


## WHY PERCEPTUAL EXPERIENCES CANNOT BE PROBABILISTIC

BY MATTEO COLOMBO<sup>1</sup> AND NIR FRESCO <sup>2</sup>

*Perceptual Confidence is the thesis that perceptual experiences can be probabilistic. This thesis has been defended and criticised based on a variety of phenomenological, epistemological, and explanatory arguments. One gap in these arguments is that they neglect the question of whether perceptual experiences satisfy the formal conditions that define the notion of probability to which Perceptual Confidence is committed. Here, we focus on this underexplored question and argue that perceptual experiences do not satisfy such conditions. But if they do not, then ascriptions of perceptual confidence are undefined; and so, Perceptual Confidence cannot be true.*

**Keywords:** perceptual confidence, probabilistic conscious experience, algebraic structure of experience, perceptual confidence scales, bayesian brain.

### I. INTRODUCTION

*Perceptual Confidence* (*PC*, henceforth) is the thesis that conscious perceptual experiences can be probabilistic (Morrison 2016; Munton 2016; Moss 2018: Sections 5.3–5.4). Suppose, for example, that I sip a glass of wine and report that it is probably sour; or that you look at the painter’s palette and say that it looks as though it is green; or that they hear a sound in the desert and are doubtful whether it is a baby or a coyote (cf., Siegel 2022; Morrison 2024). According to *PC*, each of these examples would plausibly involve probabilistic experiences. To be able to evaluate ascriptions of perceptual confidence such as these ones, however, and to understand what *PC* is committed to exactly, we should be clear on its nature and scope.

First, notice that *PC* makes a general claim about conscious perceptual experiences. This general claim does not entail any view about the computational processes in the brain that produce perceptual experiences (cf., Morrison 2016: 21–2). Such computational processes may or may not be

probabilistic, and psychologists and neuroscientists working on perception may or may not use probabilistic models to study and understand neuro-computational phenomena such as neural coding and neural computing (cf. e.g. Colombo and Seriès 2012; Rescorla 2015). But these considerations do not logically bear on whether *PC* is true. Likewise, if *PC* is true, nothing logically follows about how psychologists and neuroscientists should study and explain non-conscious processes underlying perceptual experiences. Nevertheless, the truth of *PC* would be a reason to expect the unconscious producers and consumers of perceptual experiences to rely on probabilistic representations.

Notice next that the scope of *PC* is not limited to visual experiences in humans. In fact, proponents like Morrison (2016: 18; 2024) and Moss (2018: 96) refer to other perceptual modalities besides vision, and to cases of multimodal perception (and even cases involving proprioception and the vestibular system in monkeys) to support *PC*.<sup>1</sup> So, arguments relevant to assessing *PC* can legitimately appeal to conscious perceptual experiences other than human vision.

Appealing to merely possible imaginary perceivers and their possible experiences would be irrelevant because *PC* is about actual perceivers and their conscious experiences. In this respect, *PC* differs from the kinds of theses put forward in Bayesian epistemology, which are typically about the normative constraints on rational degrees of belief (or credences) for ideal epistemic agents (e.g. Lin 2022; Titelbaum 2022; Staffel 2024).

In another important respect, however, *PC* and Bayesian epistemology are similar, as they both rely on probabilities that refer to *subjective* degrees of uncertainty (cf. Hájek and Staffel 2021). As Moss (2018: 91) points out, the central insight of *PC* is in fact that ‘experiences can be probabilistic in the same way that beliefs are’. One implication of this insight is that arguments against *PC* like the one we are about to develop in this paper will have no bearing on probabilistic ascriptions in scientific practices in perceptual psychology and neuroscience that assume *objective*, rather than subjective, probabilities—for example, ascriptions grounded in repeated measurements of some neural or behavioural event under controlled lab conditions, looking for the relative frequency of the occurrence of the event relative to a specific reference class. On the other hand, our argument, if sound, may apply beyond the domain of conscious experiences, to those practices in psychology and neuroscience that ascribe *subjective* probabilities to agents or their neural mechanisms. Insofar as these ascriptions are not intended to be merely instrumentally

<sup>1</sup> Munton, whose argument focuses on visual experience, also claims that ‘[t]he argument may generalize to perceptual experience and perceptual justification more broadly’ (2016: 302).

useful idealisations and are left empirically unconstrained by available objective probabilities,<sup>2</sup> they will be undefined.<sup>3</sup>

One last aspect that we should clarify is that *PC* can be interpreted in either of two ways. According to one interpretation, the contents of experiences can themselves be probabilistic. Probabilities would be ‘integrated into the propositional structure of [the] experiences’ (Morrison 2024; see also Morrison 2016: 37 ff; Moss 2018: 89–90). Here perceptual contents would take the form, say,  $\langle x, \textit{sour}, 0.65 \rangle$ , to be read as *object x is sour with a 0.65 probability*. According to a second interpretation, perceptual experiences can assign probabilities to their contents (Munton 2016: 316; Morrison 2016: 2; Moss 2018: 89–90). For example, my current gustatory experience could assign a probability to the perceptual content *object x is sour*, which would take the form  $\langle x, \textit{sour} \rangle .65$ . Some proponents of *PC* seem to commit to the first interpretation, and other proponents to the second one.

