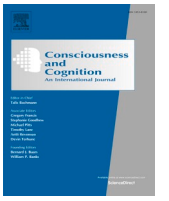
Consciousness and Cognition 106 (2022) 103419

Contents lists available at ScienceDirect

Consciousness and Cognition

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



Predictive processing and perception: What does imagining have to do with it?

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ARTICLE INFO

Keywords:
Aphantasia
Crossmodal mental imagery
Predictive processing
Imagination
Projected mental imagery

ABSTRACT

Predictive processing (PP) accounts of perception are unique not merely in that they postulate a unity between perception and imagination, but in claiming that (i) perception should be conceptualised in terms of imagination and (ii) the two involve an identity of neural implementation. This paper argues against these claims, on both conceptual and empirical grounds. Conceptually, the manner in which PP theorists link perception and imagination belies an impoverished account of imagery as cloistered from the external world in its intentionality, akin to a virtual reality, as well as endogenously generated. Yet this ignores a whole class of imagery whose intentionality is directed on the actual environment—projected mental imagery—and also ignores the fact that imagery may be triggered crossmodally in a bottom-up, stimulus-driven way. Empirically, claiming that imagery and perception share neural circuitry ignores relevant clinical results in this area. These evidence substantial perception/imagery neural dissociations, most notably in the case of aphantasia. Taken together, the arguments here suggest that PP theorists should substantially temper, if not outright abandon, their claim to a perception/imagination unity.

1. Introduction

Cognitive scientists have traditionally viewed perception as a sequence of incremental operations and computations over sensory signals. These operations might be encapsulated from each other or they might interact with one another. Either way, perception has first and foremost been conceptualised as a process that tweaks initial sensory signals, amplifying them, recovering information from them, etc. in order to build a phenomenally rich, accurate and conscious representation of the external world.

In contrast to this picture, predictive processing (PP) theories of perception reverse the functional role assigned to these signals (Friston, 2005; Hohwy, 2007; Clark, 2014). PP says that the phenomenally rich, accurate and conscious representations of the world we call 'perceptual experiences' arise from a cascade of hierarchical processes and computations that are almost exclusively top-down and expectation-driven. On this account, incoming sensory signals are not, as traditionally pictured, the building materials for perception; rather, they merely provide corrective feedback to layers of this predictive, expectational hierarchy. These then update in a Bayes-obeying fashion. As Andy Clark (2014, pp.24–5) puts it:

> Each layer in these systems thus displays two functionally distinct properties. It encodes how it takes the world to be, and it registers mismatches between those 'takings' and predictions coming from the layer above. Mismatches flow forward as error signals to the level above, while its best guesses about the state of the world flow downward as predictions to the layer below.

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https://doi.org/10.1016/j.concog.2022.103419
Received 18 March 2021; Received in revised form 29 July 2022; Accepted 29 September 2022
Available online 14 October 2022

Crucially, Clark continues:

> Perception occurs when, across multiple layers of such processing that capture regularities at many spatial and temporal scales, the hugely interanimated set of predictions matches the evolving sensory inputs, explaining them away so that the forward flow of error ceases or settles.

This makes conscious perception, with all its world-presenting phenomenology, a surprisingly endogenous affair. Hohwy (2013, p.48) concurs with Clark, claiming that PP entails that "what you experience now is given in your top-down predictions of sensory input, rather than the bottom-up [sensory] signal.".

By understanding perception to be produced endogenously in this manner, PP advocates thereby claim that perception is akin to states of the imagination. Indeed, relying on the idea that mental imagery is endogenously produced, some PP theorists have exploited this to take the sting out of the idea that a phenomenally rich conscious state like perceptual experience could arise from top-down hierarchies. Geoffrey Hinton, for instance, claims that mental imagery, along with dreaming, "suggests that the visual system can perform top-down generation" of sensory states (Hinton, 2007, p. 428; see also Seth, 2014, p.101).

