on perceptual states produces epistemological consequences for subjects, then these non-propositional mental constituents would be compelling cases of CP.

[15] Importantly, Gilbert and Li (2013) do not limit top-down influences to attention, usually excluded by strong impenetrability supporters as a real top-down effect on perception, but to a much broader range of functional roles, including perceptual task, object expectation, scene segmentation, efference copy, working memory, and the encoding and recall of learned information.

Finally, the philosophical relevance of CP when the uncertainty is solved with too low top-down modulation (when the prediction error is maximized) becomes the pertinent issue. Whether this kind of CP always describes a phenomenon that has implications for the theory-ladenness of perceptual observation, or for the epistemic role of perception, or for modular theories of mental architecture, becomes an empirical issue that, I think, is worth considering in future research.

6. Concluding remarks

In this paper, I have argued that the perceptual states of a subject are *always* influenced, affected or caused, by cognitive factors as expectations, memories, thoughts, goals and so on, *at all levels* of perceptual processing—the strong claim of CP (CPs). CPs is sustained by two claims, the first is that CP occurs at all levels of perceptual processing (the all-levels claim), and the second that this influence occurs widespread (the pervasiveness claim). I have not discussed the CP of *all* the processes that make up our perceptual experience because I think that empirical evidence has amply demonstrated that in the construction of perceptual experiences cognitive processes are necessary. This ultimately means that *at the experiential level* a sharp boundary between perception and cognition is unsustainable. What it is currently at the core of the debate is, instead, the influence of cognitive states over early visual processes. I have argued that working within the constraints of the predictive coding theory of brain function, the two claims derived from CPs are to be expected.

To account for the all-levels claim I have considered two definitions of early vision, the functional and the temporal definitions. Regarding the functional definition, I have provided evidence suggesting that predictive feedbacks directly modulate the typical functional (psychophysical) properties represented during early vision. Regarding the temporal definition, I have argued that from the point of view of PC, the temporal criterion to sustain the cognitive impenetrability of early vision does not make sense, since bottom-up and top-down signals could begin their respective paths, at least, simultaneously. I have also reviewed empirical evidence suggesting that predictions are elicited within the first 100ms. from stimulus onset, thus showing that even the initial states of perceptual processing are influenced by cognitive factors. In sum, the all-levels claim is asserted.

To account for the pervasive claim, I have first assumed that sensory inputs always have some doses of uncertainty that must be minimized in order to make sense of the world. Subsequently, from neuroscientific research, I have shown that such minimization must be mediated and modulated by top-down predictions—top-down descending pathways are ubiquitous in the brain. Finally, I have argued that such predictions are cognitive in nature. Consequently, in the construction of perceptual experiences a minimal cognitive influence there should constantly be present. The pervasive claim is, therefore, sustained.

Thus, the sum of the evidence from psychological, neurological and behavioural empirical data in addition to the fact that it fits perfectly with PC accounts of perception, suggests that CPs is the most plausible account.

Acknowledgements

Versions of this material were presented in a Seminary in the Autonomous University of Barcelona. I would like to thank those in attendance for their critical feedback, as well as to Olga Fernandez Prat for her useful comments and advise. I would also like to thank two anonymous referees for this journal, for their helpful comments on an earlier draft.

REFERENCES

Apps, M. A. J., & Tsakiris, M. (2014). The free-energy self: A predictive coding account of self-recognition. *Neuroscience and Biobehavioral Reviews, 41*, 85-97. https://doi.org/10.1016/j.neubiorev.2013.01.029

Balcetis, E. & Dunning, D. (2010). Wishful seeing: More desired objects are seen as closer. *Psychological Science*, 21, 147-52. https://doi.org/10.1177/0956797609356283

Bannert, M. M., & Bartels, A. (2013). Decoding the yellow of a gray banana. *Current Biology, 23*(22), 2268-2272. https://doi.org/10.1016/j.cub.2013.09.016

Cecchi, A. (2018). Cognitive penetration of early vision in face perception. *Consciousness and Cognition*, 63, 254-266. https://doi.org/10.1016/j.concog.2018.06.005

Cermeño-Ainsa, S. (2020). The cognitive penetrability of perception: A blocked debate and a tentative solution. *Consciousness and Cognition,* 77, 102838. https://doi.org/10.1016/j.concog.2019.102838

Clark, A. (2013). Whatever next? Predictive brains, situated agents, and the future of cognitive science. *Behavioural and Brain Sciences*, 36(3), 181-204. https://doi.org/10.1017/S0140525X12000477

Clark, A. (2019). Consciousness as generative entanglement. *The Journal of Philosophy*, 116, 645-662. https://doi.org/10.5840/jphil20191161241

Corlett, P. R., Honey, G. D., & Fletcher, P. C. (2016). Prediction error, ketamine and psychosis: An updated model. *Journal of Psychopharmacology, 30*(11), 1145-1155. https://doi.org/10.1177/0269881116650087

Cruys, S.V., & Wagemans, J. (2011). Putting reward in art: A tentative prediction error account of visual art. *i-Perception, 2*, 1035-1062. https://doi.org/10.1068/i0466aap

Cruys, S.V., Friston, K. & Clark, A. (2020). Controlled optimism: Reply to Sun and Firestone on the dark room problem. *Trends in Cognitive Science,* 24, 680-681. https://doi.org/10.1016/j.tics.2020.05.012

De Meyer, K. & Spratling, M. W. (2011). Multiplicative gain modulation arises through unsupervised learning in a predictive coding model of cortical function. *Neural Computation*, 23(6), 1536-67. https://doi.org/10.1162/NECO_a_00130

De Meyer, K. & Spratling, M. W. (2013). A model of partial reference frame transforms through pooling of gain-modulated responses. *Cerebral Cortex,* 23(5), 1230-9. https://doi.org/10.1093/cercor/bhs117

Drewes, J., Goren, G., Zhu, W., & Elder, J. H. (2016). Recurrent processing in the formation of shape percepts. *Journal of Neuroscience*, 36(1), 185-192. https://doi.org/10.1523/JNEUROSCI.2347-15.2016

Feldman, H., & Friston, K. J. (2010). Attention, uncertainty, and free-energy. *Frontiers in Human Neuroscience, 4,* 215. https://doi.org/10.3389/fnhum.2010.00215

Firestone, C. & Scholl, B. J. (2016). Cognition does not affect perception: Evaluating the evidence for 'top-down' effects. *Behavioural and Brain Sciences*, 39, 1-77. https://doi.org/10.1017/S0140525X15000965

Fletcher, P. C., & Frith, C. D. (2009). Perceiving is believing: A Bayesian approach to explaining the positive symptoms of schizophrenia. *Nature Reviews Neuroscience,* 10, 48-58. https://doi.org/10.1038/nrn2536

Friston, K. J. (2010). The free-energy principle: A unified brain theory? *Nature Reviews Neuroscience* 11(2), 127-38. https://doi.org/10.1038/nrn2787

Friston, K., Thornton, C., & Clark, A. (2012). Free-energy minimization and the dark-room problem. *Frontiers in Psychology,* 3, 130. https://doi.org/10.3389/fpsyg.2012.00130

Gamond, L., George, N., Lemarechal, J.D. *et al.* (2011). Early influence of prior experience on face perception. *Neuroimage*, 54, 1415-26. https://doi.org/10.1016/j.neuroimage.2010.08.081
Gardner, M. P. H., & Fontanini, A. (2014). Encoding and tracking of outcome-specific expectancy in the gustatory cortex of alert rats. *Journal of Neuroscience, 34*(39), 13000-13017. https://doi.org/10.1523/JNEUROSCI.1820-14.2014
Gilbert, C. D., & Li, W. (2013). Top-down influences on visual processing. *Nature Reviews Neuroscience, 14*, 350-363. https://doi.org/10.1038/nrn3476
Han, B., & VanRullen, R. (2016). Shape perception enhances perceived contrast: evidence for excitatory predictive feedback? *Scientific reports*, 6, 22944. https://doi.org/10.1038/srep22944ç
Hohwy, J. (2013). *The predictive mind*. Oxford: Oxford University Press.
Hohwy, J. (2017). Priors in perception: Top-down modulation, Bayesian perceptual learning rate, and prediction error minimization. *Consciousness and Cognition*, 47, 75-85. https://doi.org/10.1016/j.concog.2016.09.004
Hohwy, J., Roepstorff, A. & Friston, K. (2008). Predictive coding explains binocular rivalry: An epistemological review. *Cognition*, 108(3), 687-701. https://doi.org/10.1016/j.cognition.2008.05.010
Howard, J. D., Gottfried, J. A., Tobler, P. N., & Kahnt, T. (2015). Identity-specific coding of future rewards in the human orbitofrontal cortex. *Proceedings of the National Academy of Sciences, 112*(16), 5195-5200. https://doi.org/10.1073/pnas.1503550112
Jehee, J. F. M. & Ballard, D. H. (2009). Predictive feedback can account for biphasic responses in the lateral geniculate nucleus. *PLoS Computational Biology* 5(5), e1000373. https://doi.org/10.1371/journal.pcbi.1000373
Kiefer, A. (2017). Literal Perceptual Inference. In T. Metzinger & W. Wiese (Eds.). *Philosophy and Predictive Processing,* 17. Frankfurt am Main: MIND Group. https://doi.org/10.15502/9783958573185
Kilner, J. M., Friston, K. J., & Frith, C. D. (2007). Predictive coding: An account of the mirror neuron system. *Cognitive Processing,* 8(3), 159-166. https://doi.org/10.1007/s10339-007-0170-2
Kirchhoff, M.D. (2018). Predictive processing, perceiving and imagining: Is to perceive to imagine, or something close to it? *Philosophical Studies*, 175(3), 751-767. https://doi.org/10.1007/s11098-017-0891-8
Kok, P., & de Lange, F.P. (2014). Shape perception simultaneously up- and downregulates neural activity in the primary visual cortex. *Current Biology,* 24(13), 1531-1535. https://doi.org/10.1016/j.cub.2014.05.042
Kosslyn, S., W. Thompson, & Ganis, G. (2006). *The case for mental imagery*. Oxford: Oxford University Press.
Koster-Hale, J., & Saxe, R. (2013). Theory of mind: A neural prediction problem. *Neuron, 79*(5), 836-848. https://doi.org/10.1016/j.neuron.2013.08.020
Lalanne, L., van Assche, M., & Giersch, A. (2010). When predictive mechanisms go wrong: Disordered visual synchrony thresholds in schizophrenia. *Schizophrenia Bulletin, 38*(3), 506-513. https://doi.org/10.1093/schbul/sbq107
Lee, H., & Kim, J. (2017). Facilitating effects of emotion on the perception of biological motion: Evidence for a happiness superiority effect. *Perception*, 46(6), 679-697. https://doi.org/10.1177/0301006616681809
Lee, T.S., & Mumford, D. (2003). Hierarchical Bayesian inference in the visual cortex. *Journal of Optical Society of America*, 20(7), 1434-1448. https://doi.org/10.1364/JOSAA.20.001434
Levin, D., & Banaji, M. (2006). Distortions in the perceived lightness of faces: The role of race categories. *Journal of Experimental Psychology, 135*, 501-512. https://doi.org/10.1037/0096-3445.135.4.501
Ling, S., Pratte, M.S., & Tong, F. (2015). Attention alters orientation processing in the human lateral geniculate nucleus. *Nature Neuroscience*, 18, 496-498. https://doi.org/10.1038/nn.3967
Lupyan, G. (2015). Cognitive penetrability of perception in the age of prediction: Predictive systems are penetrable systems. *Review of Philosophy and Psychology, 6*, 547-569. https://doi.org/10.1007/s13164-015-0253-4

Lupyan, G., & Clark, A. (2015). Words and the world: Predictive coding and the language-perception-cognition interface. *Current Directions in Psychological Science, 24*(4), 279-284. https://doi.org/10.1177/0963721415570732

Macpherson, F. (2012). Cognitive penetration of colour experience: Rethinking the issue in light of an indirect mechanism. *Philosophy and Phenomenological Research*, 84(1), 24-62. https://doi.org/10.1111/j.1933-1592.2010.00481.x

Macpherson, F. (2015). Cognitive penetration and predictive coding: A commentary on Lupyan. *Review of Philosophy and Psychology*, 6(4), 571-584. https://doi.org/10.1007/s13164-015-0254-3

Macpherson, F. (2017). The relationship between cognitive penetration and predictive coding. *Consciousness and Cognition*, 47: 6-16. https://doi.org/10.1016/j.concog.2016.04.001

Masrour, F., Nirshberg, G., Schon, M., Leardi, J. & Barrett, E. (2015). Revisiting the empirical case against perceptual modularity. *Frontiers in Psychology*, 6, 1676. https://doi.org/10.3389/fpsyg.2015.01676

Morishima, Y., Akaishi, R., Yamada, Y., Okuda, J., Toma, K., & Sakai, K. (2009). Task-specific signal transmission from prefrontal cortex in visual selective attention. *Nature Neuroscience*, 12(1), 85-91. https://doi.org/10.1038/nn.2237

Naeije, G., Vaulet, T., Wens, V., Marty, B., Goldman, S., & De Tiege, X. (2016). Multilevel cortical processing of somatosensory novelty: A magnetoencephalography study. *Frontiers in Human Neuroscience, 10*, 259. https://doi.org/10.3389/fnhum.2016.00259

Newen, A. & Vetter, P. (2017). Why cognitive penetration of our perceptual experience is still the most plausible account. *Consciousness and Cognition*, 47, 26-37. https://doi.org/10.1016/j.concog.2016.09.005

Nowak, L., & Bullier, J. (1997). The Timing of Information Transfer in the Visual System. In: Rockland K.S., Kaas J.H., Peters A. (eds.) Extrastriate Cortex in Primates. *Cerebral Cortex*, 12, (pp 205-241). Springer, Boston, MA. https://doi.org/10.1007/978-1-4757-9625-4_5

O'Callaghan, C., Kveraga, K., Shine, J. M., Adams, Jr. & Bar, M. (2017). Predictions penetrate perception: Converging insights from brain, behaviour and disorder. *Consciousness and Cognition*, 47, 63-74. https://doi.org/10.1016/j.concog.2016.05.003

Ogilvie, R., & Carruthers, P. (2016). Opening up vision: The Case against encapsulation. *Review of Philosophy and Psychology*, 7, 721-742. https://doi.org/10.1007/S13164-015-0294-8

Orlandi, N. (2016). Bayesian perception is ecological perception. *Philosophical Topics,* 44(2), 327-352. https://doi.org/10.5840/philtopics201644226

Panichello, M. F., Cheung, O. S. & Bar, M. (2013). Predictive feedback and conscious visual experience. *Frontiers in Psychology,* 3(620), 1-8. https://doi.org/10.3389/fpsyg.2012.00620

Paton, B., Skewes, J., Frith, C., & Hohwy, J. (2013). Skull-bound perception and precision optimization through culture. *The Behavioural and Brain Sciences*, 36(3), 42. https://doi.org/10.1017/S0140525X12002191

Pellicano, E., & Burr, D. (2012). When the world becomes 'too real': A Bayesian explanation of autistic perception. *Trends in Cognitive Sciences, 16*, 504-510. https://doi.org/10.1016/j.tics.2012.08.009

Phelps, E. A., Ling, S., & Carrasco, M. (2006). Emotion facilitates perception and potentiates the perceptual benefits of attention. *Psychological Science, 17*(4), 292-299. https://doi.org/10.1111/j.1467-9280.2006.01701.x

Phillips, B. (2019). The shifting border between perception and cognition. *Noûs*, 53(2), 316-346. https://doi.org/10.1111/nous.12218

Poltoratski, S., Ling, S., McCormack, D., & Tong, F. (2017). Characterizing the effects of feature salience and top-down attention in the early visual system. *Journal of Neurophysiology*, 118, 564-573. https://doi.org/10.1152/jn.00924.2016

Potter, M., Wyble, B., Hagmann, C., & McCourt, E. (2014). Detecting meaning in RSVP at 13 ms per picture. *Attention, Perception & Psychophysics*, 76(2), 270-279. https://doi.org/10.3758/s13414-013-0605-z

Pylyshyn, Z. W. (1999). Is vision continuous with cognition? The case for cognitive impenetrability of visual perception. *Behavioural and Brain Sciences*, 22, 341-423. https://doi.org/10.1017/S0140525X99002022

Pylyshyn, Z. W. (2003). *Seeing and visualizing: It's not what you think*. Cambridge, MA: MIT Press.

Raftopoulos, A. (2009). *Cognition and perception: How do psychology and neural sciences inform philosophy*? Cambridge, MA: MIT Press.

Raftopoulos, A. (2011). Late vision: Processes and epistemic status. *Frontiers in Psychology,* 2 (382), 1-12. https://doi.org/10.3389/fpsyg.2011.00382

Raftopoulos, A. (2014). The cognitive impenetrability of the content of early vision is a necessary and sufficient condition for purely nonconceptual content. *Philosophical Psychology,* 27(5), 601-620. https://doi.org/10.1080/09515089.2012.729486

Raftopoulos, A. (2017). Timing time: Why early vision is cognitively Impenetrable. *Proceedings of the 39th Annual Conference of the Cognitive Science Society, 26-29 July* (pp. 974-979). Austin, TX: Cognitive Science Society.