On both interpretations, *PC* has been defended based on phenomenological, epistemological, and explanatory arguments. Morrison (2016, 2017) appeals to phenomenological considerations to argue that probabilistic experiences best explain why perception can causally lead to credences about the external world with varying degrees of confidence. Focusing on the second interpretation, Munton (2016) argues that perceptual experiences must assign degrees of confidence to their contents if they are to offer non-inferential justification for some of our credences. Focusing on the first interpretation, Moss (2018: Section 5.4) offers epistemological and explanatory arguments in favour of the view that some perceptual experiences have probabilistic contents. Likewise, Morrison (2024) examines three experiments involving Bayesian modelling of visual processing in monkeys and argues that positing that the monkeys’ perceptual experiences having probabilistic contents best explains how the monkeys’ behaviours in those experiments are causally sensitive to unconscious probabilistic information.

The arguments in support of *PC* have been criticised on several grounds, including an appeal to the phenomenology of perception (Denison 2017; Block 2018; Nanay 2020; see also Holton 2016), the epistemology of perception and

<sup>2</sup> The idea that subjective prior probabilities should be ‘tuned to’ objective frequencies is widespread in Bayesian perceptual psychology (Feldman 2013). In explaining Bayesian perceptual psychology, Purves (2010, 227), for example, defines the prior as ‘the frequency of occurrence in the world of surface reflectance values, illuminants, distances, object sizes, and so on’. Jones and Love (2011), while criticising Bayesian approaches to mind and brain, likewise assume that priors ought to be based on ‘measurements from actual environments’ (both cited in Feldman 2013: 19).

<sup>3</sup> As pointed out by Hájek (2023): ‘Various studies by psychologists are taken to show that people commonly violate the usual probability calculus in spectacular ways. (See, e.g., several articles in Kahneman et al. 1982.) We clearly do not have here an admissible interpretation (with respect to any probability calculus), since there is no limit to what degrees of confidence agents might have’.

belief (Beck 2020; Byrne 2021; Raleigh and Vindrola 2021), and the explanatory relation between perceptual experiences, subpersonal probabilistic processing, and behaviour (Clark 2018; Denison, Block and Samaha 2022; Siegel 2022; Lee and Orlandi 2022). While these criticisms put a good amount of pressure on *PC*, there is a simpler, underexplored reason that undercuts *PC* in either of its two possible interpretations. That is, conscious perceptual experiences do not satisfy the formal conditions that define the concept of probability to which *PC* is committed. This means that probabilities do not meaningfully apply to actual perceptual experiences, and, consequently, that *PC* cannot be true. This is, in a nutshell, the argument that we develop in this paper.

We begin by laying out formal conditions for defining and applying a quantitative concept of subjective probability (Section II). With this background in place, we examine whether perceptual experiences satisfy three such conditions (Section III), namely: whether they have propositional content (Section III.1), whether they have an algebraic structure (Section III.2), and whether they have a suitable scale for meaningful probabilistic ascriptions of perceptual confidence (Section III.3). Based on the argument that perceptual experiences have neither an algebraic structure nor a suitable scale, we conclude that *PC* cannot be true (Section IV).

## II. FORMAL CONDITIONS FOR PROBABILITY

Proto-probabilistic, probability-like, qualitative concepts to talk and reason about uncertain situations predate formalisations of a quantitative, fully fledged, concept of probability. Although proto-probabilistic concepts presently coexist with rigorous formalisations of probability, it is the latter that play key roles in contemporary scientific practices and formal epistemology.

One seminal formalisation is Andrey Kolmogorov's (1933/1950) axiomatisation, which lays out the conditions that define the most widespread, and fruitful, quantitative concept of probability. These conditions posit a non-empty set  $\Omega$  of possible outcomes ('the universal set'), and an algebra ('field') of possible outcomes defined on  $\Omega$ , which is a set  $\mathcal{A}$  of subsets of  $\Omega$  that has  $\Omega$  as a member, and that is closed under negation and conjunction. (That is, if a possible outcome is in  $\mathcal{A}$ , then so is its complement, and if two possible outcomes are in  $\mathcal{A}$ , so is their intersection.) Given  $\Omega$  and  $\mathcal{A}$ , we can define a real-valued function  $f$ , which takes as inputs objects  $p$  belonging to  $\mathcal{A}$  and returns numbers  $x$ ,  $f(p) = x$ . To turn  $f$  into a *probability* function, three conditions should be satisfied. First, for any  $p$  in the algebra,  $0 \leq f(p) \leq 1$ . This condition sets the *scale* of probability: from 0 to 1. Secondly,  $f(\Omega) = 1$ ; and conversely,  $f(\emptyset) = 0$ . This says that the probability of outcomes corresponding to the universal set  $\Omega$  is maximal and sits at the top of the scale; and the probability of

outcomes corresponding to the empty set is minimal, sitting at the bottom of the scale. Thirdly, for all disjoint objects  $p$  and  $q$  belonging to the algebra  $\mathbf{A}$ ,  $f(p \cup q) = f(p) + f(q)$ . This third condition (or, ‘axiom of finite additivity’) specifies that the probability of a disjunction can be broken down into its additive component parts.

Kolmogorov’s axiomatisation is not the only existing formal theory of probability. Some alternative formalisations give up additivity; some allow probabilities to take infinitesimal values (smaller than every positive real number); some allow probabilities to be imprecise intervals rather than individual, precise, real numbers; some allow for probabilistic assignments to quantum superpositions of outcomes, and more (for a comprehensive survey of these alternatives, see Fine 1973; for a concise critical treatment, see Lyon 2016). More generally, probability is not the only way of representing uncertainty quantitatively; for instance, Wolfgang Spohn’s (2012) ranking functions provide us with an alternative way of representing uncertainty (for a comprehensive survey, see Halpern 2003; for a concise critical treatment, see Colombo, Elkin and Hartmann 2021: Section 4).