It is important to appreciate that the link PP theorists postulate between perception and imagination is not merely that of a metaphor, analogy, or heuristic device. While the claim that perception is akin to imagery is a conceptual one, PP theorists also advance a substantial empirical claim, one that is a cornerstone of the PP account of perception. Clark (2014, p.39), for instance, claims that PP entails that creatures who can perceive *ipso facto* have the "neural resources" to imagine and that perception and imagination "are simultaneous effects of a single underlying neural strategy." This is a substantial empirical conjecture if anything is.

Here I scrutinise this supposed unity between perceiving and imagining. Just as the PP theorist's proposed perception/imagination unity has a conceptual and an empirical reading, I shall find that postulated unity wanting from both conceptual and empirical perspectives. Conceptually, PP theorists operate with a faulty understanding of imagery, i.e. as a state that is necessarily (i) cloistered from the external world in its intentionality and (ii) endogenously generated (Section 3). By endorsing these claims, PP theorists lay flawed conceptual foundations for their theories of perception and perpetuate false claims about the imagination more generally. The empirical problem for PP theorists is that there is significant evidence that perception and imagination are neurally dissociable, *contra* Clark and other PP theorists (Section 4). In motivating this claim I focus on the case of aphantasia, an imagery deficit that can present with no perceptual deficits, as well as more local, domain-specific perception/imagination dissociations.[1] First, however, I shall say some more about what is unique about how PP's supporters propose to understand the relation between perception and imagination (Section 2).

One final matter: since these matters concern the so-called sensory, rather than propositional imagination, I will be helping myself to the convenience of using the terms 'imagination', 'states of imagination' and 'mental imagery' as synonyms. In this, I take myself to be following PP theorists. One might reasonably object to this usage, but I will concede it, for the sake of discussion.

2. Predictive processing and the imagination

Michael Kirchhoff claims that part of the uniqueness of PP is that it understands imagination and perception to be conceptually connected in the manner outlined above:

> Many philosophers think that there is a sharp distinction between imagination and perception… [PP] may be said to represent a departure from the received view by depicting perceiving and imagining as deeply unified and overlapping. (2018, p.751)

As a sociological claim, this doesn't obviously ring true. Arguably, the received view is precisely that perceiving and imagining are unified and overlapping. For instance, consider a view about the imagination that we might call 'perceptualism.' Perceptualism says that states of the imagination are a species of the genus 'perceptual experience' (Cavedon-Taylor, 2021). This view groups mental imagery together with veridical perception, illusory perception and hallucinatory perception not by claiming that the latter three all involve mental imagery, but by claiming that all four are fundamentally the same kind of mental state: perceptual experience. Crucially, one doesn't have to comb the literature on the imagination very far to find defenders of the view. Hume (1739/2000), for instance, advocates for perceptualism. Although he allows there are differences between perceiving and imagining, most notably in terms of "force and liveliness" (1.1.1.1), the two, he thinks, are one and the same:

> That idea of red, which we form in the dark, and that impression which strikes our eyes in sun-shine, differ only in degree, not in nature. (1.1.1.5)

Perceptualism, as we will see below, is not quite what PP theorists affirm. Still, perceptualism denies any sharp distinction between imagination and perception and is one of the most widely defended views about the imagination and its relation to perception currently circulating. So the claim that perception and imagination are unified or overlapping is certainly not unique to PP and that claim does not go against the 'received' view.

[1] Not all PP theorists are as internalist as Hohwy and Clark. For instance, Kirchhoff (2018) combines PP with sensorimotor enactivism (see Noë 2004) to arrive at a view that is partially externalist. Others who combine elements of PP and enactivism include Seth (2014), Clavel Vázquez (2020) and Wilkinson (2020). The conceptual objections I raise against PP in section 3 mainly target internalist varieties of the view, what Kirchhoff calls the 'inferred fantasies' approach. But insofar as any PP theorist, internalist or otherwise, sees perception and imagination as involving substantial neural overlaps, they will be vulnerable to the objections of section 4.