Rao, R. P. N. & Ballard, D. H. (1999). Predictive coding in the visual cortex: A functional interpretation of some extra-classical receptive-field effects. *Nature Neuroscience*, 2(1), 79-87. https://doi.org/10.1038/4580

Samaha, J., Boutonnet, B., & Lupyan, G. (2016). How prior knowledge prepares perception: Prestimulus oscillations carry perceptual expectations and influence early visual responses. bioRxiv. https://doi.org/10.1101/076687

Seth, A. K., Suzuki, K., & Critchley, H. D. (2011). An interoceptive predictive coding model of conscious presence. *Frontiers in Psychology, 2* (395). https://doi.org/10.3389/fpsyg.2011.00395

Seth, A. K. (2013). Interoceptive inference, emotion, and the embodied self. *Trends in Cognitive Sciences, 17*(11), 656-663. https://doi.org/10.1016/j.tics.2013.09.007

Shea, N. (2015). Distinguishing Top-Down from Bottom-Up Effects. In D. Stokes, M. Matthen & S. Biggs (Eds.), *Perception and its modalities* (pp. 73-91). Oxford: Oxford University Press. https://doi.org/10.1093/acprof:oso/9780199832798.003.0004

Siegel, S. (2012). Cognitive penetrability and perceptual justification. *Noûs*, 46(2), 1-22. https://doi.org/10.1111/j.1468-0068.2010.00786.x

Silvanto, J., Lavie, N., & Walsh, V. (2005). Double dissociation of V1 and V5/MT activity in visual awareness. *Cerebral Cortex,* 15, 1736-1741. https://doi.org/10.1093/cercor/bhi050

Silvanto, J., Lavie, N., & Walsh, V. (2006). Stimulation of the human frontal eye fields modulates sensitivity of extrastriate visual cortex. *Journal of Neurophysiology*, 96(2), 941-945. https://doi.org/10.1152/jn.00015.2006

Sims, A. (2017). The problems with prediction - The dark room problem and the scope dispute. In T. Metzinger & W. Wiese (Eds.). *Philosophy and Predictive Processing: 23*. Frankfurt am Main: MIND Group. https://doi.org/10.15502/9783958573246

Spratling, M. W. (2010). Predictive coding as a model of response properties in cortical area V1. *Journal of Neuroscience,* 30(9), 3531-543. https://doi.org/10.1523/JNEUROSCI.4911-09.2010

Spratling, M. W. (2011). A single functional model accounts for the distinct properties of suppression in cortical area V1. *Vision Research,* 51(6), 563-76. https://doi.org/10.1016/j.visres.2011.01.017

Spratling, M. W. (2012). Predictive coding accounts for V1 response properties recorded using reverse correlation. *Biological Cybernetics,* 106(1), 37-49. https://doi.org/10.1007/s00422-012-0477-7

Spratling, M. W. (2013). Image segmentation using as parse coding model of cortical area V1. *IEEE Transactions on Image Processing*, 22(4), 1631-43. https://doi.org/10.1109/TIP.2012.2235850

Spratling, M. W. (2014). A single functional model of drivers and modulators in cortex. *Journal of Computational Neuroscience,* 36(1), 97-118. https://doi.org/10.1007/s10827-013-0471-7

Stefanucci, J. K., Gagnon, K. T., Tompkins, C. L. & Bullock, K. E. (2012). Plunging into the pool of death: Imagining a dangerous outcome influences distance perception. *Perception,* 41, 1-11. https://doi.org/10.1068/p7131

Stokes, D. (2013). Cognitive penetrability of perception. *Philosophy Compass*, 8(7), 646-663. https://doi.org/10.1111/phc3.12043

Stokes, D. (2015). Towards a consequentialist understanding of cognitive penetration. In A. Raftopoulos and J. Ziembekis (Eds.), *Cognitive Effects on Perception: New Philosophical Perspectives* (pp. 75-100). Oxford: Oxford University Press.

Sun, Z. & Firestone, C. (2020). The dark room problem. *Trends in Cognitive Science,* 24, 346-348. https://doi.org/10.1016/j.tics.2020.02.006

Vance, J., & Stokes, D. (2017). Noise, uncertainty, and interest: Predictive coding and cognitive penetration. *Consciousness and Cognition, 47*, 86-98. https://doi.org/10.1016/j.concog.2016.06.007

Vetter, P., & Newen, A. (2014). Varieties of cognitive penetration in visual perception. *Consciousness and Cognition, 27*, 62-75. https://doi.org/10.1016/j.concog.2014.04.007

Vetter, P., Edwards, G., & Muckli, L. (2012). Transfer of predictive signals across saccades. *Frontiers in psychology*, 3, 176. https://doi.org/10.3389/fpsyg.2012.00176

Vetter, P., Grosbras, M. H., & Muckli, L. (2015). TMS over V5 disrupts motion prediction. *Cerebral Cortex*, 25(4), 1052-1059. https://doi.org/10.1093/cercor/bht297

Wacongne, C., Changeux, J. P. & Dehaene, S. (2012). A neuronal model of predictive coding accounting for the mismatch negativity. *Journal of Neuroscience* 32, 3665-78. https://doi.org/10.1523/JNEUROSCI.5003-11.2012

SERGIO CERMEÑO-AÍNSA is a doctoral student enrolled in the Cognitive Science and Language (CCiL) program at the Autonomous University of Barcelona. He specializes in foundations of cognitive science, philosophy of mind and epistemology, in particular, topics related to perception and its relation to cognition. He has published a paper ("The Cognitive penetrability of perception: A blocked debate and a tentative solution") in a top rank journal (*Consciousness and Cognition*), and he also has three papers under review in top-ranking journals. In addition to the cognitive penetrability of perception and the perception/cognition distinction, he is currently interested in the mechanisms behind the phenomenon of implicit bias.

ADDRESS: Escuela de Doctorado de la UAB. Programa de Doctorado en Ciencia Cognitiva y Lenguaje. Universidad Autónoma de Barcelona, 08193 Cerdanyola del Vallès, Barcelona. E-mail: elsergei@hotmail.com
ORCID: https://orcid.org/0000-0002-9598-8386

Review of Philosophy and Psychology
https://doi.org/10.1007/s13164-021-00558-1

Is Perception Stimulus-Dependent?

Sergio Cermeño-Aínsa[1]

Accepted: 4 May 2021/Published online: 31 May 2021

Abstract
The most natural way to distinguish perception from cognition is by considering perception as stimulus-dependent. Perception is tethered to the senses in a way that cognition is not. Beck *Australasian Journal of Philosophy* 96(2): 319-334 (2018) has recently argued in this direction. He develops this idea by accommodating two potential counterexamples to his account: hallucinations and demonstrative thoughts. In this paper, I examine this view. First, I detect two general problems with movement to accommodate these awkward cases. Subsequently, I place two very common mental phenomena under the prism of the stimulus-dependence criterion: amodal completion and visual categorization. The result is that the stimulus-dependent criterion is too restrictive, it leaves the notion of perception extremely cramped. I conclude that even the criterion of stimulus-dependence fails to mark a clearly defined border between perception and cognition.

1 Introduction

Theorists of mind have long been committed to the idea that differences between perception and cognition are differences of kind (Fodor 1983; Pylyshyn 1999; Firestone and Scholl 2016) —anyone can appreciate the difference between seeing objects and thinking about them. However, the idea that there is no clear distinction between perceptual states and cognitive states has sparked much discussion in recent years, for its consequences for foundational epistemologies and some well assented theoretical frameworks are profound (Lupyan 2015; Clark 2013). Indeed, there is no clear and consensual criterion to distinguish perception from cognition, no one has shown the specific point where one ends and the other begins, and yet various debates in philosophy and psychology presuppose that perception and cognition belong to separate categories. Debates on the cognitive penetrability of perception, the epistemological role of perception, the richness of perceptual content, or debates on the very

✉ Sergio Cermeño-Aínsa
elsergei@hotmail.com

1 Department of Philosophy, The Autonomous University of Barcelona, Edifici B, 08193 Bellatera, Barcelona, Spain

existence of non-conceptual content, largely assume that perception and cognition are different categories defining different mental phenomena. For this reason, the interest in marking the border, if any, between perception and cognition, has increased.

Efforts to mark such a border have followed different strategies. The representational strategy, for example, postulates that perception is distinguished from cognition because the former produces representations with non-conceptual content and iconic format, whereas the latter generates representations with conceptual content and discursive format (Carey 2009; Burge 2010, 2014; Block 2014, Block unpublished). The architectural strategy, on the other hand, proposes that perception is modular and informationally encapsulated, whereas cognition is not (Fodor 1983; Pylyshyn 1999; Raftopoulos 2009; Firestone and Scholl 2016; Mandelbaum 2018). These two strategies have, of course, detractors; the iconic and non-conceptual character of perceptual states has been deeply questioned (Quilty-Dunn 2016; Mandelbaum 2018), and its modular nature too (Churchland 1988; Prinz 2006). In this paper I am interested in a third strategy: the stimulus-dependence strategy. The stimulus-dependence strategy basically suggests that perception depends on sensory stimulation in a way that cognition does not. It seems, in fact, natural to claim that perception is stimulus-dependent; just as perceptual representations are, in order to exist, connected to objects in the world, cognitive representations are not.[1] This is the stimulus-dependence criterion outlined by Beck (2018), roughly, just as perception is constrained by its inputs, cognition is not. This proposal, however, rapidly invokes possible counterexamples: hallucinations, which seem to be non-stimulus-dependent perceptual states; and demonstrative thoughts, which seem to be stimulus-dependent cognitive states. Beck's paper is, in fact, an in-depth discussion of the nature of these two phenomena and their possible accommodation to the stimulus-dependence criterion.[2] In this paper, I examine this view and place the phenomena of amodal completion and visual categorization under the lens of the stimulus-dependence criterion. I demonstrate that, from this perspective, the notion of perception becomes exceedingly restricted.

This paper is structured as follows: Section 2 outlines the stimulus-dependence criterion (S-D) proposed by Beck to draw the perception/cognition border; Section 3 presents some general difficulties in taking S-D as an appropriate criterion; Section 4 analyses the nature (be it perceptual or cognitive) of the phenomenon of amodal completion placed under the lens of the S-D criterion; Section 4 does the same with visual categorization; Section 5 concludes that considering the analysis of sections 3 and 4, and the difficulties remarked in section 2, the S-D criterion is too restrictive —the remaining notion of perception becomes puzzling and theoretically uninteresting— thus raising questions about the need to draw such a border.

[1] This is not to state that cognition invariably operates free of the influence of external stimuli —cognition is, in fact, usually related to objects— what is stated is that perception, unlike cognition, is *fully* restricted to such a dependency on objects.

[2] Of course, these are not the only intriguing cases. When considering the stimulus-dependence criterion, other mental phenomena are also difficult to be classified as perceptual or cognitive: the perception of phantom limbs (Ramachandran and Hirstein 1998); some cases of perceptual learning without stimulus presentation (Shibata et al. 2011); or even the perception of time or the perception of pain, are potential cases of perception without stimulus. Emotional perception (Pessoa 2008) can be a potential case of cognition dependent on stimulus.

2 The Criterion of Stimulus-Dependence

Beck (2018) proposes an outstanding attempt to distinguish perception from cognition; perceptual states are distinguished from cognitive states by being stimulus-dependent, more specifically, for having the function of being fully stimulus-dependent.[3] If this story is on track, then we have strong reasons to divide the mind in at least two parts; on one side perception, a stimulus-driven process, and on the other, cognition, a non-stimulus-driven process. A direct and easy way to reject this view is by considering extreme cases. For example, when rubbing your eyes, you can perceptually experience flashlights, or when closing your eyes, you can still have a perceptual experience of darkness. These tricky cases are, however, of limited theoretical interest, so I will leave them aside and focus on the more common cases. For example, you cannot see apples or hear thunder if there are no apples or thunder to be seen and heard. It is in this sense that perception is considered stimulus-dependent. In an initial approximation, perceptual states are dependent on a causal link that derives from the distal stimulus (the actual physical stimulus) and is mediated by the proximal stimulus (what directly impinges on the perceiver sensory organs —in vision, for instance, the image that falls on the retina). This is an important distinction because the actual physical stimulus and the energy falling on a receptor surface do not necessarily coincide (e.g. perceptual illusions). There is, of course, a causal link between the distal stimulus and the perceptual state, but such a causal link requires the mediation, whether it be veridical or not, of the proximal stimulus. So, ultimately, the occurrence of a mental state is stimulus-dependent only in the case that it is causally sustained by present proximal stimulation (Beck 2018: 323).

To be appropriate as a mark of the perception/cognition boundary, Beck notes, the stimulus-dependence criterion should accommodate two problematic cases: hallucinations, where perception is independent of stimulus, and demonstrative thoughts, where cognition is dependent on the stimulus. His efforts are, then, focused on accommodating these disturbing cases to his account. He begins by offering a simple formulation:

> S-D SIMPLE: Ψ is perceptual if, necessarily, all veridical occurrences of Ψ are stimulus-dependent; otherwise, Ψ is cognitive (Beck 2018: 323).

The problem with this simple formulation is that hallucinations or perceptual illusions count as stimulus-independent since referring explicitly to veridical occurrences, non-veridical perceptions stay out of the formulation. Here is the first problem; by assuming that hallucinations and illusions are perceptual, how can they be accommodated in S-D simple? To solve this problem Beck first distinguishes between exogenous and endogenous hallucinations, while the first is a deviation of a proximal stimulation (there are stimuli but the perceptual experience is not under the causal control of such proximal stimuli) the second does not require proximal stimulation (everything occurs in the absence of sensory stimulation). The former case (as well as the case of perceptual illusions) only requires a slight modification in the formulation —removing the veridical value of the occurrences; the latter case, endogenous hallucinations, is more

[3] In the same vein, Philips (2019) elaborates the perception/cognition distinction on the notion of stimulus-control.

complicated to resolve. The complete absence of stimuli leaves Beck's account uncovered, so further elaboration is needed. One solution is to put forward evidence for the non-perceptual nature of these type of hallucinations, for example, one can argue that endogenous hallucinations are more similar to imagination than to genuine perception, since neither of the two is sustained by proximal stimulation. However, there are also reasons to think that at least some kind of endogenous hallucinations may be perceptual —endogenous hallucinations (as well as imaginations) are phenomenally and introspectively identical to perceptions. This makes it difficult to consider the real nature of endogenous hallucinations. However, Beck finds a way to account for endogenous hallucinations by elaborating a functional definition:

> S-D FUNCTION: Ψ is perceptual if, necessarily, all occurrences of Ψ have the function of being stimulus-dependent; otherwise, Ψ is cognitive (Beck 2018: 326).

In this new formulation, the veridical value of the mental occurrences is removed, thus allowing exogenous hallucinations and perceptual illusions to be accounted for. The concerns posed by endogenous hallucinations are resolved by introducing the functional definition. If the neural mechanism triggered by a given endogenous hallucination has the function of producing states that are stimulus-dependent, then such a hallucination is perceptual, otherwise it is cognitive. A further distinction is needed here: there should be endogenous imaginative hallucinations and endogenous perceptual hallucinations; while the former is stimulus-independent and non-perceptual, the latter is stimulus-dependent and accordingly perceptual. But, how can we distinguish one from the other? The answer, according to Beck, lies in neural mechanisms. If the hallucination is produced by neural mechanisms whose function is to generate stimulus-dependent outputs, then we are facing an endogenous perceptual hallucination, otherwise it is an endogenous imaginative hallucination. The former counts as perceptual, the latter as cognitive. Thus, what counts as perceptual or imaginative endogenous hallucination becomes, in the long run, an empirical question determined by the parts of the brain activated. In short, there may be no stimulus, but if endogenous hallucinations are *carried out in typically perceptual brain areas*, then they should still have the function of being stimulus-dependent and therefore will be perceptual. On the contrary, if endogenous hallucinations are *not carried out in typically perceptual brain areas,* then they do not have the function of being stimulus-dependent and in consequence will be cognitive. Beck reasons as follows:

> If we have reason to believe that a mechanism has the function of producing stimulus-dependent outputs, and we also have reason to believe that a mental state is the product of that mechanism, we will have reason to count that mental state as perceptual rather than as cognitive (Beck 2018: 327).

The core issue is that introducing the functional formulation, where perceptual states are distinguished from cognitive states by virtue of having the function of being stimulus-dependent, Beck claims to avoid endogenous hallucinations as a dangerous exception for his account. Simply, in the extent that a perceptual state has the function of representing the occurrences of the environment, the representation of deviant occurrences (exogenous hallucinations and illusions) or even the very absence of the occurrences (endogenous hallucinations) in the environment are, by the functional formulation, tolerated.

Things also get complicated when we look towards demonstrative thoughts. It is exactly the opposite case of hallucinations; here cognitive states depend on stimuli, and therefore stimulus-dependence criteria cannot be taken as a reliable distinction between perception and cognition. Here a further distinction must be also drawn. There are perceptually grounded demonstrative thoughts (PGDT) and mnemonically grounded demonstrative thoughts (MGDT). Only the former is relevant, since mnemonically grounded demonstrative thoughts do not rely on current perception and therefore cannot have the function of being stimulus-dependent —they fall within cognition. Perceptually grounded demonstrative thoughts are, by contrast, stimulus-dependent, and therefore a potential hindrance for S-D function.