There are significant differences between different theories of probability, but these differences do not matter for our argument against *PC*. After all, any formal theory of probability that defines the kind of quantitative, subjective probabilities posited by *PC* is committed to the existence of a function from a set of *propositions* that forms some *algebra*, and to some *suitable scale* for defining, measuring, and comparing subjective probabilities. These commitments are requirements for a concept of probability in the way that legal chess moves are requirements of the game of chess. If you fail to satisfy the legal chess moves—say, by moving a bishop horizontally, you no longer play chess. Analogously, failing to satisfy the formal conditions of a theory of probability is to give up a certain concept of probability, and this would render certain probabilistic ascriptions meaningless. The failure to satisfy these formal conditions is the main motivation behind our argument, which is developed in the next section.

### III. DOES A QUANTITATIVE NOTION OF SUBJECTIVE PROBABILITY APPLY TO PERCEPTUAL EXPERIENCE?

We cannot explore the full range of probability theories here. But if we showed that perceptual experiences do not have an algebraic structure or do not have a suitable scale, then our conclusion that probability does not meaningfully apply to experiences would not depend on the specifics of Kolmogorov’s axiomatisation.<sup>4</sup> Instead, our conclusion would apply to all formal theories

<sup>4</sup> Proponents of *PC* might claim that a new, nonstandard theory of probability is needed to ground their view. The burden of proof, however, lies with the proponent of *PC*, as it is opaque what this new theory tailored to perceptual probabilities should look like.

requiring some algebraic structure involving conjunction, disjunction, or negation, and a suitable scale for meaningful measurements and ascriptions of subjective probabilities. Before arguing that perceptual experiences have neither an algebraic structure nor a suitable scale, we briefly consider whether they have propositional contents.

### *III.1 Do perceptual experiences have propositional contents?*

Let us start from the requirement that the *subjective* probabilities posited by *PC* should be defined on a set of *propositions*, as opposed to a set of events, which may instead be used to define objective probabilities. *PC* can satisfy this requirement, as one prominent approach to the nature of perceptual content posits that it is propositional similarly to doxastic content, because both belief and perception would be propositional attitudes. Unlike belief, perception purports to present us with how things *actually* are when we perceive them; its contents might constitutively involve token perceived objects; and it would possess a distinctive phenomenology. These differences might suggest that perceptual experiences have a different kind of propositional content than beliefs. But, if perceptual experiences have *some* kind of propositional content, the differences between perception and belief constitute no problem for *PC*.

However, several philosophers of perception have made the stronger claim that perceptual experiences do not have *any* kind of propositional content at all (e.g. Crane 2009; Hill 2022: Chapter 8; Block 2023). This claim is inconsistent with *PC*, as subjective probabilities attach to propositions. And in accepting that perception is propositional, proponents of *PC* would at least make a substantive, contentious assumption about the nature of perceptual content. Yet, making a contentious, unargued assumption is no strong reason to reject *PC*.

### *III.2 Do perceptual experiences have an algebra?*

Let us now examine the requirement that an adequate probability function should be defined on an *algebra*. By ‘algebra’ we refer to a mathematical structure consisting of a set of elements and operators for manipulating those elements. An algebraic structure is a requirement for meaningful definitions and applications of probabilities and their calculus.<sup>5</sup>

Considering the two interpretations of *PC* that we distinguished in the Introduction, it is important not to conflate two claims here. One claim is that the propositional contents of perceptual experiences form an algebra. The

<sup>5</sup> In fact, some algebraic structure is a requirement for defining precise, quantum, and imprecise probability, Dempster-Shefer functions, Dubois and Prade’s possibility framework, and Spohn’s ranking framework (see e.g. Halpern 2003; Colombo, Elkin and Hartmann 2021: Section 4).

other claim is that the experiences themselves form an algebra. While it is hard to understand what it would take for experiences themselves to form an algebra, it is still important to distinguish these two claims. The first claim does not entail that, for every proposition in the algebra, there is an experience with that as its sole content. It also does not entail that, for every proposition in the algebra, there is an experience that assigns it a non-zero confidence. In this section, with these disclaimers in place, we focus on the first claim only. Thus, if perceptual experiences satisfy this requirement, then they possess a logical structure, such that if  $p$  and  $q$  are contents of my conscious perceptual experiences, then their conjunction (intersection), disjunction (union), or negation (complement) must also be possible contents of perceptual experiences.

Perceptual contents can be conjoined, disjoined, and negated, but only in a rather specific sense. Logical operations apply to perceptual contents as far as we can *judge* that the content of visual experience  $E_1$  obtains and the content of visual experience  $E_2$  also obtains; or we can judge that either the content of  $E_1$  obtains or the content of  $E_2$  obtains; or we can judge that the content of  $E_1$  does not obtain. From these judgements, however, it does not follow that our seeings can have conjunctive, disjunctive, or negative contents.

One route to showing that perceptual experiences themselves do not have a logical structure starts from the idea that all perceptual experiences are iconic, or picture-like, rather than propositional (e.g. Crane 2009; Hill 2022; Block 2023). If this is so, then perception, unlike belief, does not have a logical structure, since the content of pictures cannot be conjoined, disjoined, or negated. If no perceptual experience can present us with either conjunctive, disjunctive, or negative contents, then perception lacks an algebra. And if perceptual experiences do not have algebraic structure, then they cannot be probabilistic either.