In support of the claim that postulating a connection between perception and imagination is fairly orthodox, consider some statements of support for perceptualism by its more recent defenders. Alex Byrne, for instance, writes as follows:

> Visualizing a tiger is similar to seeing a tiger; auditorily imagining clashing cymbals is similar to hearing clashing cymbals, and so on. Why is that? The received view, supported by various lines of converging evidence, is that visualizing a tiger (for example) involves "visual representations"—mental representations that are proprietary to the sense of sight; likewise for auditorily imagining clashing cymbals… When one visualizes a tiger, one is in a state with a distinctively visual content. (Byrne, 2007, pp.134–135)

In a similar vein, Alvin Goldman claims that seeing O to be F and imagining O to be F are "a shared kind of state, in this instance a *visual* kind of state." (Goldman, 2006a, p.47) and that there exists "a strong equivalence between visual perception and imagery." (Goldman, 2006b, p.154). Finally, consider the following remarks in the *Stanford Encyclopedia of Philosophy*'s entry 'Imagination' (Liao & Gendler, 2019): "To have a (merely) mental image is to have a perception-like experience triggered by something other than the appropriate external stimulus." To characterise states of the imagination in this way, i.e. in relation to 'appropriate' external stimuli, even if by their absence, is to characterise them in perceptual terms. Indeed, it suggests a kinship between imagination and hallucination (see also Nanay, 2016).

So, if there is something unique in how PP theorists think about perception and imagination that goes against the 'received view', it is not simply that the two are "deeply unified and overlapping" or that there is, as Clark sometimes says, a "duality" (Clark, 2016, p.94) between them. Nonetheless, Kirchhoff is right that there is something unique about how PP theorists understand the relation between perception and imagination; my suggestion is that what is unique to PP in this regard is that it is the explanatory inverse of perceptualism.

Consider: when defenders of perceptualism advance their proposed view of the alleged perception/imagination unity, they take the central explanans to be 'perceptual experience.' They attempt to conceptualise mental imagery and the imagination in terms of such states. By 'perceptual experience', we may understand perceptualists to refer to a state of mind with sensory phenomenal character whose content has a so-called iconic or pictorial format (see Quilty-Dunn, 2020 for discussion). There may be other commitments here too, e.g., that both justify beliefs about their objects in an immediate, non-inferential manner.

By contrast, the distinctiveness of how PP theorist understand the alleged perception/imagination unity is that they reverse the above order of explanation. PP theorists take the central explanans to be 'imagination' or 'mental imagery' and they attempt to conceptualise perceptual states in terms of these. By 'mental imagery' or 'imagination' defenders of the PP account of perception mean to refer to a state of mind with a sensory phenomenal character that is, crucially, cloistered from the external world in its intentionality (occurring in the 'mind's eye') and which is endogenously generated, rather than bottom-up or exogenously caused. It is important to see that these two claims are distinct. One concerns the representational nature of the imagination. The other concerns its causal origins. Either way, PP's uniqueness, I suggest, does not reside in its postulating a unity between perceiving and imagining, but its taking imagination to be the fundamental concept when doing so. This makes the PP theorist's account of that unity different from the perceptualist's. Perceptualism and PP theorists agree: imagination and perception are fundamentally unified. Where they disagree is about what explains what.