Now, by delving into the constitution of perceptual demonstrative thoughts, one can easily see a demonstrative element, whose reference is determined by perception and therefore maintains the function of being stimulus-dependent, and a conceptual element (or attribute), which does not have the function of being stimulus-dependent. Perceptual demonstrative thoughts are therefore partially but not fully stimulus-dependent. So, the new formulation is as follows:

> S-D FULL: Ψ is perceptual if, necessarily, all occurrences of all elements of Ψ have the function of being stimulus-dependent; otherwise, Ψ is cognitive (Beck 2018: 331).

Beck deploys two reasons to argue for the non-perceptual nature of the attributive elements of PGDTs. The first is that conceptual attributives in PGDTs are not proximally constrained. To use Beck's example, when seeing a sandpiper, you can veridically entertain the PGDT, *That bird is spotted*, and this occurs even when you cannot perceive the distinctive pattern of dark spots on its breast. The second reason is that conceptual attributives in PGDTs are bounded only by one's conceptual repertoire. For example, when visually attending to a copy of The Brothers Karamazov, you can surely entertain the PGDT, *That book is an instance of an existential masterpiece*, but this is, beyond all doubt, a property that is far from being a perceptible property, but a property that is part of the subject's conceptual repertoire. These reasons, according to Beck, mark the difference between perception (fully stimulus-dependent) and PGDT (partially stimulus-dependent). By adding the clause *all elements* to the formulation, in principle, Beck eludes the problems raised by demonstrative thoughts, thus accommodating them into his account.

3 General Difficulties in Taking S-D Full as a Criterion to Demarcate Perception from Cognition

There are, however, controversial assumptions in conceding the variations introduced by Beck to the original formulation of S-D to accommodate hallucinations and demonstrative thoughts. First, to accommodate hallucinations, S-D function rests on neuroscientific evidence about perceptual brain mechanisms, and second, to accommodate demonstrative thoughts, S-D full assumes the object-independent theory of demonstrative thoughts.

On the one hand, in introducing the functional formulation, where perceptual states are distinguished from cognitive states by virtue of having the function of being stimulus-dependent, Beck claims to avoid endogenous hallucinations as a dangerous exception for his account. However, by taking the mechanism as the brain area carrying out a determined function, we are granting a narrow relation between the mechanism and its function. This would be, in principle, an acceptable statement, although this decrement in abstraction at the explanatory level —note that we have gone from perception to its function and from function to its neural mechanism— runs the risk of losing, or perhaps altering, the explanatory continuity. Imagine, however, that these concerns dissolve by appealing to explanatory bridges that successfully connect the more concrete with the more abstract levels (perhaps via some kind of successful reductionism). This being the case, taking a perceptual state (hallucinatory in this case) as a functional state and a functional state as a certain mechanism carried out by a neuronal state, entails that a certain perceptual state can be explicatively aligned with certain brain areas. Ultimately, following this line of reasoning forces us to focus on the brain —it appears that the whole argument will be, in the long run, upheld by appealing to neuronal mechanisms.

Therefore, for the functional formulation to make sense the S-D criterion must depend on, and go hand in hand with, differences in the stimulation of typically perceptual or typically cognitive brain areas. At this point, the S-D criterion has been transformed into a neurobiological criterion.[4] It is the same to state that perception is distinguished from cognition by being stimulus-dependent, as stating that they are distinguished by the neural mechanisms implicated for each one. If perception is distinguished from cognition by having the function of being stimulus-dependent, and the distinction between perceptual endogenous hallucinations (which count as perceptual and therefore are stimulus-dependent) and imagistic endogenous hallucinations (which count as cognitive and therefore are not stimulus-dependent) depends on the brain areas implicated, there is nothing to prevent us from thinking that the stimulus-dependence criterion is coextensive with neurological criteria.[5]

The following natural step cannot be other than examining the neural basis of hallucination: Can we neurobiologically distinguish perceptual endogenous hallucinations from imagistic endogenous hallucinations? Although the neural mechanisms that produce hallucinations and other psychotic symptoms remain, to a large degree, unclear, the most recent research provides very interesting results. Let me focus on one of the examples cited by Beck as a typical perceptual hallucination: the Charles Bonnet Syndrome. The peculiarity of this syndrome is that despite being caused by loss of vision due to eye diseases, with no clear pathology in the brain itself and no necessary impairment to mental health other than the hallucinations, it produces very complex and vivid hallucinations. Beck relies on Ffytche et al. (1998) study to argue

[4] At this point, however, one runs the risk of falling into a circular argument. After all, having the function of being stimulus-dependent is coextensive to the brain areas stimulated, and stimulating determined brain areas is coextensive to having the function of being stimulus-dependent.

[5] Note that this reasoning implies a sharp perception/cognition distinction in the brain. If, ultimately, we have to look at brain mechanisms to demarcate what counts as perception and what as cognition, then why not directly appeal to brain mechanisms to mark the perception/cognition distinction?

that the Charles Bonnet Syndrome is an instance of perceptual endogenous hallucination, since it is correlated with activity in areas of the visual cortex closely linked to mechanisms of visual perception (rather than to mechanisms of visual imagination), particularly, with cerebral activity in the ventral extrastriate visual cortex (Beck 2018: 329). Instead, recent studies on the Charles Bonnet Syndrome suggest different mechanisms. Reichert et al. (2013), for example, suggest a generative model to explain the syndrome (see also Powers III et al. 2016; Corlett et al. 2019). According to this model, the disorder is produced by an impairment or a disconnection in the balance of top-down predictive processing conveying prior expectations and more high-level learnt concepts, and bottom-up processing driven by sensory input. In these cases, the system is able to internally synthesise rich representations of image content, such as objects, even in the absence of (corresponding) sensory input. Simply, in hallucinations top-down influences tend to dominate visual processing and erroneous perceptions prevail in the face of contradictory sensory evidence (O'Callaghan et al. 2017: 68). Therefore, the content of complex hallucinations cannot be accounted for by only appealing to anatomical organisational properties of visual areas, but on distributed, high-dimensional, hierarchical representations that go beyond local visual features. In sum, the syndrome might arise when prior predictions exert an inordinate influence over perceptual inferences, thus creating percepts with no corresponding stimuli at all. The issue is that the very distinction between imagistic and perceptual endogenous hallucinations loses sense when we approach the neurological basis of hallucination presented.

On the other hand, the variation incorporated to the S-D function in order to accommodate perceptual demonstrative thoughts, that is, the appealing to the stimulus-dependence of *all* and not only a part of the elements of the mental state, is not without controversy either. Indeed, S-D full depends on the object-independent theory for demonstrative thoughts (Burge 2010), but we can consider the object-dependent theory of demonstrative thoughts (Evans 1982; McDowell 1984).[6] These theories are currently cause for discussion (see Crawford 2020). Let me consider them briefly.

Beck strongly relies on Burge's theory of perceptual demonstrative thoughts, according to which perceptual demonstrative thoughts have, like perceptual states, a demonstrative element that makes the object causally impinge on the thinker's sensory organs, but differs from perceptual states in the attributive element. Just as in perceptual states the attributive elements are typically perceptual, in perceptual demonstrative thoughts, the attributive elements are conceptual. This is key for Beck's account since it makes the difference between the relational state of the subject with the object conveyed during perception, whose content is purely perceptual, and perceptual demonstrative thought, whose content is a hybrid of perception and cognition. Accordingly, the conceptual nature of the attribution in demonstrative thoughts seems to be beyond the perceptual experience of the object itself. This is, in the long run, what allows him to solve the difficulties posited by perceptual demonstrative thoughts, classifying them as cognitive rather than perceptual.

In stark contrast to Burge's account, one can consider a theory of perceptual demonstrative thoughts in which the attributive elements, even though conceptual, fall

[6] These labels, object-independent theory of demonstrative thoughts and object-dependent theory of demonstrative thoughts, are due to Crawford (2020), and exemplify, I think pretty accurately, the two essential theories on perceptual demonstrative thoughts.

into the perceptual scope. Indeed, taking into account that in the absence of sensorial input there is no attribution at all, it is the presence of the input that specifies the whole content of the perceptual demonstrative thought. Evans (1982) and McDowell (1984) are two prominent examples of this view. As McDowell (1984), for example, puts it, '*contents* … are *de re*, in the sense that they depend on the existence of the relevant *res*' (p. 291). The idea is that, contrary to Burge, the attributives of a perceptual demonstrative thought enters into the specification of perceptual content. To take an example, young children (and perhaps even babies and animals) are perfectly capable of having perceptual demonstrative thoughts, but do not possess the capacity to conceptually attribute what such demonstrative thoughts bring to bear in their perceptual thinking.[7] This shows that the reference of demonstrative thoughts is not necessarily determined in a descriptive manner through conceptual material associated with the object, but by the very fact of the perceptual relation to it. What this kind of example seems to show is that the attribution of a perceptual demonstrative thought might be stimulus-dependent, which would leave the S-D full in Beck's account in a complicated situation.

To explore which of these theories is on the right track exceeds the aim of this paper, but arguably, for the S-D full criterion to demarcate perception from cognition, the theory at stake must be that of Burge —that is, that perceptual demonstrative thought must be, unlike pure perceptual states, composed of a perceptual demonstrative element and a conceptual attributive element, the latter being what marks the difference with pure perceptual states.

The general complications just discussed in establishing S-D full as a valid criterion for determining the border between perception and cognition are, of course, not definitive. A defender of S-D might insist on the correct accommodation of the awkward cases by embracing the plausibility of the modifications imposed to the original formulation. One can, indeed, accept both: appealing to neurological mechanisms to account for differentiating between perceptual and imagistic endogenous hallucinations, and appealing to the object independent theory for perceptual demonstrative thoughts. Let me, therefore, overlook these difficulties and assume that the variations imposed by the potential counterexamples (hallucinations and demonstrative thoughts) on the original formulation of S-D simple are appropriate. Suppose that S-D full is the final and suitable formulation of the perception/cognition distinction. With this assumption in hand, let me analyse the possible accommodation of other mental states that seem to be halfway between perception and cognition; in particular, amodal completion, which is prima facie perceptual yet stimulus-independent, and visual categorization, which is prima facie cognitive yet stimulus-dependent.

4 The Case of Amodal Completion

Amodal completion is the capacity to see objects as having occluded parts. For example, when we see a cat behind a picket fence, our perceptual system represents those parts of the cat that are occluded by the picket fence. Such a completion is part of

[7] Note that this discussion goes hand in hand with discussions on the conceptual/nonconceptual content of perceptual states. Just as Burge prominently defends the nonconceptual character of perception, McDowell supports a conceptualist view on perceptual content. Evans´ position is halfway between the two.

our ordinary perceptual experiences; in the real world, we constantly represent features of perceived objects occluded or sometimes hidden from us.[8] This is easily achieved; even with very limited information we are able to reconstruct an appropriate percept on what it is out there.[9] However, the mechanism by which this is achieved is a cause of discussion. Some researchers argue that we amodally perceive an object's occluded features by imaginatively projecting them into the relevant regions of visual egocentric space (Nanay 2010), others think that amodal completion is characterized by genuinely visual representations (Gibson 1972) and others that amodal completion is represented by means of beliefs inferred from the object's visible features as well as relevant background knowledge (Briscoe 2011).

These disputes are currently in vogue, but arguably, when we consider the varieties in which amodal completion is represented, the three possibilities have something to say (Briscoe 2011). For example, there can be situations in which we project a mental image of a perceived object's occluded features, (in the manner suggested by Nanay 2010), and these features are constrained by past experiences and beliefs recorded in subject's mental repertoire (Briscoe 2011). Consider for example Fig. 1. When an observer represents the hidden parts of the occluded animal (a horse facing to the right), the attributed features must be constrained by their past experiences and beliefs. Of course, if the observer has never seen a horse, they will have difficulties in attributing properties to the occluded part of the figure (Nanay 2010: 247), but if they have previously seen horses or have acquired enough knowledge as to recognize horses, then it is unlikely that the observer will represent the occluded part as hiding the front half of a cat, a bird or a person. Thus, the kind of completion illustrated in Fig. 1 (as well as the cat example above) should have an intuitively cognitive component.

But plausibly, there are also situations in which we form beliefs about a perceived object's occluded features directly based on the object's visible features and other collateral information, and this occurs without first projecting a mental image of its occluded features and without the need for any extra background knowledge triggered by the perceiver. Consider Fig. 2. We see a single, white surface partially occluded by a grey stripe. Our visual impression is not of four unrelated image regions on the same plane of depth, but of a grey stripe that appears to be closer in-depth, and hiding parts of a white surface that complete behind it. In this situation, the completion seems to be stimulus-driven and not depending on background knowledge or imagining processes.

Therefore, amodal completion is a multi-faceted phenomenon, on occasions explained by means of mental imagery and other cognitive processes, and on

[8] The same goes for the backside of any solid object—sometimes referred to as self-occlusion. We do not receive any sensory stimulation that would correspond to the backside of solid three-dimensional objects, but there seems to be perceptual processing of this missing information—in a way reminiscent of amodal completion (Nanay 2010).

[9] Of course, this ability is present in non-human brains alike. A predator completes the figure of the prey when it is partially occluded in the foliage. In addition, already 3.5- to 4.5-month-old infants are capable of amodal completion (de Wit et al. 2008).

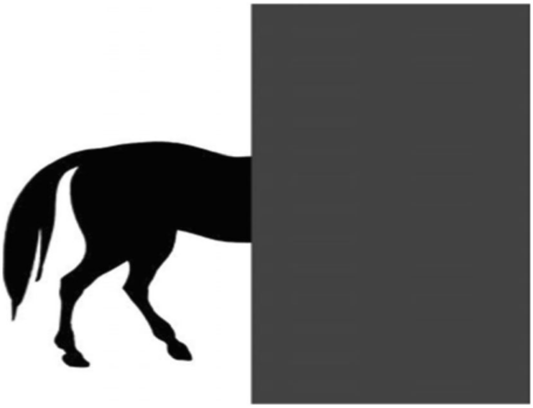

Fig. 1 Illustration of a cognitive-driven amodal completion

occasions explained by means of pure perceptual mechanisms. The former are cases where S-D simple formulation is not satisfied, since the completion is, at least in part, stimulus-independent, that is, are cases where completion is not fully stimulus-driven. However, they might satisfy the S-D function formulation. After all, we complete the right side of the horse because there is a visible part on the left side showing the back half of the horse. So, plausibly, this

Fig. 2 Illustration of a stimulus-driven amodal completion

completion potentially has the function of being stimulus-dependent.[10] The kind of completion achieved by genuinely visual representations is, prima facie, perception without proximal stimulation, and therefore a potential counterexample to Beck's account. The case of perceptual amodal completion is, in fact, parallel to the case of perceptual endogenous hallucinations —neither of them satisfy S-D simple (it is perception without proximal stimulation), though plausibly, they satisfy S-D function. Since satisfying S-D function requires considering the brain mechanisms involved in the completion of objects, Beck's account requires that the brain mechanisms deployed by cognitive amodal completion be different than the brain mechanisms deployed by genuinely perceptual amodal completion. It is worth assessing the current empirical evidence in order to unravel these concerns.

So, what are the differences between the brain mechanisms of cognitive and perceptual amodal completion? In an initial approximation, it is easy to see that completing Fig. 1 requires at least one extra mechanism than completing Fig. 2: one cannot adequately complete Fig. 1 if one has never seen a horse. The completion of Fig. 2, instead, does not require additional knowledge besides the picture itself. Shortly, while Fig. 1 involves the influences of previous recognition and categorization, Fig. 2 does not. This indicates that the brain mechanisms involved in imagistic (or cognitive) completion are different, or at least require further processing than the brain mechanisms involved in the mere perceptual completion. Indeed, current evidence points out that simple stimuli such as oriented bars squares, circles, crosses, or stars might restrict the neural representation only to low-level visual areas, whereas more natural scenes and actual objects such as tools, faces, or animals might recruit higher-order visual areas (for review see Thielen et al. 2019).

Recapitulating, if we apply the S-D simple formulation to all types of amodal completion, the result is that both cognitive (and imagistic) and perceptual amodal completion are not sustained by present proximal stimulation and therefore do not satisfy S-D simple. If we revisit S-D function and focus on brain mechanisms, the most recent empirical evidence suggests that cognitive amodal completion requires the recruitment of higher-level visual areas, whereas perceptive amodal completion is restricted to low-level visual areas. Thereby, whereas the former does not have the function of being stimulus-dependent, the latter does. So that, perceptual and cognitive amodal completion are instances of mental states without present proximal stimulation, but only the first has the function of being stimulus-dependent. Furthermore, if we take a look at S-D full, perceptual amodal completion clearly has the function of being *fully* stimulus-dependent (there is not a conceptual attributive in this sort of completion), while cognitive amodal completion requires the use of prior conceptual information, and therefore, it is only partially stimulus-dependent, so it does not satisfy S-D full.