One problem with this line of argument is its starting point. That experiences have propositional content is a widely held idea in philosophy of perception, as we explained in the previous subsection; and it is also a presupposition of *PC*, given its commitment to subjective probability. It would be unfair to criticise *PC* for presupposing that perception has propositional content. We should find a fairer line of argument that does not assume that the content of perceptual experiences must be iconic and non-propositional. This line of argument directly relies on evidence that perceptual experiences, unlike beliefs, do not adhere to the rules governing operations like conjunction, disjunction, and negation. Let us start from a couple of suggestive cases.

When I have a gustatory experience, my experience involves the attribution of some qualitative property from the set {sweet, bitter, sour, salty, umami, cold, hot, crunchy} to some object of taste perception. If the qualitative properties involved in my gustatory experiences form an algebra, then if I perceive that the soup is probably umami, it should follow that I can also perceive that the soup is probably *non-umami*. In that case, the content of this experience

involves the complement of {umami}, which is the set of properties {sweet, bitter, sour, salty, cold, hot, crunchy} attributed—all simultaneously—to the object of that experience with some probability. But this attribution is absurd, as it is a ‘law of appearance’, as Pautz (2021: 130–5) puts it, that we cannot experientially represent the same object as cold and hot at the same time. Or, similarly, if all experiences of odours that I can have involve qualitative properties from the set {floral, fruity, nutty, sweet, minty, woody}, it does not follow that I can also perceive any disjunction of any such properties, attaching a subjective probability to the content *object x is either fruity or minty or woody or sweet*. This sort of experiential content would be ruled out by another law of appearance, according to which ‘an individual cannot experientially represent merely [for instance] *that there is either a red square in front or a green sphere on the right*, without experientially representing anything more specific’ (Pautz 2021: 131). There is, thus, no reason to think that complements or unions of experiences are themselves possible experiences of mine; and indeed, there is reason to think that they are not.

These two cases would probably leave proponents of *PC* unimpressed. One thing they may point out is that we seem to assume that for every proposition in the relevant algebra associated with a certain perceptual modality, there must be an actual experience with that content. But why does that matter for *PC* if I cannot have an experience, whose content, say, corresponds to the complement of {umami} in the example above? After all, there might be propositions in a certain mathematical domain that we cannot think, but that does not mean that we cannot be confident with a specific probability that other propositions in the same domain will turn out to be theorems. Relatedly, proponents of *PC* may also point out that the couple of cases we described do not properly distinguish between perceptual experiences failing to have algebraic structure and perceptual systems failing to output experiences that cover all possible propositions within an algebraic structure. A perceptual system may in actual fact never deliver specific outputs, but, again, this does not imply that the outputs it does deliver fail to have algebraic structure at all.

Our reply is in three steps. First, we agree that *PC* is compatible with the idea that actual perceptual systems fail to (be capable of) outputting experiences covering all possible conjunctions, disjunctions, or negations of perceptible contents within an algebraic structure. And for some phenomena in some modalities, we have an explanation for why perceptual systems fail to do that in terms of neurocomputational constraints on sensory processing. For instance, in the case of human colour perception, our visual system works with opponent channels that cannot be simultaneously activated. Such channels reduce the spectral dimensionality of all the reflected light signals it receives to three, partly because of the kind of spectral sensitivity of the three types of cone sensors in the retina (see e.g. Hurvich and Jameson 1957; Packer and Williams 2003). Thus, our visual system fails to process a substantial amount



of the information contained in the light signals, which would correspond to merely possible colour experiences.

Having clarified this point of agreement, the second step is to clarify that the two cases we sketched are meant to elicit intuitions about whether actual perceptual experiences have an algebraic structure in their own right. If, as we are about to argue, they do not, then the third step is to draw the conclusion that *PC* cannot define and make sense of the probability of perceptual experiences involving complex qualitative properties and their (synchronic or diachronic) relationships. It could only make sense of the probability of atomic propositional contents of experience. That is, if *PC* is true, but its probabilistic assignments are not grounded in any algebra, then when we experientially represent *that a surface has a dark colour with a grainy texture*, our experience could assign a perceptual confidence to the content *that a surface has a dark colour* and assign a perceptual confidence to the content *that a surface has a grainy texture*. But we could not assign probabilities to the union (disjunction) or intersection (conjunction) of these atomic perceptual contents. Without an algebra, no conditional probability can be defined. *PC* would also make no sense of trivial assignments of perceptual confidence such as this one: It is 100% probable that it is an experience of a dark colour, given that it is an experience of a dark colour with a grainy texture.<sup>6</sup>

Let us conclude this subsection by examining more closely whether actual perceptual experiences have at least some algebraic structure (i.e. conforming to conjunction, negation, or disjunction) in their own right. Most plausibly, an algebraic constraint on *PC* seems to be satisfiable for conjunction (or the intersection of sets). After all, complex experiences within a perceptual modality involve objects having a conjunction of different properties, such as shape properties, luminance properties, colour properties, and so on. The same point applies more generally to multi-modal perceptions, where a unified conscious experience is a composite, or conjunction, of other experiential contents bound up together. For example, I am now jointly conscious of various phenomenal properties like colours, shapes, odours, sounds, warmth, the stomach gurgling, and so on. Thus, it seems that actual human perceptions adhere with the operation governing conjunction introduction that conjoining two well-formed propositional contents (or two well-formed predicate representations) yields a well-formed conjunctive propositional content (or well-formed conjunctive predicate representation). As Block (2023: 181) explains, a natural, more specific, suggestion is that perceptual conjunction is the same operation as perceptual binding and is guided by the temporal synchronisation of neural firing patterns representing the conjoined contents. Thus, conjunction seems to be a plausible algebraic constraint that is applicable to perceptual confidences.