In support of this rather different reading of the PP theorist's account of the perception/imagination unity, consider the following remarks from Hohwy:

> [Perception] is like a fantasy or virtual reality constructed to keep the sensory input at bay. It is different from the conscious experience that is truly a fantasy or virtual reality, which we enjoy in mental imagery or dreaming, because such experiences are not intended to keep sensory input at bay. But normal perception is nevertheless at one remove from the real world it is representing. (Hohwy, 2013, pp.137–138)

Here, Hohwy analyses perception in terms of mental imagery, though he admits there is a difference in sub-personal function. In particular, we are told that one thing, *perception*, 'is like', i.e. is to be understood in terms of another, *imagination*. What both share, Hohwy says, is their isolation ('remove') from the external world. Crucially, the two claims outlined above about intentionality and causal origin are implied. First, in saying that perception is 'constructed', I take Hohwy to be making the causal claim that perception is like imagination in its being an endogenous assemblage of the brain (see also Clark, 2016, p.94; contrast Campbell, 2002, p.119). Second, in saying that perception is a 'virtual reality', I take Hohwy to be saying that perception is like the imagination insofar as its intentionality is cloistered from the external world in the way that, say, a computer screen display is. Implied here is the idea that states of the imagination occur within 'the mind's eye' and so their intentionality fails to reach the external world. In sum, the uniqueness of PP accounts of perception is a matter of their taking imagination to be the 'lens' through which we should understand perception. We might call this an 'imagination first' account of perception, since it grants the imagination conceptual priority over the latter (see also Jones and Wilkinson, 2020).

3. Conceptual issues

We have seen that PP theorists make both a conceptual and an empirical claim about the connection between imagination and perception. In this section I focus on the conceptual claim. I will argue that the way PP theorists proceed here shows them to assume a too-narrow and flawed conception of mental imagery; namely, as necessarily endogenously generated and cloistered from the external world in its intentionality. This might seem like a tangential matter for PP theories of perception; after all, their claim is centrally about perception, not the imagination. So why should it matter if there are problems with their account of mental imagery? In fact, the error

is no small matter at all. Given that PP accounts of perception wish to conceptualise such states in terms of the imagination, success here will be significantly limited if it turns out that PP theorists assume a defective account of the imagination. This is what I aim to show is the case below. Moreover, for some PP theorists, their claims are not simply about perception, but "everything mental." (Hohwy, 2013, p.1) For these PP advocates, misconstruing the imagination risks being a significant error. Let us start by examining the intentionality of mental imagery.

3.1. Environment-directed mental imagery

The intentionality of mental imagery is often pictured as failing to reach objects in one's immediate environment. Typically, imagery is pictured as representing merely possible states of affairs. Even when it is pictured as representing actual ones, imagery is not thereby pictured as representing objects as immediately before one. Byrne, for instance, claims that imagination concerns "the appearance of actuality, not possibility." (Ibid.) He says that when one imagines a purple polar bear one thereby represents "that purple polar bears exist, not (merely) that they could have existed." But even if Byrne is right about this, we typically think that someone who imagines a purple polar bear does not represent it to be actualised in their immediate environment, where the things that they see are located.

Of course, our ordinary conception of mental imagery allows that it is sometimes cloistered from the immediate environment, making it akin, as Hohwy says, to a 'virtual reality.' Yet to assume that the intentionality of mental imagery is always cloistered in this way, such as to provide a model for the PP view of perception, is to make a serious error. It is to ignore a crucial distinction between two ways of having imagery: tokening mental imagery 'in the mind's eye' versus projecting mental imagery out into one's immediate environment. For instance, when arranging flowers in a vase, one may project imagery of flowers in the vase. Or, when trying to work out if a piano will fit through a doorway, one may project imagery of the piano positioned in the door frame. It might be true that imagery in the mind's eye is environmentally cloistered in its intentionality. But this is false when it comes to projected mental imagery. If what PP theorists require, in order to explicate perception along their favoured lines, is a state of mind that is necessarily insulated from 'actual reality', then imagery is the wrong state to appeal to.

Projected mental imagery has been put to several explanatory uses. Alan Thomas (2009), Bence Nanay (2010) and Amy Kind (2018) claim that it explains amodal perception, i.e. how we represent the occluded parts of environmental objects before us and are thus able to experience such objects as 3-D, despite being unable to see all their sides simultaneously. Gregory Currie and Ian Ravenscroft (2002, pp.28–30) claim that projected mental imagery explains the visual character of the imaginings one undergoes when watching a film; one sees the screen image and in it the actors and sets recorded, and then imagines these to be fictional characters and locations. The question is begged of such views when PP theorists consider the intentionality of mental imagery to fall short of the environment. On the views outlined in this paragraphs, there is nothing 'virtual' about the reality that imagery can potentially concern.