Therefore, the verdict is that in a similar way to endogenous hallucinations and in consonance with Beck's account, the phenomenon of amodal completion has, depending on the stimuli, two faces: one perceptual, since even without proximal stimulation

[10] At this point the different cases of amodal completion work in a similar way than the different cases of endogenous hallucination, both can be invoked via cognitive processes or straightforwardly via perception. Does this mean that when completing occluded figures our brains employ the same mechanisms than when hallucinating them? Although I shall not explore this implication in-depth here, I think this is a very interesting direction.

the completion can have still the function of being fully stimulus-dependent; and the other cognitive, since without proximal stimulation the completion does not have the function of being fully stimulus-dependent. Now, the crucial point is to evaluate the prevalence of each one of these faces in our everyday perceptual lives. It can rapidly be argued that in the vast majority of everyday perceptual scenarios, stimuli are completed in a cognitive manner. Indeed, real perceptual experiences are not usually composed of oriented bars, squares, circles or crosses, but rather by more complex stimuli like tools, animals, faces or moving objects. That is, in natural conditions, it is very rare to amodally complete stimuli through only sensory stimulation-driven perception. This is important because taking the perceptual side of the amodal completion story as a residual and rare phenomenon only present in labs, in controlled situations and with deliberately designed stimuli, one is tempted to claim that the phenomenon of amodal completion is mostly cognitive, and therefore, according to Beck's logic, stimulus-independent. For the moment, I am only interested in the verdict —that amodal completion is mostly cognitive— later we will see the vast consequences of such a verdict. Let me now apply Beck's constraints to another very common mental phenomenon, sometimes labelled as cognitive and sometimes as perceptual: visual categorization.

5 The Case of Visual Categorization

Pictured objects and scenes can be understood in a brief glimpse, conceptual information is effortlessly available in the blink of an eye, almost instantaneously. Recent evidence shows that conceptual understanding can be reached when a novel picture is presented as briefly as 13 ms from stimulus onset (Potter et al. 2014). Whether visual identification falls on the perceptual or on the cognitive side of the story is a debated issue. Firestone and Scholl (2016), for example, argue that as far as object (or face) recognition necessarily involves the intervention of concepts stored in long-term memory, it should count as a genuine cognitive capacity. On the contrary, other researchers focus on other typical aspects of object recognition such as swiftness (Grill-Spector and Kanwisher 2005; Potter et al. 2014) or automaticity (Mandelbaum 2018) to include it as a typical perceptual capacity. The condition of visual categorization, whether it be perceptual or cognitive, is therefore an unsettling issue. Let me then apply the constraints of the stimulus-dependence criterion.

Considering the stimulus-dependence strategy to mark the perception/cognition border, visual categorization clearly satisfies S-D simple. Categorizing objects is causally sustained by proximal stimulation, one cannot visually categorize an object if the object is not visually present. Hence, as all veridical occurrences of visual categorization are stimulus-dependent, visual categorization satisfies S-D simple. Let me then examine whether visual categorization satisfies S-D function. Recall that according to Beck, in order to have the function of being stimulus-dependent, the *mechanisms* deployed by a mental state must be correlated with activity in areas of the cortex that are closely linked to mechanisms of perception. What are the brain mechanisms activated during visual categorization? Following the most recent neuroimaging studies, visual categorization is represented in a distributed fashion throughout the brain, and multiple neural systems are involved. The highest-level areas of the visual system, particularly the inferotemporal cortex, prefrontal cortex, parietal cortex, premotor and motor cortex, and other areas as the hippocampus, medial temporal lobe, basal ganglia, cortico-striatal loops, midbrain dopaminergic system, and the interactions between all these neural systems play a key role in the encoding of object categories and category learning (for reviews see Seger and Miller 2010; Freedman and Miller 2008). While some authors associate categorical discrimination (e.g. 'animate' vs 'inanimate') with the prefrontal cortex (Freedman et al. 2003), others suggest that features at the stage of the inferotemporal cortex are already optimized for category discrimination (Kriegeskorte et al. 2008). It seems then that whatever the decisive area for discriminating between categories, in principle there are not enough reasons to hold that visual object categorization can be achieved without the intervention of higher-level visual areas or even other non-visual brain areas. This suggests that the mechanisms of visual categorization are not correlated with activity in areas of the cortex closely linked to mechanisms of perception, since other non-perceptually grounded brain areas are involved. So, in principle visual categorization does not satisfy S-D function, and should therefore count, according to Beck's logic, as cognitive.

Nevertheless, there is a way of conceding that the brain mechanisms engaged during visual categorization are perceptually grounded. Let's imagine that visual categorization is achieved by the mere implication of parts of the cortex associated with visual processing. Indeed, decades of evidence suggest that even implicating different brain areas located in different brain lobes, the activity through the ventral visual stream (the "what pathway") is sufficient to recognize and categorize objects (Ungerleider and Mishkin 1982). Although visual categorization is most likely achieved during the last sections of the ventral stream —particularly the Inferotemporal Cortex, involved in recognizing complex object features (Tanaka 1996), and the Prefrontal Cortex, involved in linking perception to memory and action (Riley and Riley and Constantinidis 2016; Haller et al. 2018)— the functional mechanisms activated along the ventral pathway are sufficient for categorizing objects perceptually. Let us, therefore, carefully and reluctantly grant that the ventral pathway (from V1 to Prefrontal Cortex) is a perceptual mechanism that has the function of being stimulus-dependent. This being the case, visual categorization could satisfy S-D function and therefore count as perceptual.

What about S-D full? Does visual categorization have the function of being partially or fully stimulus-dependent? Recall that the disturbing case to accommodate in S-D function is the perceptually grounded demonstrative thoughts (PGDTs), thoughts with the schematic form "that X is p". Recall also that we have assumed Burge's account on PGDT's, to wit, that as in perception, PGDTs have a demonstrative element and an attributive element, in both, the demonstrative element counts as perceptual, but in PGDTs, unlike paradigmatic perception, the attributive element counts as cognitive. PGDTs are, therefore, partially stimulus-dependent and in consequence, do not count as perceptual but as cognitive (since they do not meet S-D full). Now, note that in visual categorization the schematic form is similar to PGDT, when objects are categorized, e.g. a flower, subjects plausibly take the schematic form "that X is p" ("that object is a flower"), where there is a demonstrative element "that X" and an attributive element "is p".

Recall now that Beck raises two reasons to argue for the non-perceptual nature of the attributive elements in PGDT. The first is that conceptual attributives in PGDT are not proximally constrained, the second that conceptual attributives in PGDTs are bound only by one's conceptual repertoire. These reasons, according to Beck, mark the difference between perception (fully stimulus-dependent) and perceptually grounded demonstrative thoughts (partially stimulus-dependent). The question is: Do the attributive elements of visual categorization count as perceptually or cognitively grounded? Let us apply the constraints. First, as in PGDT's, you can visually categorize objects veridically even when you cannot attribute some distinctive patterns of such object. For example, you can categorize a face as your friend face even without seeing the distinctive freckles of his face, and at the same time truly think: *That face is my friend's freckled face*. That is, as you can visually categorize objects without seeing all the distinctive properties of the object, then the attributive elements in visual categorization are not necessarily proximally constrained. The second constraint is also satisfied. When you visually categorize, for example, a soccer ball, you are not employing exclusively perceptual attributives (e.g. its roundness, its colour), but also conceptual attributives (this is a soccer ball and not a basketball or a tennis ball), that is, your conceptual repertoire also plays this game. As a matter of fact, the property of being a ball that is used to play soccer is not the kind of thing that one can visually perceive. So, by applying Beck's logic, one can conclude that, as in PGDT's, the attributive element of visual categorization is not proximally constrained. Thus, visual categorization has at most the function of being only partially stimulus-dependent and consequently, it counts as cognitive.[11]

At the beginning of this section, I have previously pointed out the exaggerated swiftness of visual categorization, we can recognize an object categorically as near as 13 ms from stimulus onset (Potter et al. 2014).[12] Indeed, using a rapid serial visual processing task (RSVP) Potter et al. (2014) presented participants with a series of visual images: the subjects' goal was to detect and categorize a specified target from the sequence of the rapidly presented images. They found that observers could determine the presence or absence of a specific picture even when the pictures in the sequence were presented for just 13 ms each. These results are usually taken to argue in favor of feedforward models in visual categorization, to wit, that an initial feedforward wave of

[11] One can ask for the differences, if any, between visual categorization and PGDT's, after all, both are schematically similar and both are cognitively rather than perceptually grounded. In my view, the difference is one of degree, while visual categorization is limited to a basic conceptual repertoire, PGDT's are bounded by a wider conceptual repertoire. Beck's example perfectly illustrates the difference. You can entertain the PGDT, *That book is an instance of an existential masterpiece*, but this is far from being a simple visual categorization, at most, you can perceptually categorize a book as *That book* or simply as *A book*. It might simply count as a very basic, perhaps the simplest conceptual attributive, or as the immediate conceptualization of a perceptual attributive (Burge 2010). All that matters to us is, that the concept book also floats free from perception, that is, it is not a perceptual attributive.

[12] Importantly, this time window is evaluated using rapid serial visual presentation (RSVP) of a series of pictures. Pictures are presented in intervals of 13 ms and subjects are subsequently asked if they recognize the target pictures; if subjects are able to categorize them, then 13 ms is enough to complete object categorization. Other studies operate differently, unlike RSVP, subjects are presented with pictures, and they have to respond immediately when the picture is perceived. Of course, by including the decision-theoretic and motoric elements (that is, the overall response) the times are longer, but certainly do not rigorously capture the accurate time consumed by perceptual processing and categorization (see Mandelbaum 2018: 275). It is also important to note that 13 ms is the quickest refresh rate that (in Potter et al. study) experimenters screen could display, thus opening the possibility of even shorter times to categorize objects (see Mandelbaum 2018: footnote 11).

neural activity through the ventral stream is sufficient to allow identification of a complex visual stimulus. And most importantly, this evidence also suggests that perception outputs conceptualized representations in form of basic-level categories, or in other words, that the connection between the object and the belonging category, must be carried out during perception properly (Mandelbaum 2018).

There is, however, another possible interpretation of this evidence. We can argue that conceptualization is a genuine cognitive process by holding that perception is the process developed during this reduced space of time (the first 13 ms). This being the case, perception becomes a very narrow process, but perhaps still significant. Indeed, at this point, the speed of the visual system should not surprise us; if instead of the speed of processing we attend to what it is processed during this short period of time (the representation of shape, colour, and so on), it is reasonable to think that what occurs before conceptualization enters into play is what has the function of being fully stimulus-dependent, and therefore it is what counts as genuine perception. Summing up, S-D full demands that perception is a pre-conceptualized representation, since conceptual attributives, the kind of attributives present in PGDT and visual categorization, do not have the function of being fully stimulus-dependent, and therefore counts as cognitive.

Thus far, the only option left to Beck's account is that perception is what it is registered pre-conceptually, that is, the intrinsic properties of perceptual experiences processed during the early levels of visual processing (again, the processing of shape, colour, size, texture, brightness or motion). But even this is at odds with current research on visual categorization. Let us look at what the most recent evidence shows in a little more detail. Studies of temporal dynamics have found overlapping signatures of low- mid- and high-level visual representations (Groen et al. 2013; Harel et al. 2016), thus suggesting co-occurring and co-localized visual and categorical processing (Ramkumar et al. 2016). Such evidence questions the classical hierarchical model and the utility of the very distinction between levels of properties (Groen et al. 2017). For example, Ramkumar et al. (2016) studied the temporal relationship between visual information representation and rapid-scene categorization. They used confusion matrices (matrix whose entry represents the fraction of trials for categorization errors) to track the pattern of errors produced by visual representation or by other processes that lead to categorical choice. They found that the very same regions that represented low-level features could also explain unique variance in neural confusions that were directly related to behavioural confusions. Crucially, both visual and behavioural confusions predicted neural confusions nearly simultaneously, thus suggesting a temporal overlap in the encoding of visual features and processing that influences behavioural choice (see also Dima et al. 2018). Something similar occurs with mid-level representations. Some studies suggest that object recognition can co-occur or even occur before figure-ground organization (Peterson 1994; Grill-Spector and Kanwisher 2005), others, even show that visual categorization based directly on low-level features, without grouping or segmentation stages, can benefit object localization and identification (Torralba and Oliva 2003) and others even suggest that visual category responsive regions are not purely driven by low-level visual features but also by the high-level perceptual stimulus interpretation (Schindler and Bartels 2016). Critically, this evidence shows that the representation of low-level visual features, mid-level segmentation and processing that informs categorical information is not sequential, but co-occur at the same time and within the same cortical networks. Significantly, this evidence is consistent with Potter et al.'s (Potter et al. 2014) results, and at odds with the idea that perception is an unconceptualized process. What remains to be clarified are the low-level contributions needed to ascribe meaning to scenes, but, as a matter of fact, the co-occurrence of these levels makes it hard to draw a limpid line between the non-conceptualized and conceptualized parts of visual processing.

The core of the above discussion was to analyse the nature, whether it be perceptual or cognitive, of visual categorization as seen through the prism of S-D criterion. Now we have a prognosis. Visual categorization does not fulfil S-D full criterion for two reasons. Firstly, because in order to have the function of being stimulus-dependent, the mechanisms deployed by a mental state must be correlated with activity in areas of the cortex closely linked to mechanisms of perception, and this does not seem to be the case for visual categorization. Though, with many qualms, I have conceded that visual categorization may be achieved by the mere implication of parts of the cortex associated with visual processing, thus escaping from the functional constraint. The second reason is, nevertheless, insurmountable. Visual categorization has, at most, the function of being only partially stimulus dependent; the demonstrative element has the function of being causally sustained by present proximal stimulation, but the attributive element does not.

Finally, if visual categorization is a cognitive process that can be reached as close as 13 ms from stimulus onset, then Beck's account requires that perception is what is registered pre-conceptually. This being the case, we have a problem with the scope of the purely perceptual side of the story, since perception becomes a very narrow mental process. Furthermore, recent evidence suggests that the representation of low-level visual features, mid-level segmentation and processing that informs categorical information is not sequential, but co-occurs at the same time and within the same cortical networks. Definitely, these arguments run against the S-D criterion to mark the perception/cognition border, since, at least based on evidence on visual categorization, the purely perceptual part of the process is difficult to address.

6 The Final Verdict: By Way of Conclusion

After submitting both hallucinations and demonstrative thoughts to S-D full scrutiny, Beck concludes that only perceptual endogenous hallucinations are purely perceptual states —imagistic endogenous hallucinations and perceptually grounded demonstrative thoughts fall on the side of cognition. When extending the S-D full restrictions to cases like amodal completion and visual categorization, it follows that only some rare cases of amodal completion (perceptual amodal completion) are, in principle, typically perceptual states, the other more common and naturalistic cases of amodal completion and cases of visual categorization fall on the side of cognition. Furthermore, in my discussion on visual categorization, I have put forward some studies which show that pre-conceptualized representations show overlapping signatures with conceptualized ones, that is, the representation of low-level visual features, mid-level segmentation and categorical information is not sequential, but co-occurs at the same time and within the same cortical networks. The question now is: if these arguments are on the right track, what is it like to be in a pure perceptual state? The answer is that, according to S-D full criterion, to be in a pure perceptual state is a very rare (if not an unfeasible) situation. This makes it unsuitable to speak of perception as a natural kind, since perceptual states are, in order to exist, predominantly combined with other mental states (cognitive, imagistic, or whatever). Of course, this is not to say that there are no stimulus-dependent mental states (in the sense of S-D simple), but rather that it is hard to find a mental state whose function is to be fully stimulus-dependent.[13]

A general diagnosis can be drawn from all this. If we want to keep perception as a theoretically and scientifically useful term, we have to change our thinking about it. One possibility is to get rid of the idea of a demarcated line between perception and cognition and consider these terms not as natural kinds, but as mostly interdependent mental phenomena which refer to a unique mental state, and whose intervention is variable depending on external factors (ambiguity, noise or uncertainty). If we decide to take this step, perception and cognition appear predominantly intertwined. This means, there can be pure perceptual states, pure cognitive states and mental states with different degrees of perception and cognition. Pure cognitive states are common (e.g., linguistic judgements), pure perceptual states are, as we have seen, very unusual, and the intertwined state encompasses the majority of our everyday experiential situations —it is, in sum, the prevailing state in our mental lives.

Both philosophers and experimental psychologists have long tried (with little success) to isolate, terminologically and experimentally, pure perceptual states from other non-perceptual states. In this paper, I have considered the criterion of stimulus-dependence as perhaps the most compelling way to stipulate such a division. Indeed, the idea that perceptual states, in contrast to cognitive states, are causally sustained by proximal stimulation actually sounds convincing. However, a closer examination uncovers a different reality. When applying the constraints of the S-D full criterion the notion of pure perception becomes so narrow that it is extremely difficult to even grasp it. The full version of the S-D criterion is therefore so restrictive that the differences between perception and cognition should perhaps be considered more in degree than in kind.

[13] Remarkably, this view is consistent with the most recent neuroscientific and theoretical research. On the one hand, anatomical data indicates that only 10% of synapses entering the primary visual cortex originate from the thalamus, which brings sensory information from the retina, the remaining 90% of these synapses originate from the cortex itself (Peters 2002: 184), with nearly equal densities of neurons projecting backward and forward along the visual pathways —for every feedforward connection there is a reciprocal feedback connection (Gilbert and Li 2013). On the other hand, the emerging predictive coding framework states that the brain produces top-down generative models, or representations of the world, that constitute predictions of how the world is (Rao and Ballard 1999; Friston 2009; Hohwy 2013; Clark 2013; Cermeño-Aínsa 2020). It is said that these top-down predictions facilitate perceptual processing by reducing the need to reconstruct the environment via exhaustive bottom-up analysis of incoming sensory information. One can argue that the existence of top-down influences over perception is not in tension with the S-D criterion (Beck 2018: 323), but the obliteration of these influences is inherent to the full version of the S-D criterion, since determining the limits of pure perception requires the abolition of any element conceived as non-perceptual.

References

Beck, J. 2018. Marking the perception–cognition boundary: The criterion of stimulus-dependence. *Australasian Journal of Philosophy* 96 (2): 319–334.