<sup>6</sup> A similar example is discussed in relation to alternative algebras underlying different formal theories of probability by Fine (1973: 62).

One problem with this suggestion is that the relationship between different perceptual features bound up together in my current experience is not best explained in terms of conjunction of atomic contents (or predicate representations). Rather, the best explanation is in terms of the different perceptual features occurring at the same time as parts of a common unified perceptual experience. Because conjunction introduction ‘cannot be analysed in terms of temporal co-occurrence or common parthood’ (Hill 2022: 202), perceptual binding cannot be a form of perceptual conjunction. This conclusion becomes more plausible still when we consider the operation governing conjunction elimination that a well-formed conjunction yields well-formed conjuncts. In Block’s (2023: 181–2) words: ‘I can bind red and triangular in perception, but I can’t just un-bind these aspects of the perception, seeing something as just red or just triangular’. If perceptual binding provides us with the best explanation of how different experiential contents or qualitative properties are attributed to a single scene or object in perception, and perceptual binding is not the same operation as conjunction, then we have no reason to posit perceptual conjunctions.

Consider negation next. One way to understand what it would be for perceptual experiences to adhere to the logic of negation is in terms of the complement of a given set, like in the case we described above involving an experience of non-umami. But we saw that there does not seem to be any specific type of phenomenology of tasting something as simultaneously sweet, bitter, sour, salty, cold, hot, and crunchy. There does not seem to be such experience of tasting the complement of umami. A different idea is that for a perceptual experience to express negation is to represent contradictions. For instance, when looking at figures like Maurits C. Escher’s *Belvedere*, it might seem we are perceiving a contradiction. But this conclusion is too quick, since, as Hill (2022: 200) puts it, ‘we never represent an impossibility, only the possible parts of an impossibility’. I must attend successively to different visual features of *Belvedere*, like the disposition and size of the pillars or the angles of the corners of different floors, and then try to combine them into a perception of a whole building before I realise that the depicted belvedere building is an impossible object. A third suggestion is that perceptual negation consists in perceiving absences. For instance, when I enter the café expecting to see Pierre at the table, but I do not find him there, it might seem that I perceive his absence (Sartre 1943/1956: 9–11). But again, this conclusion is too quick, since it confuses the successful perceptual experience of an absence with the perceptual *judgement* that someone is absent, which is inferred from the successful perception of whatever is present along with a certain expectation (cf., Varzi 2022). Thus, we have no reason to posit perceptual negation.

Finally, consider disjunction. If perception adheres to the principles governing disjunctive operations, then, from my current experience of a red blob on my left, I can form the disjunctive perceptual content *that either there is a red*

*blob on my left or there is a blue dot in front of me.* But I cannot form this content. There is no type of phenomenology associated with any disjunctive content because perception does not adhere to the logical principles governing disjunction (Hill 2022: 203; Pautz 2021: 131). Thus, we have no reason to posit perceptual disjunction either.

Morrison (2016: 35) seems to agree with this conclusion when he writes that ‘[t]he set of possibilities represented by your perceptual experiences might not be a  $\sigma$ -algebra, because your experiences might not represent every countable union. This might be another respect—he adds—in which they fall short of the ideal’. Here Morrison refers to countable additivity, which is one version of Kolmogorov’s third axiom that says that, given a countably infinite sequence of disjoint possibilities, their total probability is the sum of their individual probabilities. He denies that perceptual experiences adhere to this axiom—in fact, as we mentioned above, some alternative formalisations of probability do without countable additivity. However, Morrison’s reference to ‘the ideal’ might be confusing, especially in the context of perception.

Morrison seems to conflate the *constitutive* and *regulative* roles of axiomatisations of probability, when he writes that ‘we shouldn’t assume that our experiences assign confidences in ways that satisfy the axioms of probability theory. Just as our doxastic confidences can be more or less ideal, our perceptual confidences can be more or less ideal’ (2016: 21, and 34–5). But these claims are confusing, as the questions we naturally expect that proponents of *PC* address after they acknowledge that ‘perceptual experiences might not be a  $\sigma$ -algebra’ are whether experiences might be *any* algebra, and if so, *which one*. Morrison, like anyone else, has not shown that they might. But if my experiences do not have an algebraic structure, it is not only that they fall short of ‘the ideal’, but also that they may not be probabilistic *at all*, as some algebra of experiences is required to define and meaningfully apply quantitative probabilities to perception.

At least two replies are available to Morrison and other proponents of *PC* here. One reply is that the algebraic structure of perceptual experiences should not be established a priori, but it should rather be worked out based on the relevant empirical evidence. For example, if probabilistic experiences are individuated by neural representations of probability distributions, then the operations governing the dynamics of these neural representations and their relationships might provide us with clues about the algebra of perceptual experience. Researchers have been exploring different hypotheses concerning the way that neural activity might represent probabilities for decades (for a recent overview, see Ma, Körding, and Goldreich 2023: Chapter 14). Some of these proposals make some operations easier to be performed by neural systems compared to others. For instance, the hypothesis that neural activity represents log probabilities (rather than probabilities) would make multiplication easier, while the hypothesis that neural activity represents probabilities

(rather than log probabilities) would make addition easier (Pouget *et al.* 2013: 1172–3). Unfortunately, it remains controversial which of the several hypotheses currently available is the best candidate for how neural systems underlying perception might represent probabilities and perform probabilistic inferences.