Naturally, the above views are controversial. Other accounts of amodal perception and filmic experience are available, or at least conceivable. But one needn't hold a particular theory of these two phenomena in order to appreciate how imagery is sometimes environmentally directed, rather than cloistered. For one, consider using one's imagination to see clouds to be different kinds of objects, e.g., a clown, a rabbit, etc. Second, consider an example like the following: suppose you are driving late at night and visibility is drastically reduced when a car suddenly appears on the road before you. At least you assume the object to be a car–all you can make out are its two headlights. In order to work out whether there is space for your car to pass on the narrow lane, you must make an educated guess as to the approaching car's size and shape, given the position of the headlights. But you need to do so in such a way that can directly guide your action. Solution: you use mental imagery to project, out into the pitch black and surrounding the headlights, the outline shape of a car that strikes you as the correct size and shape (see also Van Leeuwen, 2011).

The above two examples are fairly anodyne. It is thus part of our ordinary conception of mental imagery that its intentionality can be environmentally directed. It is worth emphasising that projected mental imagery is a respectable posit of perceptual psychology too: "real, reliable, and replicable" (Segal, 1972, p.226). For it is implicated in experimental paradigms as diverse as binocular rivalry tests (Keogh & Pearson, 2018), superstitious perception (Gosselin & Schyns, 2003) and temporal integration studies (Brockmole et al., 2002).

3.2. Exogenous mental imagery

So much for the PP theorist's assumption that states of the imagination are a kind of 'virtual reality' on which they may model their view of perception. The other assumption I suggested PP's supporters make about the imagination is that it must be endogenously caused or assembled (Clark, 2016, p.94; Hohwy, 2013, pp.137–138). Again, the assumption is not correct. Not only may states of the imagination be environmentally directed, they may also be exogenously caused, i.e. via bottom-up cues. This is what occurs in certain forms of crossmodal mental imagery.

Crossmodal mental imagery is when an inducer perceived via one sensory modality causes mental imagery proprietary to another (Spence & Deroy, 2013; Nanay, 2018). Consider watching a celebrity talking on the television with the sound muted or grasping a die with one's eyes closed. In the first case, one may 'hear' the celebrity's voice when seeing their face move on the television screen. This is sight-induced auditory mental imagery. In the second case, one may 'see' a die in one's mind's eye when running one's fingers over its vertices, faces and dimples. This is touch-induced visual mental imagery. Crucially, both are stimulus-driven in that the following counterfactual holds: had there been no bottom-up stimulation of the relevant sense-modality (vision for case one; touch for case two), then there would not have been mental imagery.

One might reasonably object that these cases are uninterestingly stimulus-driven. Crucially, they still seem to require a top-down

influence, i.e. familiarity with the celebrity's voice and familiarity with dice, respectively. Indeed, it appears that a second counterfactual holds: had one not already been familiar with the inducer (the particular celebrity in case one; dice in case two), then there would not have been mental imagery. So these cases seem, at best, hybrid in nature, involving a mix of bottom-up and top-down influences. That makes them both endogenously and exogenously caused.

Are there any 'pure' cases of crossmodally induced mental imagery? That is, cases that don't involve top-down, endogenous elements and which might unambiguously challenge the PP theorist's assumed view of imagery? Consider a kind of crossmodal mental imagery that Spence and Deory (2013, p.165) call *immediate crossmodal imagery* and which they distinguish from *crossmodally induced top-down mental imagery*.[2] In the latter cases, learned concepts and associations play a crucial role in determining the nature of the ensuing imagery. In the former cases, imagery occurs automatically and without conceptual or top-down mediation; stimulating one sense automatically brings about imagery in another.