Block, N. 2014. Seeing-as in the light of vision science. *Philosophy and Phenomenological Research* 89 (1): 560–572.

Block, N. unpublished. A joint in nature between perception and cognition without modularity of mind. Book manuscript.

Briscoe, R.E. 2011. Mental imagery and the varieties of amodal perception. *Pacific Philosophical Quarterly* 92: 153–173.

Burge, T. 2010. *Origins of objectivity*. Oxford: Clarendon Press.

Burge, T. 2014. Reply to Block: Adaptation and the upper border of perception. *Philosophy and Phenomenological Research* 89 (3): 573–583.

Carey, S. 2009. *The origin of concepts*. Oxford: Oxford University Press.

Cermeño-Aínsa, S. 2020. The cognitive penetrability of perception: A blocked debate and a tentative solution. *Consciousness and Cognition* 77: 102838.

Churchland, P.M. 1988. Perceptual plasticity and theoretical neutrality: A reply to Jerry Fodor. *Philosophy of Science* 55: 167–187.

Clark, A. 2013. Whatever next? Predictive brains, situated agents, and the future of cognitive science. *Behavioral and Brain Sciences* 36 (3): 181–204.

Corlett, P.R., G. Horga, P.C. Fletcher, B. Alderson-Day, K. Schmack, and A.R. Powers 3rd. 2019. Hallucinations and strong priors. *Trends in Cognitive Sciences* 23 (2): 114–127.

Crawford, S. 2020. Perceptual Demonstrative Thought: A Property-Dependent Theory. *Topoi* 39 (2): 439–457.

de Wit, T.C., S. Vrins, P.J. Dejonckheere, and R. van Lier. 2008. Form perception of partly occluded shapes in 4-month-old infants. *Infancy* 13: 660–674.

Dima, D.C., G. Perry, E. Messaritaki, J. Zhang, and K.D. Singh. 2018. Spatiotemporal dynamics in human visual cortex rapidly encode the emotional content of faces. *Human Brain Mapping* 39 (10): 3993–4006.

Evans, G. 1982. In *The varieties of reference*, ed. John McDowell. Oxford: Clarendon Press.

Ffytche, D.H., R.J. Howard, M.J. Brammer, A. David, P. Woodruff, and S. Williams. 1998. The anatomy of conscious vision: An fMRI study of visual hallucinations. *Nature Neuroscience* 1 (8): 738–742.

Firestone, C., and B.J. Scholl. 2016. Cognition does not affect perception: Evaluating the evidence for "top-down" effects. *Behavioral and Brain Sciences* 39: 1–72.

Fodor, J.A. 1983. *The modularity of mind*. Cambridge, Massachusetts: MIT Press.

Freedman, D.J., and E.K. Miller. 2008. Neural mechanisms of visual categorization: Insights from neurophysiology. *Neuroscience and Biobehavioral Reviews* 32 (2): 311–329.

Freedman, D.J., M. Riesenhuber, T. Poggio, and E.K. Miller. 2003. A comparison of primate prefrontal and inferior temporal cortices during visual categorization. *Journal of Neuroscience* 23: 5235–5246.

Friston, K. 2009. The free-energy principle: A rough guide to the brain? *Trends in Cognitive Sciences* 13 (7): 293–301.

Gibson, J.J. 1972. A theory of direct visual perception. In *The psychology of knowing*, ed. J. Royce and W. Rozeboom, 215–240. New York: Gordon and Breach.

Gilbert, C.D., and W. Li. 2013. Top-down influences on visual processing. *Nature Reviews of Neuroscience* 14 (5): 350–363.

Grill-Spector, K., and N. Kanwisher. 2005. Visual recognition as soon as you know it is there, you know what it is. *Psychological Science* 16 (2): 152–160.

Groen, I.I.A., S. Ghebreab, H. Prins, V.A.F. Lamme, and H.S. Scholte. 2013. From image statistics to scene gist: Evoked neural activity reveals transition from low-level natural image structure to scene category. *The Journal of Neuroscience* 33: 18814–18824.

Groen, I.I.A., E.H. Silson, and C.I. Baker. 2017. Contributions of low- and high-level properties to neural processing of visual scenes in the human brain. *Philosophical Transactions of the Royal Society B* 372: 20160102.

Haller, M., J. Case, N.E. Crone, E.F. Chang, D. King-Stephens, K.D. Laxer, P.B. Weber, J. Parvizi, R.T. Knight, and A.Y. Shestyuk. 2018. Persistent neuronal activity in human prefrontal cortex links perception and action. *Nature Human Behaviour* 2 (1): 80–91.

Harel, A., I.I. Groen, D.J. Kravitz, L.Y. Deouell, and C.I. Baker. 2016. The temporal dynamics of scene processing: A multifaceted EEG investigation. *eNeuro* 3 (5): ENEURO.0139–ENEU16.2016.

Hohwy, J. 2013. *The predictive mind*. Oxford: Oxford University Press.

Kriegeskorte, N., M. Mur, D.A. Ruff, R. Kiani, J. Bodurka, H. Esteky, K. Tanaka, and P.A. Bandettini. 2008. Matching categorical object representations in inferior temporal cortex of man and monkey. *Neuron* 60 (6): 1126–1141.

Lupyan, G. 2015. Cognitive penetrability of perception in the age of prediction: Predictive systems are penetrable systems. *Review of Philosophy and Psychology* 6: 547–569.

Mandelbaum, E. 2018. Seeing and conceptualizing: Modularity and the shallow contents of perception. *Philosophy and Phenomenological Research* 97 (2): 267–283.

McDowell, J. 1984. De re senses. *The Philosophical Quarterly* 34: 283–294.

Nanay, B. 2010. Perception and imagination: Amodal perception as mental imagery. *Philosophical Studies* 150: 239–254.

O'Callaghan, C., K. Kveraga, J.M. Shine, R.B. Adams, and M. Bar. 2017. Predictions penetrate perception: Converging insights from brain, behaviour and disorder. *Consciousness and Cognition.* 47: 63–74.

Pessoa, L. 2008. On the relationship between emotion and cognition. *Nature Reviews. Neuroscience* 9: 148–158.

Peters, A. 2002. Examining neocortical circuits: Some background and facts. *Journal of Neurocytology* 31: 183–193.

Peterson, M.A. 1994. Object recognition processes can and do operate before figure-ground organization. *Current Directions in Psychological Science* 3: 105–111.

Philips, B. 2019. The Shifting Border Between Perception and Cognition. *Noûs* 53 (2): 316–346.

Potter, M., B. Wyble, C. Hagmann, and E. McCourt. 2014. Detecting meaning in RSVP at 13 ms per picture. *Attention, Perception, & Psychophysics* 76 (2): 270–279.

Powers, A.R., III, M. Kelley, and P.R. Corlett. 2016. Hallucinations as top-down effects on perception. *Biological Psychiatry. Cognitive Neuroscience and Neuroimaging* 1 (5): 393–400.

Prinz, J.J. 2006. Is the mind really modular? In *Contemporary debates in cognitive science*, ed. R. Stainton, 22–36. Oxford: Blackwell.

Pylyshyn, Z. 1999. Is vision continuous with cognition? The case for cognitive impenetrability of visual perception. *Behavioral and Brain Sciences* 22 (3): 341–365.

Quilty-Dunn, J. 2016. Iconicity and the format of perception. *Journal of Consciousness Studies* 23 (3–4): 255–263.

Raftopoulos, A. 2009. *Cognition and perception: How do psychology and neural science inform philosophy?* MIT Press.

Ramachandran, V.S., and W. Hirstein. 1998. The perception of phantom limbs. The D. O. Hebb lecture. *Brain* 121: 1603–1630.

Ramkumar, P., B.C. Hansen, S. Pannasch, and L.C. Loschky. 2016. Visual information representation and rapid scene categorization are simultaneous across cortex: An MEG study. *Neuroimage* 134: 295–304.

Rao, R.P.N., and D.H. Ballard. 1999. Predictive coding in the visual cortex: A functional interpretation of some extra-classical receptive-field effects. *Nature Neuroscience* 2 (1): 79–87.

Reichert, D.P., P. Seriès, and A.J. Storkey. 2013. Charles bonnet syndrome: Evidence for a generative model in the cortex? *PLoS Computational Biology* 9 (7): e1003134.

Riley, M.R., and C. Constantinidis. 2016. Role of prefrontal persistent activity in working memory. *Frontiers in Systems Neuroscience* 9: 181.

Schindler, A., and A. Bartels. 2016. Visual high-level regions respond to high-level stimulus content in the absence of low-level confounds. *NeuroImage* 132: 520–525.

Seger, C.A., and E.K. Miller. 2010. Category learning in the brain. *Annual Review of Neuroscience* 33: 203–219.

Shibata, K., T. Watanabe, Y. Yuka Sasaki, and M. Kawato. 2011. Perceptual learning incepted by decoded fMRI neurofeedback without stimulus presentation. *Science* 334: 1413–1415.

Tanaka, K. 1996. Inferotemporal cortex and object vision. *Annual Review of Neuroscience* 19: 109–139.
Thielen, J., S. E. Bosch, T.M. van Leeuwen, M. A. J. van Gerven, and R. van Lier. 2019. Neuroimaging findings on Amodal completion: A review. I-Perception.
Torralba, A., and A. Oliva. 2003. Statistics of natural image categories. *Network.* 14 (3): 391–412.
Ungerleider, L.G., and M. Mishkin. 1982. Two cortical visual systems. In *Analysis of visual behavior*, ed. D.J. Ingle, M.A. Goodale, and R.J.W. Mansfield, 549–586. Cambridge, MA: The MIT Press.

Contents lists available at ScienceDirect

Consciousness and Cognition

journal homepage: www.elsevier.com/locate/concog

The perception/cognition distincton: Challenging the representational account

Sergio Cermeño-Aínsa

Autonomous University of Barcelona, Cognitive Science and Language (CCiL), Edifici B, Campus de la UAB, 08193 Bellaterra, (Cerdanyola del Vallès), Spain

A R T I C L E I N F O

Keywords:
Perception
Cognition
Content
Format
Non-conceptual
Iconic

A B S T R A C T

A central goal for cognitive science and philosophy of mind is to distinguish between perception and cognition. The representational approach has emerged as a prominent candidate to draw such a distinction. The idea is that perception and cognition differ in the content and the format in which the information is represented —just as perceptual representations are nonconceptual in content and iconic in format, cognitive representations are conceptual in content and discursive in format. This paper argues against this view. I argue that both perception and cognition can use conceptual and nonconceptual contents and be vehiculated in iconic and discursive formats. If correct, the representational strategy to distinguish perception from cognition fails.

There are, in general, two strategies to demarcate the line between perception and cognition: the architectural and the representational (see Quilty-Dunn, 2020)[1]. The former focuses on differences in architecture —a mental state is perceptual only if the information processed by such state is restricted to a predetermined set of information; otherwise, it will be cognitive (Fodor, 1983; Phylysyn, 1999; Firestone and Scholl, 2016; Mandelbaum, 2018). The latter, on the other hand, focuses on structural differences —perception and cognition produce different representational contents, which in turn are vehiculated in different representational formats (Carey, 2009; Burge, 2010, 2014; Block, 2014, forthcoming). While the former strategy aims to ground the border in differences in types of processes, the latter does so by appealing to differences in types of representations. This paper critically discusses the latter.

In this paper, I argue that drawing the perception/cognition distinction by attending to differences in the content and format of their representations is unsound. The paper is arranged as follows. First, I introduce some caveats and clarifications. I carefully distinguish between the content and the format of mental representations and clear up what I understand by conceptual/nonconceptual content and discursive/iconic formats (section 1). Having made this clear, I examine the distinction based on content differences (section 2). I offer reasons to hold that some cognitive processes can have nonconceptual content (section 2.1) and reasons to hold that a suitable and complete account of perception requires the involvement of conceptual content (section 2.2). I conclude that the arguments that distinguish perception from cognition based on content differences are not strong enough. Then I focus the discussion on format (section 3). I show that some cognitive processes can be vehiculated in iconic format (section 3.1) and some

E-mail addresses: elsergei@hotmail.com, Sergio.Cermeno@e-campus.uab.cat.

[1] I say *in general* because there are other attempts to do so; for example, Bayne and Montague (2011) argue that perception is phenomenal in character while cognition is intentional. Block (2014) claims that adaptation is ubiquitous in perceptual processes but not in cognitive ones. Burge (2010) claims that constancy is ubiquitous in perceptual processes but not in cognitive ones. And Beck (2018) has recently argued that, in contrast to cognition, perception is stimulus-dependent.

https://doi.org/10.1016/j.concog.2021.103216
Received 6 November 2020; Received in revised form 22 September 2021; Accepted 23 September 2021

perceptual processes in discursive format (section 3.2). I conclude that distinguishing perception from cognition by appealing to differences in format is not appropriate. If the arguments are strong enough, then we are forced to conclude (section 4) that both cognitive and perceptual representations can have conceptual and nonconceptual content, and both can be encoded iconically and discursively. Consequently, the border between perception and cognition cannot be marked either by differences in the type of content or by differences in the type of format; that is, the representational strategy fails.

1. The representational approach: Caveats and clarifications

While much of the discussions on the perception/cognition distinction talk over differences in the type of processes, specifically whether perception is (or is not) informationally encapsulated, other discussions deviate from informational criteria and focus on differences in the nature of their representations. Discussions about the nature of perceptual representation, in turn, have focused predominantly on content, particularly as to whether perceptual states are characterized by their content being nonconceptual (Evans, 1982; Crane, 1992; Peacocke, 2001). Others, instead, have focused on differences in the format in which these contents are represented, particularly as to whether perceptual states are distinguished by their iconic format (Carey, 2009; Burge, 2010, 2014; Block, 2014). Understanding mental representations, therefore, requires understanding both the content and the format of these representations. The representational strategy fundamentally postulates that perception and cognition speak in different languages; perception, unlike cognition, outputs nonconceptual and iconic representations. The representational approach (RA) thus rests on the following two claims:

The Content Claim (CC): the content of perception is nonconceptual, whereas the content of cognition is conceptual.

The Format Claim (FC): the format of perception is iconic, whereas the format of cognition is discursive[2].

Clearly, one content can be vehiculated in different formats, and one format can vehiculate different contents. The same content (e.g., the sentence "John has taken the dog for a walk") can be represented in spoken English, written French, codified in Morse code or represented in a photograph; that is, it can be represented in different formats. The same occurs with the format; the same format can be the vehicle for different contents. The same artwork (same format) may have different content for a layman than for an art expert, or the same word can have different contents (homonymous words). So, the content and format are part of a representation but can be individuated separately.

It is uncontroversial whether formats and contents in token representations can be taken separately, but it is not clear whether certain types of contents are necessarily vehiculated in certain types of formats. In mental representations, for example, it is often argued that perceptual representations utilize nonconceptual content and iconic (or analogue) format, while cognitive representations utilize conceptual content and discursive (or digital) format. In other words, while vision is image-like and nonconceptual, thought is language-like and conceptual. There is, indeed, widespread agreement on the alignment of these labels (Burge, 2010, 2014; Block, 2014). This being the case, saying that perception and cognition are demarcated by their content type is co-extensive with saying that they are demarcated by their format type. Everything said for the content will be equally effective for the format and vice versa. In contrast to this view, this paper assumes a robust vehicle/content distinction for mental representations. I take CC and FC as two independent claims and suggests that all possible combinations between content types and format types are, in principle, feasible. In other words, I assume that the format/content distinction is also relevant for types —having nonconceptual content does not require being purely analogue, and being purely discursive is not sufficient for being conceptual[3].

Now, what does it mean for the content of a representation to be conceptual or nonconceptual? Because it is fundamentally contrastive, the notion of nonconceptual content, generally attributed to perceptual experiences, is elucidated by distinguishing it from some particular conception of conceptual content. A common way of understanding conceptual content is by appealing to Evans' Generality Constraint (GC), which is formulated as follows:

> …if a subject can be credited with the thought that a is F, then he must have the conceptual resources for entertaining the thought that a is G, for every property of being G of which he has a conception (Evans, 1982: 104).

According to GC, no thinker can entertain a thought with a particular structure unless she can recombine the elements of that structure to form other related thoughts. A natural consequence of GC is that all our possible mental states are restricted under closure conditions; it is not possible to create new thoughts apart from all the possible (and comprehensible) combinations between the concepts that a subject possesses[4]. Accordingly, a mental state is conceptual if it satisfies GC; otherwise, it will be nonconceptual. This

[2] Note that theorists who pursue the representational route are not, in principle, committed to the idea that the truth of CC is tantamount to the truth of FC or vice versa. The truth of just one of these claims suffices to keep RA. This deploys a potential dispute between RA supporters, one can be a content representationalist, a format representationalist or both. In this paper, I leave these potential disputes aside. The important point is that CC and FC can be addressed separately.

[3] See Beck (2012: 592) for arguments showing that being discursive is not sufficient for being conceptual and being iconic is not sufficient for being nonconceptual.