Another reply that proponents of *PC* might develop is that all scientific and philosophical models include idealisations. Some think that it follows that we should be antirealists about ascriptions based on these idealised models to real-world target systems. But subtler, more plausible, views also exist, which would warrant taking at face value ascriptions of probability to persons and their experiences based on probabilistic models from epistemology, or from the sciences and philosophy of perception. In that case, we can acknowledge that psychological phenomena do not satisfy the formal requirements of probability theory, while still meaningfully attributing probabilities to them. And we would not thereby be conflating the constitutive and regulative roles of probability theory.

One potential problem with this reply is that it risks conflating two notions of idealisation. In one sense, idealised models are deliberately simplified or distorted representations of real-world target systems with the aims of making the model easier to build, manipulate, and analyse, or of focusing attention on key explanatory factors in the target system. In another sense, idealised (or ideal) models are representations of how rational agents ought to think or behave; and some norms would be constitutive of what it is to think or behave, while others would be regulative of what it is to think or behave well.

Now, *PC* is concerned with actual perceivers and their experiences, whereas in Bayesian epistemology the focus is on both constitutive and regulative normative constraints on credences. For instance, *probabilism* is a normative constraint in probabilistic models in epistemology that says that the credences of an ideal rational agent at a given time ought to satisfy the axioms of the probability calculus. Accordingly, probabilism assumes an axiomatic structure defining (or constituting) a concept of probability and makes a *regulative* claim about how one ought to reason probabilistically. Defended based on Dutch book arguments (e.g. Vineberg 2022) or epistemic utility arguments (e.g. Pettigrew 2023), the kind of claim probabilism makes is analogous to the regulative norm in chess according to which you ought to castle as soon as you are not defending any piece that is under attack. If you do not comply with this norm, you are still playing chess, but you might be playing it badly. Analogously, if your perception does not comply with probabilism, models of perceptual experience grounded in *PC* could involve the idealisation (in the first sense) that perceivers still comply with probabilism, contrary to the fact that they do not. But from this modelling assumption, we should not conclude that you do not perceive probabilistically at all; at best, it follows that you might be doing it badly.

But if it makes sense to say that our perceptual confidences can be ‘more or less ideal’ or more or less rational, perceptual experience must satisfy the formal conditions (or norms) constitutive of probability. If it does not, then there is no question about perception being more or less probabilistically ideal (or rational); and—as we already pointed out in footnote 3, referring to Hájek (2023)—we would not have any admissible subjective (or objective) interpretation with respect to any probability calculus. It is hard to see how to meaningfully attribute probabilities to perceptual experiences and how to evaluate these ascriptions, if perception just does not satisfy the norms constitutive of probability (A different route to the same conclusion starts by noting that it is a plausible regulative ideal on rational credences that they satisfy Kolmogorov’s axioms of probability, because credences *can* satisfy any precondition for those axioms—e.g. possible contents of credences form an algebra. If perceptual states do not satisfy those preconditions, then one cannot even make the regulative claim that they should conform to *probabilism*.)

To recap: in this subsection, we argued that perceptual experiences have no logical structure corresponding to conjunction, negation, or disjunction, which means they have no algebraic structure either. If perception is not an algebra, then *PC* could still be true; but it could not define and make sense of any complex perceptual experience and their relationships. Its scope would be limited to atomic contents of experience only. In the next subsection, we argue that *PC* cannot define and make sense of the probability of atomic contents of experience either, because perceptual confidences have no meaningful scale.

### *III.3 Do perceptual confidences have a meaningful scale?*

Analogously to how we sometimes use some generic notion of information in ways that do not satisfy any formal condition of information theory, one might assume that the notion of probability posited by *PC* may likewise not satisfy any formal condition for it to be meaningful and useful. We might assume that, analogously to information, we do not need any scale for defining, and talking meaningfully of perceptual probabilities.

This assumption is misguided, however; and the analogy with informal usages of a generic notion of *information* is not apt. This should be clear when we consider how proponents of *PC* qualify their thesis and its truth conditions. Morrison, for instance, clarifies that ‘if your perceptual experience assigns confidence to two propositions, there must be a ratio that approximately describes the amount that it assigns to each. It thus isn’t enough for perceptual experiences to involve an ungraded representation of uncertainty such as ‘possibly’ or ‘maybe’ (2024: 5). Neither is it enough that perceptual experiences involve some ordinal assignment such as ‘more or less probable than’, or some proto-probabilistic, probability-like, or non-quantitative ‘phenomenal hedge makers’ (cf. Siegel 2022). Rather, as we already explained, *PC* is committed to

a fully fledged, quantitative notion of subjective probability with a real-valued, numerical scale with a top and a bottom. The question then is whether there is such a scale for perceptual degrees of confidence.

Our answer is negative and is based on two arguments that we develop in the remainder of this subsection. First, graded properties of perceptual experience studied within perceptual psychology either do not have a ratio scale or, if they do, their ratio scale does not define or measure probabilistic, perceptual confidences. Secondly, *PC* is committed to subjective probabilities, but the main approaches used in psychology and measurement theory to study and try to measure subjective probabilities in human reasoners are not well-defined or meaningful. These two reasons indicate that ascriptions of perceptual confidences currently lack a suitable scale for defining and assessing them, but also that such a scale is not forthcoming.