Spence and Deroy do not offer concrete examples of non-concept-necessitating, immediate crossmodal imagery. I suspect that the most likely ones will involve simple, low-level sensory properties. One promising candidate is the crossmodal, sound-induced flash illusion or 'double-flash' illusion (Shams et al., 2000): a single visual flash presented with two short auditory beeps automatically and immediately triggers an experience of a second flash, one that is plausibly understood to be a matter of mental imagery (Nanay, 2018, p.129). This is a case of audition-induced visual imagery, one that can also be induced tactually (Violentyev et al., 2005). Since the inducer here is relatively simple, experience of it is not a candidate for necessary mediation by top-down mechanisms of conceptualisation. In addition, the leading view in the literature on crossmodal interactions is that while these may be strengthened by concepts and top-down influences, they are primarily a bottom-up, stimulus-driven matter. Factors related to the spatial congruency of the stimuli and their occurring within a so-called 'temporal window' of multisensory integration, in addition to processing in early cortical areas, are crucial for the double-flash illusion in particular and crossmodal interactions more generally (Shams et al., 2005; Watkins et al., 2006; Mishra et al., 2007). Thus, the sound-induced flash illusion may be taken to illustrate that mental imagery can be exogenously produced. States of the imagination are not necessarily endogenous assemblages of the brain in the way that PP theorists wish to think of perception.[3]

4. Empirical issues

I have been pursuing the idea that the distinctiveness of PP theories of perception is that they take an 'imagination-first' approach to perception, conceptualising perception in terms of mental imagery in the following respects: perception is a virtual reality in terms of its intentionality, at one remove from the external world, and perception is endogenously assembled via top-down mechanisms in the brain. Subsequently, I have claimed that this assumes to narrow a conception of mental imagery, entailing that PP theorists operate with a flawed account of the imagination when developing their views.

As well as making a conceptual claim about a perception/imagination unity, PP theorists, we have seen, also make an empirical claim. For instance, Clark (2014, p.39) claims that perception and imagination are simply "different ways of deploying the very same circuits and fundamental capacities" and even goes so far as to claim that "imagery and perception are not simply activating overlapping neural areas but are actually deploying the very same fine-grained internal representations when they do." (n.16)[4]

This is too quick, however. There exist several controversies about whether perception and imagination share a substantial neural substrate. Granted, one can certainly find neuropsychologists who claim that perception and imagination neurally overlap. For instance, one recently defended hypothesis is that imagery processing in the brain is just perceptual processing reversed (Dijkstra et al., 2020; see Pearson, 2019, pp.625–626 for discussion). Moreover, it has been claimed for some time that mental imagery makes use of circuitry in the early visual brain, i.e. V1/primary visual cortex (Kosslyn et al., 2001).

The above claims are grounded in brain-imaging-based observations of healthy, neurotypical subjects in experimental contexts. Yet they are starkly at odds with behaviourally-based observations of brain damaged subjects in clinical settings. The latter supply striking evidence that mental imagery and perception are neurally dissociable. In closing I will review some relevant clinical findings that bear on this discussion. When one considers these findings alongside the aforementioned experimental ones, a confusing and equivocal picture emerges concerning whether perception and imagination share substantial neural implementation. I will suggest that the situation should be resolved in favour of the clinical findings, as against PP theorists.

To begin, let us consider aphantasia. Aphantasia is an imagery disorder that can occur both congenitally and following brain damage; congenitally, aphantasia has been estimated to occur in up to 2% of the population (Zeman et al., 2015). Those with the condition are standardly claimed to lack mental imagery. Evidence for aphantasia was initially founded upon self-reports, i.e. low scores on the 'Vividness of Visual Imagery Questionnaire' or VVIQ (Zeman et al., 2010). More recently, at least two psychophysical correlates of the condition have been identified and which may be used to confirm its presence more objectively. These include an absence of imagery-based priming effects on vision in conditions of binocular rivalry (Keogh & Pearson, 2018) and the absence of

[2] Spence and Deroy (2013) make several distinctions among types of crossmodal imagery.