[4] The general idea expressed by GC is also expressed by the notion of systematicity (Fodor & Pylyshyn, 1988). Systematicity describes the human ability to entertain semantically related thoughts; to genuinely understand a thought is to understand other related thoughts (for a critical position, see Camp, 2009). However, systematic recombinations are necessary but not sufficient to satisfy GC. Indeed, systematicity is a weaker requirement than GC, as it lacks the "generality" part. According to GC, once a thinker entertains a thought, the elements of this thought could, in principle, recombine indefinitely with any other appropriate concept that a person possesses. This requirement is not part of systematicity since it leaves open the possibility of finite recombinations.

is the understanding of conceptual and nonconceptual I consider here. So ultimately, if perception and cognition are separable by their type of content —cognition is conceptual and perception nonconceptual—, then the content of cognition will be subject to the GC, while the content of perception will not.

And now, what does it mean for the format of a representation to be iconic or discursive? Perceptual representations are the paradigmatic case of iconic mental representations. To say that perceptual representations are iconic, image-like or map-like is to say that they are syntactically and semantically distinct from discursive representations such as sentences and propositional thoughts. For example, in a picture of an elephant all the parts of the picture represent parts of the elephant, whereas in the word "elephant" the compositional letters of the word do not represent anything at all; they are not part of what is represented in the word "elephant", they are, in short, arbitrary. There is, therefore, a fundamental syntactic difference between iconic and discursive formats[5]. Similarly, discursive representations possess a distinctive semantic composition than iconic representations. Just as the meaning of the sentence "the elephant is in the forest" is determined by its components along with its syntactic structure, the meaning of an iconic representation is not determined by the meaning of its constituents. I think there is nothing to object to here. Carey (2009) illustrates it as follows:

> Iconic representations are analog; roughly, the parts of the representation correspond to the parts of the entities represented. A picture of a tiger is an iconic representation; the word "tiger" is not. The head in the picture represents the head of the tiger; the tail in the picture represents the tail. The "t" in "tiger" does not represent any part of the tiger (Carey, 2009: 458).

Accordingly, some researchers have suggested that iconicity responds to the following principle:

> Iconicity Principle (IP): *every part of the representation represents some part of the scene represented by the whole representation* (Quilty-Dunn, 2016: 256)[6].

(IP) means that if P is a picture of X, then parts of P are pictures of parts of X. Therefore, unlike discursive format representations, the pure cases of iconic representation do not have a canonical decomposition into constituents, and therefore they cannot recombine (Fodor, 2007). Two other principles emerge from IP. First, every part of an icon corresponds to parts of what it is represented (Kulvici, 2015), this is the part principle, and second, that parts of icons can represent multiple properties simultaneously (Quilty-Dunn, 2019: 3), this is the holistic principle. The holistic and part principles underlying IP will be crucial to discuss the last part of this paper and will be expanded upon there. For now, suffice it to say that iconic representations are representations that obey IP.

A final and important clarification. The representational approach supporter can hold that, for example, the content of cognition is both conceptual and nonconceptual and still maintaining the distinction by arguing that what makes the difference is the exclusively nonconceptual nature of the content of perception. Equally for the format. One can hold that the format of cognition is both discursive and iconic and still maintaining the distinction by arguing that what makes the difference is that the format of perception is uniquely iconic. Of course, the same can be said on the opposite side; if the content of cognition is entirely conceptual, then although the content of perception is conceptual and nonconceptual, one can use this to make the distinction. And the same for the format, even if the format of cognition is entirely discursive, and the format of perception is both iconic and discursive, one can use this to make the distinction. So, to show that the content and the format cannot be good candidates to mark the perception-cognition distinction, one should show that both perception and cognition can share the same contents and formats. To put it more explicitly, one should show that both perceptual and cognitive representations can have conceptual and nonconceptual content, and both can be vehiculated in iconic and discursive formats. Showing this is the goal of this paper.

All of this served to pave the ground. To recap: mental representations have content and format. Roughly, the content of a mental representation is the way the representation represents the world to be, and the format of a mental representation is the structure in which such representational content is vehiculated. On the one hand, I assume there is a distinction between the content type and the format type. Plausibly, arguments for content type are not extensible to arguments for format type. On the other hand, I distinguish conceptual from nonconceptual by attending to the Generality Constraint —conceptual content is subject to the Generality Constraint, while nonconceptual content does not—, and distinguish iconic from discursive by attending to the Iconicity Principle —iconic format obeys the Iconicity Principle, while discursive format does not. Next, I develop the arguments for why, taking into account these restrictions, the representational strategy fails to draw the perception/cognition border. Let me first analyse the content type suggestion.

2. The distinction from content type

Some philosophers have argued that the perception/cognition divide may be marked by substantial differences in the content type

[5] Another way to see the difference between iconic and discursive formats is by noting that icons are analogue. Analogue in the sense that the representations are continuous, there are no gaps between the representational parts of the scene (Haugeland, 1998: 82–83). Discursive formats are instead digital; there is no continuity between the parts of the sentences.

[6] This principle is inspired by Fodor (2007). The idea is that icons are isomorphic to what they represent (Kulvicki, 2004) or resemble what they represent. In addition, icons are distinctive in their homogeneity, inability to express negative, hypothetical, or quantified propositions, and inability to 'represent as' (Fodor, 2007).

of each one. While the content of perception is nonconceptual, the content of cognition is conceptual (Burge, 2010; Block, 2014). Concepts are which mark the territory of cognition; the rest is perception[7].

Recall that the distinction from content ultimately depends on the supposition that cognition is conceptual all the way down or that perception is nonconceptual all the way down. I will argue against these possibilities. I aim to provide examples where the content of cognition does not satisfy GC, thus showing that cognition, while typically conceptual, is also composed of nonconceptual content. And the same for perceptual content. On occasions, the content of perception satisfies GC, and therefore, though in many ways nonconceptual, also possesses conceptual content. If correct, it shows that there is no room for the perception/cognition distinction from content. The content claim (CC) fails.

2.1. Nonconceptual content in cognition

The first option rests on the idea that the content of cognition is exclusively conceptual. Incorporating conceptual content into perception is irrelevant; perception differs from cognition because the content of cognition is entirely conceptual. Some theorists, instead, suggest that non-conceptualism seeps beyond perception and permeates cognition. Analogue magnitude states (Beck, 2012); the constituents of concepts, e.g., their properties and relations (Stalnaker, 1998); certain recognitional abilities (Bermúdez, 1998: 182); the emphasis in speech acts, e.g., the force or the tone (Stalnaker, 1998); some cases of cognitive ensemble representations (Whitney and Leib, 2018); some forms of epistemic feelings, e.g., tip-of-the-tongue experiences, feelings of knowing, and feelings of confidence (Greely, 2021); some forms of metacognition (Carruthers, 2021); or some important aspects of emotional processing (Tappolet, 2016), are mental states that even being cognitive do not presumably satisfy the Generality Constraint, and therefore challenge the idea that cognition is exclusively conceptual. This being the case, CC will not be a suitable candidate to draw the perception/cognition border. Let me review one of these cases.

Beck (2012) has argued that analogue magnitude states (AMS) are nonconceptual cognitive processes. AMŚs are primitive representations of spatial, temporal, numerical, and other magnitudes (say, for example, representations of approximate numbers) shared by humans and animals[8]. Of course, humans are unique representing magnitudes upon the acquisition of concepts of natural numbers and units of measurement, but we share with other organisms a primitive 'analogue magnitude' system (Beck, 2014: 5-6)[9]. Think, for example, of your belief that your house is approximately ten minutes away, or your belief that there are more neurons in the brain than stars in the universe, or try to put yourself in the predator shoes when estimates that the prey is at the proper distance to attack. The idea is that these thoughts lack the systematic recombinability required to satisfy GC and, therefore, can be harboured without the need of possessing concepts —they are, in sum, nonconceptual.

To see this point clearer, Beck introduces Webeŕs law, which roughly holds that the ability to discriminate two magnitudes is a function of their ratio. When the ratio of two magnitudes exceeds a certain threshold (Webeŕs constant), the quantities become indiscriminable (p.569). According to Webeŕs law, the greater the ratio between two magnitudes, the easier they are to distinguish. The example proposed by Beck is quite illustrative. Just as pigeons can represent the sentences (1) 40 pecks are fewer than 50 pecks and (2) 38 pecks are fewer than 47 pecks, they cannot represent (3) 38 pecks are fewer than 40 pecks nor (4) 47 pecks are fewer than 50 pecks. Note that although the constituents of sentences (1) and (2) are the same as the constituents of sentences (3) and (4), pigeons can represent the former but not the latter. This means that AMŚs are not closed under all meaningful recombinations of the constituents of the sentences and, therefore, are not systematic. The argument goes on: since systematic recombinability is necessary to satisfy GC, and GC is a requirement for the content to be conceptual, the content of AMŚs should be, at least in part, nonconceptual. Furthermore, as we have assumed that AMŚs are mental states shared by humans and animals—whenever explicit counting is not possible, human numerical discriminations resort to Weber's Law— the pigeońs example may be extrapolated to human minds. So, just like pigeons, human AMŚs do not satisfy GC and therefore are nonconceptual[10].

Following , Halberda, J. (2016) one can object that the incapacity to discriminate between specific dimensions is more a product of epistemic limitations than representational limitations. That is, we are potentially competent to discriminate, recombine or compare (above chance) any two AMS representations; failures in discrimination are, consequently, not a failure of competence but a failure in performance. This being the case, Becḱs argumentation might collapse, since GC applies to a subject́s cognitive competence, not performance; for systematicity to be violated, subjects must lack the conceptual capacity to represent certain contents, but according to Halberda, Webeŕs Law predicts that failures in discrimination are rather the consequence of accidental factors that prevent from putting concepts to work. This objection can be answered. First, note that Halberdás conclusion stems from a mathematical idealization —the idea that the curves representing subject performance will never overlap whatever the difference (even minimal) between magnitudes. The problem is that this kind of idealizations can, in principle, be applied all over. For example, humans can only

[7] Publications concerning the very existence of nonconceptual content in perception are endless. I will set aside the debate and assume its existence; after all, it is the only way to make sense of the discussion here. The question is whether the content of perception is wholly nonconceptual or perception possesses concepts too.

[8] See Beck (2015) for a philosophical introduction to analogue magnitude representations.

[9] A perhaps straightforward way to show that analogue magnitude states are nonconceptual is that they are present in infants and non-human animals who supposedly lack the capacity to use concepts. In humans, for example, these effects are detectable in infants at 6 months (McCrink & Wynn, 2007). I do not follow this track because it is far from clear that infants and animals do not possess and cannot use concepts (or perhaps something like proto-concepts).

[10] See Gillet (2014) and Gray (2014) for criticisms and Beck (2014) for responses.

remember certain amounts of items, although potentially, there should be no limit in the items remembered. Likewise, there should also be no limits in the items attended in any perceptual situation, but in practice, one can only attend to a certain number at once. We must, I think, be extremely careful in transferring this kind of mathematical idealizations to genuine mental functioning. Second, just as our perceptual systems are only able to discriminate certain kinds of stimuli —e.g., our auditory system cannot represent noises falling outside certain frequencies (infrasounds or ultrasounds), or our visual system cannot represent colours situated outside from spectral colours (the human eye is only capable of perceiving light at wavelengths between 390 and 750 nm)— our AMS system could also be subject to certain kind of representational restrictions. One of these restrictions might be that we can represent discriminations between magnitudes only if these discriminations do not exceed certain thresholds.[11] Finally, in so far as mental capacities are restricted by brain processes, and brain processes have, by their biological nature, limits (see, e.g., Marois and Ivanoff, 2005), our competence to represent differences between certain magnitudes should also be limited.[12]

Now, why AMŚs are better characterized as cognitive than as perceptual? One reason is that the representation of an AMS does not depend on the stimulation of any particular sensory modality; that is, sense organs are not in causal contact with the object represented.[13] Indeed, just as many other non-perceptual mental phenomena (such as visual imagery, visualizations or episodic memory) AMŚs can be activated even in the absence of the stimuli that they represent. One can state (a la Block, 2014) that, like paradigmatic perceptions, AMŚs are susceptible to adaptation effects and therefore might count as perceptual. However, adaptation is, most likely, not an exclusive property of perception; voluntary imagery, for example, is not a perceptual process and can produce adaptation effects (Philips, 2019). Finally, when someone asks you how far the railway station is from your workplace, you are clearly not perceiving anything but making an approximate estimation of the distance —you make an AMS where your sense organs have nothing to do.[14]

I will not consider the other candidates above mentioned; the nonconceptual nature of AMS provides enough reasons to embrace the idea that some cognitive processes are nonconceptual in content. Consequently, the notion of cognition is not delimited by the notion of conceptual since some cognitive states do not require the presence of concepts. The ordinary attribution of conceptual content to cognition and nonconceptual content to perception is not sustainable; the presence of nonconceptual content permeates a good part of our non-perceptual mental states. If correct, the first alternative of CC, that perception is distinguished from cognition because cognition is entirely conceptual, fails.

2.2. *Conceptual content in perception*

The non-conceptualist can argue that what draws the line between perception and cognition is not the nature of the content of cognition (it can be conceptual, nonconceptual or both), but the exclusively nonconceptual nature of the content of perception. This is the second option left to the CC supporter. In this case, conceptual content is unique to cognition; the content of perception is fully nonconceptual. Let us call this the perceptual non-conceptualism view. Perceptual non-conceptualism holds that the outputs of perception are non-conceptualized representations that match with a concept in central cognition, visual identification and object categorization occur post-perceptually. So that, perceptual content does not satisfy GC since conceptual information is processed once perception has completed its work[15].

Recent evidence on ultra-rapid object categorization seems, however, to contradict such possibility. It is a fact that objects and scenes can be understood in a brief glimpse; conceptual information is effortlessly, automatically, efficiently and very quickly available. We can categorize objects in the blink of an eye, almost instantaneously. Indeed, using a rapid serial visual processing task (RSVP), Potter et al. (2014) found that conceptual understanding could be reached when a novel picture is presented as briefly as 13 ms from stimulus onset[16]. Potter et al. (2014) presented subjects with a series of visual images. The subjects' goal was to detect and categorize a specified target from the sequence of the rapidly presented images. They found that observers could determine the presence or absence of a specific picture even when the pictures in the sequence were presented for just 13 ms. each.

This evidence suggests that perception might output conceptualized representations —13 ms. is just a too short time to allow for top-down effects from cognition to perception (see also Mandelbaum, 2018). This evidence, therefore, runs against perceptual non-conceptualism and supports some sort of perceptual conceptualism —the studies on ultra-rapid object categorization leave the distinction from content in trouble. At this point, however, we must be strict. Potter et al.ś evidence, in fact, unfolds two possibilities.

[11] This potential objection is not overlooked by Beck (see Beck, 2012: 576-577).

[12] Thanks to an anonymous referee for raising this issue.

[13] For a more extensive explanation, see Beck (2012: 585-589).

[14] Furthermore, as an anonymous reviewer of this journal rightly points out, AMŚs are often involved in non-perceptual tasks such as arithmetic calculations (addition, subtraction, multiplication and division), thus placing them closer to cognitive than perceptual processes.

[15] Note that appealing to GC as a requirement for concept possession is less relevant in this part of the discussion. Simply, in order to categorize objects, possessing the concepts ascribed to such categories is required. Therefore, if we include conceptual information in perception, perception will satisfy GC; otherwise, it will not.

[16] Importantly, this time window is evaluated using rapid serial visual presentation (RSVP) of a series of pictures. Pictures are presented in intervals of 13ms., and subjects are subsequently asked if they recognize the target pictures; if subjects are able to categorize them, then 13ms. is enough to complete object categorization. Other studies operate differently. Unlike RSVP, subjects are presented with pictures, and they have to respond immediately when the picture is perceived. Of course, by including the decision-theoretic and motoric elements (that is, the overall response), the times are longer but certainly do not rigorously capture the accurate time consumed by perceptual processing and categorization (Mandelbaum, 2018: 275). It is also important to note that 13ms. is the quickest refresh rate that (in Potter et al. study) experimenters screen could display, thus opening the possibility of even shorter times to categorize objects (Mandelbaum, 2018: footnote 11).

First, that rapid object categorization counts as perception. In this case, CC fails to distinguish perception from cognition because perceptual processes include conceptual content. And second, that rapid object categorization counts as cognition. We can maintain that categorization is a genuine cognitive process and concede that perception is the processing developed during this very reduced space of time. In this case, perception becomes a very narrow but perhaps still significant process[17].

The CC supporter is forced to adopt the second option. What occurs during this very cramped space of time is what counts as genuine perception, and it should be enough to construct an accurate theory of perception —the limit of perception will end where conception begins. At this point, more than the extreme speed of the visual system, we should attend to what is processed during this short period of time. What is registered non-conceptually are the intrinsic properties of perceptual experiences, that is, the early levels of visual processing (e.g., shape, colour, and so on); the representations registered at the late levels (e.g., object recognition) are already conceptualized and therefore are not perception but cognition[18]. So, I do not perceive apples, chairs or faces but the low-level properties of these apples, chairs or faces. The perception/cognition line is, according to this view, demarcated by the low-level and high-level contents of the perceptual experience, which ultimately will correspond to the nonconceptual and conceptual content distinction. In what follows, I will argue against this view.