Consider the first line of argument. The clarity, intensity, grain, temporal stability, and the hedonic value of a perception are graded experiential properties that can be quantified and ordered on a scale; and in the scientific study of perception these dimensions of experiences are quantified and can be used to construe perceptual spaces for modelling mental qualities. It has also been suggested that the clarity and grain of perceptual experiences are partly determined by probabilistic neural computations controlling the allocation of attention—more specifically, perceptual experiences would be partly determined by the precision, or reliability of the neurally encoded sensory signal (Denison 2017; Fazekas and Overgaard 2018; Vance 2021; Nave 2022). But *PC* is not a claim about the clarity, intensity, grain, temporal stability, or hedonic value of perceptual states. It is a claim about probabilities being assigned to contents of experience, or probabilities being part of the contents of experience. This claim presumes that perceptual experiences can be states of uncertainty that must be quantifiable numerically as probabilities; but perception does not seem to satisfy this constraint.

Take olfaction, for example. For olfactory experiences to be meaningfully quantifiable on a ratio scale, the ratios of the values (whatever they are) of two olfactory experiences on a scale must be invariant under any change from one scale assignment to another. In other words, they must be invariant under multiplication by a positive number—for example, given that volume is quantifiable on a ratio scale, multiplication by 568.26125 converts from imperial pints to millilitres. Furthermore, given the kind of ratio scale required for defining probability, if *PC* is true, some values of olfactory experiences must be placeable at the top of this scale, and some at the bottom. Existing scales and questionnaires in scientific practices for quantifying properties of taste and smell do not have these properties.

There are nevertheless various, qualitative, categorical, multidimensional scales quantifying the intensity, grain, and clarity of reported experiences in the sciences of olfaction and taste (e.g. Han *et al.* 2021; Niklassen *et al.* 2022).

None of these scales behaves as a probability scale, but this does not entail that some suitable scale for perceptual confidence in some other modality does not exist. For example, a potentially promising idea for proponents of *PC* is that suitable scales, as well as an algebraic structure, for defining and measuring probabilistic perceptual confidences, at least in some domain in some modality, can be found in recent work on perceptual spaces, or quality-space modelling (for general treatments, see Zaidi *et al.* 2013; Rosenthal 2015; Lee 2021; Kleiner and Ludwig 2023).

A perceptual, phenomenal space is a domain of qualities, which can be represented and studied based on a mathematical model of it. This model is defined by its dimensionality and geometry. For instance, most phenomenal colour spaces have a convex, three-dimensional geometry with one dimension representing hue, one saturation, and another representing lightness. Different points (or regions) in this three-dimensional space represent different experienced colour qualities. The main structural relationship between different points is a similarity (or distance) relationship, where points at closer distances would pick out colour qualities experienced as highly similar, or as indistinguishable. In fact, the dimensionality and geometry of all perceptual spaces are consequences of the operation that defines similarity relationships between different points. This operation is construed based on several types of behavioural and neurophysiological data about human perceptual judgments, and about neurones tuning curves or correlated neural firings (cf. Zaidi *et al.* 2013).

While there are several distinct kinds of perceptual spaces for a given domain in a specific modality,<sup>7</sup> similarity (or distance) relationships between points (or regions) in these spaces do not constitute an algebraic structure for perception, nor do they offer a suitable scale for perceptual confidences. Lee (2021) suggests that his framework for modelling mental qualities using regions or sets of points (rather than individual points) can be extended to accommodate *PC*. This can supposedly be done by defining a function (or ‘field’) from points to probabilistic values. Lee (2021: 293) is explicit that this function (or field) should be distinguished from the algebraic notion of a field; and he also recognises that his suggestion lacks many details. In particular, he does not specify the formal constraints for this function to be akin to a credence function.<sup>8</sup>

<sup>7</sup> For a review of colour spaces with different geometry and dimensionality, see Kuehni (2010).

<sup>8</sup> Note that existing scales for quantifying and studying graded aspects of perceptual experiences tend to confound properties of the contents of perception and properties of conscious experiences themselves (Rosenthal 2019; Michel 2019). If we assume *PC* is true and that experiences can be probabilistically structured in a way that is quantifiable on a probability scale, then this type of confound will at least make it harder to differentiate which one of its two interpretations is empirically more adequate.

Consider next our second line of argument that existing approaches used in psychology and measurement theory to study and try to measure subjective probabilities in actual human reasoners are not well-defined or do not allow for meaningful statements. Roberts (1985: Chapter 8; see also Eriksson and Hájek 2007) describes three approaches to the measurement of subjective probability. The first is to ask individuals to assign different possibilities a number that represents their subjective probability that the possibility obtains. One problem with this approach is that individuals' assignments do not track any well-defined probabilistic concept, and they do not form a ratio scale allowing for meaningful comparisons between different individuals. For instance, the sum of judged probabilities may not equal to unity; the probability of a conjunction of events may be judged as higher than the probability of individual conjuncts; or the difference between 1% and 2% may be judged as larger than the difference between 51% and 52%.

Another problem with this approach is that it does not obviously apply to perceptual confidences, since, under *PC*, probabilities are 'assigned by a state that's conscious, automatic, accessible, dissociable from doxastic states, directed toward perceived objects and properties, and fast enough that we can't detect any delay' (Morrison 2016: 20). Because of these properties, simply asking individuals to estimate their perceptual confidences will not reliably pick out any distinctively perceptual subjective probability. This method will then be unhelpful to make meaningful statements about perceptual confidences, where a 'statement involving (numerical) scales is *meaningful* if and only if its truth or falsity is unchanged under admissible transformations of all the scales in question' (Roberts 1985: 59). After all, admissible transformations of a scale for probability based on subjective judgements must be defined as functions preserving the empirical data the scale is meant to capture. But, as we noted a moment ago, the empirical data do not allow for the same transformations of each individual's probability scale (or of the same individual's probability scale across time), which means that comparisons between different probabilistic ascriptions are devoid of meaning. The first approach is, thus, highly problematic and does not allow us to construe a suitable scale for perceptual confidences.