[3] Potentially, a second example of exogenous mental imagery is synaesthetic experiences. These are commonly identified with crossmodally-induced mental imagery, making ordinary crossmodally induced imagery continuous with synaesthesia, rather than distinct (Martino & Marks 2001; but see Seth 2014). Synaesthetic percepts, like imagery, can be experienced as either environment-directed or cloistered in their intentionality. (Dixon et al., 2004).

[4] The idea that perception and imagination rely on identical neural substrates is common wisdom in much of the philosophical literature on mental imagery. Highly developed lines of argument based on this claim can be found in Goldman (2006b) and Nanay (2016).

autonomic system arousal when reading emotionally-charged texts (Wicken et al., 2021). Some have claimed that aphantasia should not be considered an imagery disorder, arguing that it is more fundamentally a disorder of the episodic system (Blomkvist, 2022) but this won't matter for my purposes.

Research on aphantasia, while currently flourishing, remains in its infancy. Hence, some caution is needed when characterising the condition. It might be that what aphantasics lack is merely the capacity to self-generate mental imagery (Zeman et al., 2015). More controversially, it has been suggested that aphantasics have imagery, and merely lack introspective access to it (Nanay, 2021). Furthermore, many puzzles exist concerning the condition's relation to memory, dreaming, cognitive development, creativity, etc. (Dawes et al., 2020; Zeman et al., 2020; Dance et al., 2021; see also Whiteley, 2021).

Cases of 'pure' aphantasia following brain damage, i.e. without other impairments, are rare. But examples do exist. Consider a patient described by Moro et al. (2008, p.112), who acquired aphantasia and despite being unable to imagine objects was able to navigate their environment and visually identify objects without issue. Despite being unable to imagine objects, this patient had "no apparent impairments in their visual perceptual abilities." Thus, Moro and their collaborators claim the case provides evidence of "a very clear dissociation" between vision and visual imagery. Consider a second patient with acquired aphantasia, R.M., reported by Farah et al., (1988). R.M. retained "good" (p.161) visual object-recognition abilities, but was nonetheless unable to imagine objects.[5]

The relevance of aphantasia for Clark's claim that perception and imagination rely on the same neural circuits and capacities is clear. As authors of one of the first, large-scale studies of the condition put it:

> [Aphantasia] suggests perception and imagery do not rely upon identical neural substrates and representations [and] acts as further evidence towards a growing body of work demonstrating key differences between imagery and perception. (Bainbridge et al., 2021, p.160; see also Spagna et al., 2021, p.202)

What growing body of work is being referenced here? Tellingly, perception/imagination dissociations are not only found at a global level, as in aphantasia. In clinical contexts, a range of fine-grained, domain-specific dissociations have been observed, including:

- impaired colour imagery, despite normal colour perception (De Vreese, 1991);
- impaired colour vision, despite normal colour imagery (Bartolomeo et al., 1997);
- impairment to the ability to identify words and numbers via imagery, but not perception (Bartolomeo et al., 1998); and
- impairment to the ability to identify words and numbers via perception, but not imagery (Sirigu & Duhamel, 2001).

As one clinical review puts it, "every type of dissociation is possible" between vision and visual imagery (Bartolomeo, 2002, p.372; see also Zeman, 2020, pp. 694–698). Yet these local dissociations are not what should be observed if, as Clark proposes, perception and imagery are "different ways of deploying the very same circuits and fundamental capacities" as well as "activating overlapping neural areas" and "deploying the very same fine-grained internal representations when they do." (n.16) At the very least, PP theorists like Clark owe an account of how such claims are consistent with the local and global perception/imagination dissociations briefly reviewed here.