The most recent models of visual categorization, indeed, postulate a different view. Studies of temporal dynamics have found overlapping signatures of low-, mid-, and high-level representations (Groen et al., 2013; Harel et al., 2016), suggesting co-occurring and co-localized visual and categorical processing (Grill-Spector and Kanwisher, 2005; Ramkumar et al., 2016)[19]. Such evidence questions the hierarchical serial model of visual perception and the utility of the very distinction between levels of properties (Groen et al., 2017). For example, Ramkumar et al. (2016) studied the temporal relationship between visual information representation and rapid-scene categorization. They used confusion matrices (matrix whose entry represents the fraction of trials for categorization errors) to track the pattern of errors produced by visual representation or other processes that lead to categorical choice. They found that the very same regions that represented low-level features could also explain unique variance in neural confusions that were directly related to behavioural confusions. Crucially, both visual and behavioural confusions predicted neural confusions nearly simultaneously, thus suggesting a temporal overlap in encoding visual features and processing that influences behavioural choice (see also Dima et al. 2018). Something similar occurs with mid-level representations. Some studies suggest that object recognition can co-occur or even occur before figure-ground organization (Peterson, 1994; Grill-Spector & Kanwisher, 2005). Others even show that visual categorization based directly on low-level features —without grouping or segmentation stages— can benefit object localization and identification (Torralba & Oliva, 2003). And others even suggest that visual category responsive regions are not purely driven by low-level visual features but also by high-level perceptual stimulus interpretation (Schindler & Bartels, 2016). Critically, this evidence shows that the representation of low-level visual features, mid-level segmentation and processing that informs categorical information is not sequential but co-occur simultaneously and within the same cortical networks. This evidence is consistent with Potter et al.'s results for ultra-rapid object categorization and seems to be at odds with the idea that perception is an unconceptualized process. What remains to be clarified are the low-level contributions needed to ascribe meaning to scenes, but as a matter of fact, the co-occurrence of these levels makes it hard to draw a limpid line between the non-conceptualized and conceptualized parts of visual processing.

To uncover the possible contributions of low-level representations in perceptual categorization, let me focus on spatial frequencies. Data on the functional neuroanatomy of visual pathways suggest that the visual system rapidly extracts the low spatial frequencies (LSF) from a visual scene through fast magnocellular pathways. LSF signal conveys coarse information about the global shape and structure of the scene. The processing of this information precedes the processing of high spatial frequencies (HSF), which conveys more refined information about the scene, such as edges and object details, through slower parvocellular pathways. Accordingly, theories of visual perception have proposed that visual information is integrated in a coarse-to-fine manner (Bar, 2003; Kauffmann, Ramanoël & Peyrin, 2014). Interestingly, evidence shows that low spatial frequencies (LSF) are sufficient to elicit categorical representations (Thorpe et al., 2001; Kauffmann et al., 2017). Hence, by adopting this leading model of visual processing, and considering that object categorization can be achieved at poor resolutions, we can bear out that the amount of processing ranging from the information entering the retina to perceptual recognition can be extremely scarce[20]. Consequently, if perceptual categories may be recognized via general shape properties and detected via low-spatial frequencies, then the intervention of low-level properties in the

[17] There is a third possibility. Namely, taking object categorization as a combination of perceptual and cognitive processes. The introduction of an intermediate phase between perception and cognition is not contemplated here, but arguably it forces us to reinterpret the idea of a border between perception and cognition.

[18] All this is consistent with the traditional views of visual processing, that is, with the idea that visual processing comprises a series of discrete stages that successively produce increasingly abstract representations. These different stages are often considered in terms of low-, mid-, and high-level representations. Low-level vision involves the representation of elementary features, such as colour, luminance or contrast. Such processing is typically linked to the flow of information to the primary visual cortex (V1). The immediate stages beyond V1, the areas V2–V4, encompass mid-level vision. These areas allow the representation of conjunctions of elementary features and properties such as perceptual grouping, figure-ground organization, depth, and shape perception. Finally, high-level areas reflect the abstraction of the visual input into categorical or semantic representations that enable categorization or identification.

[19] Even conceptual information might be, on occasions, first encoded. Caddigan et al. (2017) found that categorization influences detection. So, conceptual representation not only does not require an exhaustive representation of low-level properties, but sometimes it might be triggered intermingled to, or even prior to such properties.

[20] Of course, the speed of the process is expected to depend on familiarity with the stimulus; the more inconsistent, vague, or uncertain, the more low-level information to retrieve conceptual information is needed, but when stimuli are familiar, only a scant amount of low-level information is enough to recognize it.

consecution of categorical information becomes minimal. The perceptual non-conceptualist is forced to reduce the scope of perception to an exaggeratedly limited amount of nonconceptual information.

Finally, if the nonconceptual/conceptual distinction coincides with the perception/cognition distinction, as CC claims, then the space corresponding to perception is exceptionally narrow. The responsibility for perception in vision is, in this case, almost insignificant. The question is: is this scant amount of processing enough to make a theory of perception worthwhile? I do not think so. A complete theory of visual perception cannot be restricted to addressing how minds extract the handful of properties necessary to make sense of the world. Perceptual non-conceptualists advocate for a theory that only explains a minimal part of visual processing, but the goal of visual perception must go beyond extracting low-level properties and bound them —visual systems seek conceptualized forms. Even perceiving disorganized forms, ambiguous figures or even in the absence of previous cues, our brains automatically tend to infer the most probable conceptualization of what is represented. Our perceptual systems have evolved to extract meaning from the external world, and attaining that meaning must be part of what perceptual systems do.

To summarize, Potter et al.'s outcomes widely favour perceptual conceptualism, but even when one deeply analyses what occurs during the first 13 ms. (before object categorization is achieved) in terms of low-level properties and low spatial frequencies, the idea that the content of perception is exclusively nonconceptual does not make sense. Hence, the second option of the CC claim —that cognition is distinguished from perception by the fully nonconceptual nature of the latter— weakens a lot. In conclusion, if some cognitive states possess nonconceptual content and some perceptual states possess conceptual content, the perception/cognition border marked by the nonconceptual/conceptual distinction fails. The CC claim does not follow.

Now, as I have assumed that types of content (conceptual/nonconceptual) do not correlate with types of format (discursive/iconic), discussion on contents does not suffice to make a definitive diagnosis of RA. More than differences in content type, perception and cognition can be distinguished by differences in format type. So, to establish my thesis that the perception/cognition distinction cannot be marked by differences in their representations, I need to show that perception and cognition also share types of formats.

3. The distinction from format type

Connected to the idea that the content of perception is nonconceptual and the content of cognition conceptual (CC) is that the format of perception is iconic and the format of cognition discursive (FC). The pressing question is whether the iconic/discursive distinction can be aligned with the perception/cognition distinction. Many theorists have argued in this fashion (Kulvicki, 2004, 2015; Carey, 2009; Burge, 2010, 2014; Block, 2014, forthcoming).

First of all, just as in content discussion, for the iconic/discursive format to be an appropriate candidate to distinguish perception from cognition, the FC thesis supporter must show either that iconicity is a property exclusive of perception or that, though present in cognition, it is pervasive in perception. I argue against both. I show first that some forms of cognition deliver an iconic format (satisfy IP) and posteriorly that the format of perception is not wholly iconic; that is, some forms of perception deliver a variety of representational formats, some of them shared with cognition (do not satisfy IP).

3.1. *Iconic format in cognition*

The first claim demands, therefore, that iconicity is present in cognition. One can, of course, bring up here the arguments deployed above for analogue magnitude states. The content of these states is not only nonconceptual in content but also analogue in format. However, some researchers have recently suggested that icons are only one kind of analogue representation; analogue magnitude representations might be analogue but non-iconic (Clarke, forthcoming a). To avoid confusion, I do not follow this route. Instead, to show that the vehicles of cognition may be iconic, I put my finger in a well-known type of cognitive representations —imagistic memories and imaginations— which count as cognitive processes and presumably satisfy the iconicity principle.

Indeed, visual imagery and imaginations are plausibly iconic in format, and despite their strong similarities to online visual perceptive processes —e.g., brain processes of visual perception and visual imagination coincide (Kosslyn et al., 2001)—, it might count as a cognitive process. If true, this is a direct argument against the first claim. If mental imagery is a cognitive process conveyed in an iconic format, then iconicity will not belong to perception. Critics can argue both against the real iconicity of mental imagery or against the real cognitive nature of mental imagery. Let me concisely analyse these possibilities.

First, does mental imagery satisfy the iconicity principle? Consider, for example, phenomena such as mental rotation, image scanning or the completion of occluded figures (amodal completion). Indeed, mental images seem to be the kind of things we use when faced with these phenomena. There seems to be a pictorial image representation whose parts represent some part of the scene represented by the whole representation. It is, in fact, hard to see what kind of propositional thinking could do this job; words seem not to be the appropriate vehicle to do this kind of things. For example, when explaining rotation effects in mental imagery, Shepard and Metzler's (1971) observed that differences in processing speed are proportional to spatial differences in what is represented. This correlation between the degree of rotation and the reaction time suggests that there is a correspondence between the manipulation of the mental representation and the physical rotation of the object —the elements of the mental object coincide with the elements of the physical object (see also Kosslyn et al., 2006). Likewise, Kosslyn et al. (1978) shown that the time to scan across visual mental images increases linearly with the distance to be scanned. Consequently, in both perception and mental imagery, metric distances must be incorporated in a similar way. Contrary to discursive formats, the representation cannot be decomposed nor recombined. Hence, when figures are mentally rotated, scanned or completed, every part of the mental representation represents some part of the scene represented by the whole representation, thus indicating that mental imagery satisfies IP and, therefore, that it is conveyed in an iconic format[21].

Second, does mental imagery count, strictly speaking, as a genuine cognitive process? On the one hand, one can argue that, unlike paradigmatic perception, mental imagery can occur in the absence of the appropriate external stimuli (they occur offline) and can be guided by the will (one can decide what to imagine). On the other hand, imagining is not the same as pure thinking. We usually imagine objects or scenes (real or not); we can imagine unicorns or golden mountains, but not squared circles, infinity or objects outside space and time. Imagining seems less cognitive than pure thinking but more cognitive than genuine perception. Therefore, mental imagery (just as episodic memories, visualizations, object recognition or certain forms of multisensory integration) must occupy a vast space between paradigmatic perception and pure cognition; it requires a visual object but not its real presence or existence.

So why not contemplate mental imagery as a third class of states halfway between perception and cognition? The answer to this question depends on how far we are willing to extend the upper border of perception or the lower border of cognition; after all, mental imagery takes on typical properties of both. The crucial point is that there is no essential property in mental imagery that suggests the need to introduce an independent mental state; all the properties of mental imagery are in both perceptual and cognitive processes[22]. Furthermore, the introduction of an independent class of mental states between perception and cognition exceedingly complicates the purpose of this paper, which is no other than refusing the existence of a perception/cognition border by appealing to the kind of representations deployed by each one. Thus, for the sake of argument, I assume that mental imagery belongs to cognition or perception (or at least closer to one than the other). Now, why do I take mental imagery to be closer to cognition than to perception? The main reason does not appeal to phenomenological considerations or the brain areas implicated in its consecution but to the sort of processing involved. Whereas paradigmatic perception requires bottom-up processing from external stimuli passing through sense organs, visual imagery does not. Thus, mental imagery shares with cognitive processes its autonomy regarding the stimulation of sense organs, and therefore, it cannot be explained in terms of changes occurring within bottom-up processing but with changes occurring during top-down processes. In short, the essential commonality between visual imagery and typical cognition, which encourages me to classify it as cognitive instead of perceptual, lies in the absence of bottom-up processing coming from sense organs.

All this shows that we cannot divide perception and cognition only by attending to the non-iconicity of cognition. The format of cognition plausibly goes beyond discursivity and, therefore, the first part of FC fails. We are already positioned to confront the second part —that, unlike cognitive representations, perceptual representations are entirely shaped by iconic format. I face this possibility next.

3.2. Discursive format in perception

Responding to the second claim —whether or not perception is fully conveyed in an iconic format— is a much more delicate matter. Of course, there are compelling reasons to concede that perceptual representations are, at least in part, vehiculated by iconic format. In view of the above arguments, it is, in fact, indispensable to assume this claim (for elaborated arguments, see Quilty-Dunn, 2020). The core question is: does perception also operate in discursive format? The proponent of FC should argue that although some cognitive processes may utilize iconic format, perceptual processes are genuinely and fully iconic, thus maintaining that the format criterion delimitates perception from cognition. Let me then focus on the possibility of non-iconic formats in perception.

Recall that according to the iconicity principle (IP) every part of the representation represents some part of the scene represented by the whole representation. Recall also that from IP, it logically follows the part principle, that every part of an icon corresponds to parts of what it is represented; and the holistic principle, that parts of icons can represent multiple properties simultaneously. It is time to expand on this. By way of illustration: on a chessboard, the square from the bottom left represents a black square, which corresponds to a part of the picture (the part principle), and the same square also represents a colour and a location simultaneously (the holistic principle). In contrast, in the sentence "*this is a board of 64 squares of alternating black and white colour*", parts of the sentence do not correspond to any part of the chessboard (it does not satisfy the part principle), and a single part of the sentence only represents, at most, one property of the chessboard, squares represent a shape, or black and white only represent colours, (so, it does not satisfy the holistic principle either). Some researchers, however, find this characterization of IP inadequate. Burge (2018), for example, finds problems in the arbitrariness of the part units invoked by the part principle; why should we consider a part as a part and not as a piece belonging to another part? Of course, this way of thinking about the part principle might lead to an undesirable infinite regression. There is, indeed, no consistent way to establish, not even by convention, an iconic representational unit. The part invoked by the part principle is, in sum, capriciously determined. On the other hand, and regarding the holistic principle, Burge also notes that not all iconic representation depicts multiple properties; a colour chit, for example, represents a colour shade and nothing else (footnote 27). Admittedly, the reasons adduced by Burge require further analysis, analysis that exceed the limits of this work[23]. However, seeing the

[21] For contrary positions, see Pylyshyn (2003).

[22] This may suggest that visual imagery could share the two formats, iconic and discursive; the iconic format coincides with its commonality with some parts of visual perception and the discursive format with its commonalities with typical cognitive processes. I leave open this possibility; the interest here is to show that mental imagery is a cognitive process conveyed in an iconic format.

[23] See Clarke (forthcoming b) for a possible solution to these concerns.

notion of iconic representation as a technical term (see Clarke, Forthcoming a; Quilty-Dunn, 2020) provides a way of thinking about this notion not as bricks or pixels constituting a picture but as a useful theoretical term. Finally, the reason for invoking these properties is not a definitional or constitutive way of what icons are but a helpful instrument to explain certain aspects of mental representations[24]. So, by appealing only to their explanatory value, I will restrict the notion of icon to those representations that satisfy these two principles. This is important because being these principles necessary to be considered an icon, perception will not be purely iconic if any kind of perceptual representation does not satisfy those principles.

Quilty-Dunn (2020) has recently argued that object perception does not obey these principles. Let us first distinguish between object recognition and object perception. Whereas object recognition is a high-level visual process, involves categorization and hence conceptual arrangement, basic object perception involves only the capture or apprehension (allegedly in a purely iconic format) of objects. The interest is in object perception. Let us consider the multiple-object tracking (MOT) paradigm. In MOT, participants focus their attention on a fixed square in the centre of a screen while eight objects (e.g., disks) are spread across the rest of the screen. Four of those eight disks flash, and then they all move around. Participants have to track the four flashing discs and ignore the rest. Subjects are remarkably good at tracking four objects, even when the objects are identical, intersect each other's and even when they are occluded by hidden barriers (Pylyshyn, 2003: 223-227). Critically, MOT works despite substantial changes in features such as colour, luminous flux, and various shape properties (see Zhou et al., 2010). This means that the representation of the object can persist even though features are changing or lost entirely, thus suggesting that the mechanisms to represent objects and features of these objects are different. So, there must be representations of particular objects represented via bind features attributed to the same object and not via the representation of any particular feature. The existence of these representations suggests the presence of object files, or spatio-temporal addresses of objects whose aim is to maintain identity over time and across changes. Now, as the representation of objects stored in object files persists even changing features —subjects often fail to register changes despite successfully tracking the objects—, it follows that representing objects comes apart from representing properties of these objects. The difference is that properties of objects are holistically represented, while objects do not —object representations represent individual items or properties without being holistically bound up with other items or properties. In sum, just as the representation of an object́s colour, shape, luminosity, trajectory or location follows the holistic principle, perceptual object representation lacks this sort of holistic binding and, therefore, is not iconic. Finally, the mere existence of object files indicates that perceptual object representation is not iconic (for more elaborate discussion, see Quilty-Dunn, 2020)[25].

Lets now consider face perception[26]. Again, as any intervention of high-level processing to a distal stimulus involves the application of concepts, more than face recognition, which involves the categorization of a determined face ("my mothers face"), I will focus on face perception, the mere detection of faces as such ("that is a face and not another thing"). Crucially, researchers have shown that face perception works through distinct functional and neural mechanisms than object perception (Kanwisher et al., 1997) —there is a mechanism that, prior to the face or object recognition, detects and differentiates whether we are facing faces or objects. This suggests that regardless of whether we categorically recognize certain faces or certain objects through higher-levels of processing, the perceptual system is capable (from the lower levels of processing) of distinguishing faces from non-faces very early. There should then be an initial perceptual stage, previous to face recognition, that detects faces as faces and not as other kinds of things.

Unfortunately, while the recognition of faces has been the focus of an extensive body of psychological research, the preliminary and prerequisite task of detecting a face has received limited attention. The case of prosopagnosia, however, offers interesting clues about the existence of this stage prior to recognition. Prosopagnosia is the individual's inability to recognize familiar faces despite normal sensory vision and normal intelligence (Damasio et al., 1982). The effects of prosopagnosia depend on the impaired stage of processing. Just as some subjects are able to differentiate faces but unable to recognize them, others are unable to differentiate faces at all (Sergent & Signoret 1992). On the face of it, there seems to be here an initial perceptual differentiation between faces and non-faces, but let me delve a little deeper to show this. In acquired and developmental prosopagnosia, face recognition is impaired due to failures in the visual mechanisms for processing faces. For example, de Gelder & Rouw (2000) compared patients with acquired and developmental prosopagnosia in face recognition and face detection tasks, while patients showed significant differences in the recognition tasks (e.g., differences in the inverted faces effect or in context effect), their speed in detection task was unimpaired. These results are consistent with the existence of two separate face systems, one involved in face detection and the other in face recognition. More recently, Dalrymple & Duchaine (2016) studied impairment differences in several patients of developmental prosopagnosia and found that while some patients exhibit impairment in both face detection and face identification, others perform poorly on identity processing tasks but not in detection tasks, thereby indicating that these mechanisms constitute independent abilities. This evidence clearly runs in favour of the two-process theory of face processing (Johnson et al., 2015), one initial stage for orientation toward faces (face detection), and other for other acquired and specialised aspects of face processing (face recognition).

[24] Thanks to an anonymous reviewer for pressing me this crucial point.

[25] Quilty-Dunn (2020) goes even further; he claims that even low-level features represented in an object representation are not iconic. The idea is that if low-level features are represented in an icon in each object representation, then these features must be bound holistically and therefore not separated from each other. The evidence, however, suggests otherwise. It has been shown that in trials without distractors, colour changes are detected significantly more often than shape changes; there are even cases where colour is preserved, and shape is lost (Bahrami, 2003). This is taken as evidence for non-iconicity in low-level features. It is not my aim here to explore this hypothesis thoroughly. My thesis only requires the presence of non-iconic format in object perception, and if Quilty-Dunn arguments are correct, this mission has been amply achieved.

[26] What follows is an extended discussion of Quilty-Dunn (2017: 130-131). Just as Quilty-Dunn mainly focuses on showing the non-iconicity of object perception, I go further with face perception, which is, I think, a more compelling case of non-iconic perception.

There are, therefore, cases in which even without failures in the processing of low-level properties, some subjects mistake the mere face/non-face distinction, and cases in which without failures in the face/non-face distinction subjects still present failures in face recognition. Therefore, the condition of prosopagnosia shows that the disconnection between low-level properties and face recognition plausibly involves an intermediary detection stage for processing faces as faces. So that, since low-level properties are processed iconically, but subsequent levels (detection and recognition) do not, it is reasonable to conclude that these patients, as normal people do, iconically perceive low-level properties but cannot detect and identify the information provided by these icons. So, since the intermediary stage represents the property of being a face, and this property, as well as the identity of an individual face, cannot represent multiple properties simultaneously, then it does not comply with the holistic principle. And as the holistic principle is a necessary condition for IP, it follows that face detection cannot be iconic; it should be discursive.

One can, of course, reject the idea that face detection belongs to the perceptual side of the story but the cognitive side. Perception will be, in this case, restricted to the representation of low-level properties. However, this faces a problem with the low-level properties. We should distinguish general from specific low-level properties. General properties are which allow representing faces instead of objects (the detection stage). Face detection is, for example, eased by the knowledge that the two eyes are positioned above the nose, which is above the mouth. Specific properties, on the other hand, represent more complex conceptual information associated with faces (the recognition stage). Face recognition is facilitated by the knowledge of some specific features, such as eyes and hair colour, nose size, characteristic freckles, or scars. Likely, face perception is prior to the representation of specific properties of the face (which detect the face as pertaining to), but not to the general properties of faces (which allow differentiating faces from non-faces). So, to be purely and fully iconic, perception must be restricted to general properties since specific properties are already contaminated by the discursive knowledge that we are facing a face and not another thing. In my view, this option decreases the scope of perception too much —perceiving must go further than that. By restricting the notion of perception to only the processing of the general low-level properties, the very notion of face perception (as well as object perception) becomes not only bad-labelled but trivial. In short, the only we need to incorporate discursivity in perception is to admit the existence of an intermediate stage, posterior to the processing of general low-level features but necessary for object recognition —the mere detection of faces as faces.

If correct, these arguments show that the format of perception is not fully iconic but also discursive —the second part of FC also fails. The perception/cognition border, therefore, cannot be drawn by differences in the format in which are represented, since both perception and cognition utilize iconic and discursive formats.

4. Conclusion

In this paper, I have confronted the idea that perception and cognition are distinguished by differences in the content and format in which are represented. The representational strategy (RS) to mark the perception/cognition distinction rests in two independent claims. The content claim (CC), the content of perception is nonconceptual, whereas the content of cognition is conceptual, and the format claim (FC), the format of perception is iconic, whereas the format of cognition is discursive. I have brought examples showing that the content and format of a mental state, be it perceptual or cognitive, is not exhausted either by content types (nonconceptual/conceptual) or by format types (iconic/discursive). That is, neither perception nor cognition has the exclusivity of possessing any particular type of content or being conveyed in any particular type of format —cognitive and perceptual representations can share the same contents and the same formats.

Before deploying the arguments, I have introduced some necessary conditions to be conceptual and iconic. First, a mental state is conceptual if it satisfies the Generality Constraint; otherwise, it will be nonconceptual. And second, a mental state is iconic if it satisfies the Iconicity Principle; otherwise, it will be discursive. With this in mind, I have set to work.

I have first considered the two possibilities for CC. The first is that the content of cognition is exclusively conceptual. Against this, I have brought evidence showing that analogue magnitude states are cognitive states with nonconceptual content. The second possibility is that the content of perception is exclusively nonconceptual. Against this, I have argued that object categorization is perceptual but conceptual in content. So, the differences between perception and cognition cannot be marked by the content of their representations; that is, CC fails.

Next, I have considered the two possibilities for format. The first is that cognition is exclusively vehiculated in discursive format. Against this, I have argued that visual imagery and imaginations are plausibly iconic in format, and despite their strong similarities with visual perception, count as cognitive. The second option is that perception is exclusively vehiculated in iconic format. Against this, I have argued that object perception and face perception are perceptual processes, yet discursive in format. So, the differences between perception and cognition cannot be marked by the format of their representations; that is, FC fails.

In conclusion, the border between perception and cognition cannot be marked either by differences in the content type or format type; that is, RS, as a whole, fails.

Declaration of Competing Interest

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

References

Bahrami, B. (2003). Object property encoding and change blindness in multiple object tracking. *Visual Cognition, 10*(8), 949–963.

Bar, M. (2003). A cortical mechanism for triggering top-down facilitation in visual object recognition. *Journal of Cognitive Neuroscience, 15*(4), 600–609.
Bayne, T., & Montague, M. (2011). *Cognitive Phenomenology*. Oxford University Press.
Beck, J. (2012). The Generality Constraint and the Structure of Thought. *Mind, 121*(483), 563–600.
Beck, J. (2014). Analogue Magnitudes, the Generality Constraint, and Nonconceptual Thought. *Mind., 123*(492), 1155–1165.
Beck, J. (2015). Analogue Magnitude Representations: A Philosophical Introduction. *British Journal for the Philosophy of Science, 66*(4), 829–855.
Beck, J. (2018). Marking the Perception-Cognition Boundary: The Criterion of Stimulus-Dependence. *Australasian Journal of Philosophy., 96*(2), 319–334.
Bermúdez, J. L. (1998). *The Paradox of Self-Consciousness*. MIT Press.
Block, N. (2014). Seeing-as in the light of vision science. *Philosophy and Phenomenological Research, 89*(3), 560–572.
Block, N. (forthcoming). A Joint in Nature between Perception and Cognition without Modularity of Mind. Book manuscript.
Burge, T. (2010). *Origins of objectivity*. Oxford University Press.
Burge, T. (2014). Reply to Block: Adaptation and the upper border of perception. *Philosophy and Phenomenological Research, 89*(3), 573–583.
Burge. (2018). Iconic Representation: Maps, Pictures, and Perception. In S. Wuppuluri, & F. Doria (Eds.), *The Map and the Territory*. Springer, Cham: The Frontiers Collection.
Caddigan, Eamon, Choo, Heeyoung, Fei-Fei, Li, & Beck, Diane M. (2017). Categorization influences detection: A perceptual advantage for representative exemplars of natural scene categories. *Journal of Vision, 17*(1), 21. https://doi.org/10.1167/17.1.21
Camp, E. (2009). Putting Thoughts to Work: Concepts, Systematicity, and Stimulus Independence. *Philosophy and Phenomenological Research, 78*(2), 275–311.
Carey, S. (2009). *The Origin of Concepts*. Oxford University Press.
Carruthers, P. (2021). Explicit nonconceptual metacognition. *Philosophical Studies, 178*(7), 2337–2356.
Clarke, S. (forthcoming a). Beyond the Icon: Core Cognition and the Bounds of Perception. Mind & Language.
Clarke, S. (Forthcoming b). Mapping the Visual Icon. The Philosophical Quarterly.
Crane, T. (1992). The Nonconceptual Content of Experience. In T. Crane (Ed.), *The Contents of Experience* (pp. 136–157). Cambridge: Cambridge University Press.
Dalrymple, Kirsten A., & Duchaine, Brad (2016). Impaired face detection may explain some but not all cases of developmental prosopagnosia. *Developmental Science, 19*(3), 440–451.
Damasio, A. R., Damasio, H., & Van Hoesen, G. W. (1982). Prosopagnosia: Anatomic basis and behavioral mechanisms. *Neurology., 32*, 331–341.
de Gelder, Beatrice, & Rouw, Romke (2000). Configural face processes in acquired and developmental prosopagnosia: Evidence for two separate face systems? *Cognitive Neuroscience., 11*(14), 3145–3150.
Dima, Diana C., Perry, Gavin, Messaritaki, Eirini, Zhang, Jiaxiang, & Singh, Krish D. (2018). Spatiotemporal dynamics in human visual cortex rapidly encode the emotional content of faces. *Human Brain Mapping, 39*(10), 3993–4006.
Evans, G. (1982). *The Varieties of Reference*. Oxford University Press.
Firestone, C., & Scholl, B. J. (2016). Cognition does not affect perception: Evaluating the evidence for "top-down" effects. *Behavioral and Brain Sciences, 39*, 1–72.
Fodor, J. A. (1983). *The modularity of mind*. Cambridge: MIT Press.
Fodor, J. A. (2007). The revenge of the given. In B. P. McLaughlin, & J. Cohn (Eds.), *Contemporary debates in philosophy of mind*. Oxford: Blackwell.
Fodor, Jerry A., & Pylyshyn, Zenon W. (1988). Connectionism and Cognitive Architecture: A Critical Analysis. *Cognition, 28*(1-2), 3–71.
Gillet, G. (2014). Concepts, Consciousness, and Counting by Pigeons. *Mind, 123*(492), 1147–1153.
Gray, D. M. (2014). Counting-ish Creatures and Conceptual Content. *Mind., 123*(492), 1141–1146.
Greely, N. (2021). Epistemic feelings, metacognition, and the Lima problem. *Synthese*.
Grill-Spector, Kalanit, & Kanwisher, Nancy (2005). Visual recognition as soon as you know it is there, you know what it is. *Psychological Science, 16*(2), 152–160.
Groen, I. I. A., Ghebreab, S., Prins, H., Lamme, V. A. F., & Scholte, H. S. (2013). From image statistics to scene gist: Evoked neural activity reveals transition from low-level natural image structure to scene category. *Journal of Neuroscience, 33*(48), 18814–18824.
Groen, I.I.A., Silson, E.H., Baker, C.I. (2017). Contributions of low- and high-level properties to neural processing of visual scenes in the human brain. Phil. Trans. R. Soc. B 372.
Halberda. (2016). Epistemic limitations and precise estimates in analog magnitude representation. In A. Baron, & D. Barner (Eds.), *Core Knowledge and Conceptual Change* (pp. 167–186). Oxford University Press.
Harel, Assaf, Groen, Iris I. A., Kravitz, Dwight J., Deouell, Leon Y., & Baker, Chris I. (2016). The Temporal Dynamics of Scene Processing: A Multifaceted EEG Investigation. ENEURO.0139-16.2016 *eNeuro, 3*(5). https://doi.org/10.1523/ENEURO.0139-16.2016.
Haugeland, J. (1998). *Having Thought*. Harvard University Press.
Johnson, Mark H., Senju, Atsushi, & Tomalski, Przemyslaw (2015). The two-process theory of face processing: Modifications based on two decades of data from infants and adults. *Neuroscience & Biobehavioral Reviews, 50*, 169–179.
Kanwisher, Nancy, McDermott, Josh, & Chun, Marvin M. (1997). The fusiform face area: A module in human extrastriate cortex specialized for face perception. *Journal of Neuroscience, 17*(11), 4302–4311.
Kauffmann, L., Ramanoël, S., & Peyrin, C. (2014). The neural bases of spatial frequency processing during scene perception. *Frontiers in Integrative Neuroscience, 8*, 37.
Kauffmann, Louise, Roux-Sibilon, Alexia, Beffara, Brice, Mermillod, Martial, Guyader, Nathalie, & Peyrin, Carole (2017). How does information from low and high spatial frequencies interact during scene categorization? *Visual Cognition, 25*(9-10), 853–867.
Kosslyn, S. M., Ball, T. M., & Reiser, B. J. (1978). Visual images preserve metric spatial information: Evidence from studies of imagery scanning. *Journal of Experimental Psychology: Human Perception and Performance, 4*, 47–60.
Kosslyn, Stephen M., Ganis, Giorgio, & Thompson, William L. (2001). Neural foundations of imagery. *Nature Reviews Neuroscience, 2*(9), 635–642.
Kosslyn, S. M., Thompson, W. L., & Ganis, G. (2006). *The Case for Mental Imagery*. Oxford University Press.
Kulvicki, J. (2004). Isomorphism in information-carrying systems. *Pacific Philosophical Quarterly, 85*(4), 380–395.
Kulvicki, John (2015). Analog representation and the parts principle. *Review of Philosophy and Psychology, 6*(1), 165–180.
Mandelbaum, Eric (2018). Seeing and Conceptualizing: Modularity and the Shallow Contents of Perception. *Philosophy and Phenomenological Research, 97*(2), 267–283.
Marois, R., & Ivanoff, J. (2005). Capacity limits of information processing in the brain. *Trends in Cognitive Science, 9*(6), 296–305.
McCrink, K., & Wynn, K. (2007). Ratio Abstraction by 6-Month-Old Infants. *Psychological Science., 18*(8), 740–745.
Peacocke, C. (2001). Does perception have a nonconceptual content? *The Journal of Philosophy, 98*(5), 239–264.
Peterson, Mary A. (1994). Object recognition processes can and do operate before figure-ground organization. *Current Directions in Psychological Science, 3*(4), 105–111.
Potter, Mary C., Wyble, Brad, Hagmann, Carl Erick, & McCourt, Emily S. (2014). Detecting meaning in RSVP at 13 ms per picture. *Attention, Perception, & Psychophysics, 76*(2), 270–279.
Pylyshyn, Zenon (1999). Is vision continuous with cognition? The case for cognitive impenetrability of visual perception. *Behavioral and Brain Sciences, 22*(3), 341–365.
Pylyshyn, Z. (2003). *Seeing and Visualizing: It's Not What You Think*. MIT Press.
Quilty-Dunn, J. (2016). Iconicity and the format of perception. *Journal of Consciousness Studies, 23*(3–4), 255–263.
Quilty-Dunn, J. (2017). *Syntax and Semantics of Perceptual Representation*. Ph.D. dissertation. The Graduate Center, City University of New York.
Quilty-Dunn, Jake (2020a). Is Iconic Memory Iconic? *Philosophy and Phenomenological Research, 101*(3), 660–682.
Quilty-Dunn, Jake (2020b). Perceptual Pluralism. *Noûs, 54*(4), 807–838.
Ramkumar, Pavan, Hansen, Bruce C., Pannasch, Sebastian, & Loschky, Lester C. (2016). Visual information representation and rapid scene categorization are simultaneous across cortex: An MEG study. *Neuroimage, 134*, 295–304.
Schindler, Andreas, & Bartels, Andreas (2016). Visual high-level regions respond to high-level stimulus content in the absence of low-level confounds. *NeuroImage, 132*, 520–525.

Sergent, Justine, & Signoret, Jean-Louis (1992). Varieties of functional deficits in prosopagnosia. *Cerebral Cortex, 2*(5), 375–388.
Shepard, R. N., & Metzler, J. (1971). Mental rotation of three-dimensional objects. *Science, 171*(3972), 701–703.
Stalnaker, R. (1998). What might nonconceptual content be? *Philosophical Issues, 9*, 339–352.
Tappolet, C. (2016). *Emotions, Value, and Agency*. Oxford University Press.
Thorpe, S. J., & Fabre-Thorpe, M. (2001). Neuroscience.Seeking categories in the brain. *Science, 291*, 260–263.
Torralba, A., & Oliva, A. (2003). Statistics of natural image categories. *Network., 14*(3), 391–412.
Whitney, D., & Yamanashi Leib, A. (2018). Ensemble Perception. *Annual Review of Psychology, 69*, 105–129.
Zhou, K., Luo, H., Zhou, T., Zhuo, Y., & Chen, L. (2010). Topological change disturbs object continuity in attentive tracking. *Proceedings of the National Academy of Sciences of the United States of America, 107*(50), 21920–21924.