One possible reply turns to the nature of aphantasia itself. Suppose that aphantasia affects only one's capacity to voluntarily generate mental imagery (Zeman et al., 2015). Then, the neural implementation of imagery and perception could overlap quite substantially. The difference might lie in connectivity to other areas: higher ones in the case of imagery (and which are damaged in aphantasia) but striate cortex in the case of perception.[6]

The difficulty with this reply is that aphantasia can involve a deficit to involuntarily generated and voluntarily generated imagery alike. This is evidenced by the fact that aphantasics typically score poorly not merely on the VVIQ (Zeman et al., 2010), but also on the SUIS or 'spontaneous use of imagery scale' (Keogh & Pearson, 2018). The VVIQ asks participants to imagine scenes and rate their vividness. By contrast, the SUIS asks participants how commonly, and in what scenarios, they find themselves undergoing imagery in everyday life (Reisberg et al., 2003). While the VVIQ concerns voluntarily generated imagery, several questions from the SUIS concern involuntary imagery, e.g., "When I first hear a friend's voice, a visual image of him or her almost always springs to mind." The claim that aphantasia involves a deficit to voluntary imagery alone, and that this can assist PP theorists replying to objections concerning imagery/perception dissociations, is not obviously right.

In sum, neuropsychology paints a highly ambiguous picture concerning the neural implementation of perception and imagery. Experimental evidence points towards the kind of overlap that PP theorists affirm. Clinical evidence points in the opposite direction. There appears to be a kind of stand-off here. This depth of disagreement should be sufficient to give PP theorists pause.

All told, we may have reason to place greater weight on the clinical observations than the experimental ones. Crucially, the experimental, brain-imaging results are correlational in nature. This makes all the difference. For one, it cannot be ruled out that increased activity in visual areas of the brain during imagery tasks is simply a result of the brain's suppressing visual activity, particularly when such tasks are administered in eyes-open conditions (Pylyshyn, 2002, p. 224; see also Fidelman, 1994; Winlove et al., 2018 for further complications). In other words, the experimental evidence is consistent with increased activity in visual areas of the brain being, at best, a mere background condition of imagery's instantiation.[7]

The clinical evidence is, by contrast, more conclusive: aphantasia, and more fine-grained perception/imagination dissociations,

[5] This was not a 'pure' case due to the patient's verbal alexia (p.162), from which the clinicians inferred an attentional deficit.

[6] My thanks to one of the journal's anonymous referees for suggesting this.

[7] See Martínez and Artiga (in press) for discussion of neural enabling roles versus neural causal roles.

directly evidence that visually-based capacities and processes can be intact and operative while imagery-based ones are absent (and *vice versa*). As Bartolomeo et al. (2020) recently put it:

> Where does the discrepancy between the neuroimaging and [clinical] findings come from? The neuroimaging results supporting the hypothesis of an implication of early visual areas are correlative in nature, whereas deficits in people with brain injury demonstrate a causal contribution of the lesioned circuits to the relevant cognitive ability. (Bartolomeo et al., 2020, p. 517)

In sum, the fact that perception and imagination dissociate at a global level, as in aphantasia, and in local, domain-specific ways, puts significant pressure on a central empirical claim made by PP theorists of perception. It would be one thing if the dissociations were observed only at one level. The fact that they are present globally and locally intensifies the challenge.

5. Conclusion

This paper has scrutinised conceptual and empirical relationships between perception and imagination postulated by PP theorists of perception. Both have been found wanting. The imagination is not, of necessity, a kind of exogenously generated virtual reality on which PP theorists may model perception. And there is widespread evidence that imagination and perception are neurally dissociable, as evidenced by both aphantasia and various domain-specific dissociations. Taken together, the arguments here suggest that PP theorists should substantially temper, if not outright abandon, their claim of a supposed unity between perception and imagination. PP theorists who fail to do so are at risk of laying flawed conceptual and empirical foundations for their view of perception.

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.

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