The second approach described by Roberts (1985: Chapter 8.4) relies on *preferences* among different options (or lotteries). This approach builds on earlier work by Ramsey (1926/1990) and de Finetti (1970/1974), assumes that the utilities of different options are known, and aims to derive an individual's subjective probabilities from the individual's preferences among betting quotients associated with the options, where a betting quotient is the ratio of the stake to the total winnings. There are several, well-known problems with this approach to defining and measuring subjective probabilities constituting degrees of belief, including the worries that utilities associated with different options are plausibly non-linear, that individuals might dislike betting or lotteries, that



their preferences for options might be inconsistent, and that there does not seem to be any necessary connection between preferences and degrees of belief (cf. Eriksson and Hájek 2007). If anything, applying this approach to working out a suitable scale for defining and measuring perceptual confidences, rather than degrees of belief, makes these problems more intractable.

An additional challenge is that this approach requires that we know the utilities associated with different options. But it is opaque what perceptual utilities could be. One natural suggestion borrowed from epistemic-utility arguments in Bayesian epistemology (cf. Pettigrew 2023), and broadly consistent with some decision-theoretic modelling approaches to sensory estimation and inference (e.g. Geisler and Diehl 2003; Simoncelli 2009; Maloney and Zhang 2010), is that perceptual utility measures how much you value, epistemically, the outcome of having a certain perceptual experience given different ways the world could be. The basic idea is that the greater the epistemic utility of a perceptual experience, the greater its accuracy. However, it is at least contentious that the utility of conscious perceptual experiences is fully captured by their accuracy. Extant work challenges the idea that perception is aimed at presenting us with an accurate representation of the external world, since perceptual experience involves widespread inaccuracy (e.g. Prettyman 2019)—for instance, the human perceptual experience of temperature is exaggerated for temperatures that are likely to cause damage (cf. Akins 1996). Accurate experiences do not seem to be valuable ends-in-themselves, which suggests that perceptual utility is better understood not in terms of the degree of accuracy of experiential contents but by their role in guiding organism-specific actions in a certain environment. As Churchland, Ramachandran, and Sejnowski (1994: 25) put it, vision, like other perceptual modalities, ‘has its evolutionary rationale rooted in improved motor control’ (see also e.g. Ballard 1996; Hurley 1998; Noë 2004). If this is right, then it remains opaque what perceptual utilities exactly are, and how they should be measured. But if the utilities associated with different (perceptual) options are unknown, then this second approach, too, cannot be used for defining and measuring subjective probabilities associated with perceptual experiences.

The third and final approach we consider is to ask individuals to make *comparative judgements* of whether one possibility is more probable than another (cf. Roberts 1985: Chapter 8.4.2). From these comparisons, we can construe a binary relation defined on the set of possibilities that have been judged. This binary relation can be used to indirectly infer the probability of each possibility in the set for that individual. The problem here is that for making these inferences this approach assumes that the starting set of possibilities *forms an algebra*. But if perception does not have any algebra, then this approach will not reliably carry over from comparative perceptual judgements to perceptual confidences. Since we have argued above that perceptual experiences have no algebraic structure, the third approach is also inadequate.

If the current approaches to individuals' subjective probabilities do not allow us to construe a suitable scale that provides scope for meaningful statements involving perceptual probabilities, then *PC* cannot define and make sense of the probability of atomic contents of experience either. Indeed, some aspects of conscious perceptual experience might be graded, and some perceptual states might be states of uncertainty. However, if, as we have argued, perceptual experience does not have the kind of scale required by a meaningful probability function, then *PC* cannot be true.

#### IV. CONCLUSION

The starting point for a theory of probability is the feeling of uncertainty that we experience. This is the target that this theory is meant to define. Perception might be a state of uncertainty (Siegel 2022); and, perhaps, some aspects of conscious experience come in degrees (Fazekas and Overgaard 2016, 2018). Even if perception *is* a state of uncertainty and conscious experience *comes in degrees*, these would be no reasons to believe that perceptual experiences *is*, or can be, probabilistic.

But then, are we also committed to maintaining that we have no reason to believe that doxastic states can be probabilistic? No, we are not. Applying a concept of probability should prove its worth by producing beneficial results of some sort. The probabilistic notion of *credence* (or degree of belief) has generated many fruitful theoretical and practical results in fields like decision theory, Bayesian epistemology, and statistical reasoning. Even though there may be no satisfactory analysis of what credences are, we have an excellent reason to keep using an un-analysed primitive concept of *credence* in those fields, given the productive roles it can play (Eriksson and Hájek 2007). *Perceptual confidence*, however, is not like *credence*.

*Credence* currently enjoys a higher degree of proven fertility than *perceptual confidence*, which should be unsurprising given that the fruitfulness of a concept or research programme is a diachronic virtue, and *perceptual confidence* has been advanced only recently. Proponents of *PC* have all argued that *perceptual confidence* would generate several fruitful results in epistemology, philosophy of perception, and philosophy of science. But, as noted in the Introduction, their arguments have received various replies; and so, it is currently contentious whether *perceptual confidence* yields substantive fruit. One set of questions of particular interest to probe the fertility of the concept of *perceptual confidence* concerns the origin, dynamics, and justification of the credences of ideal agents. If accounts based on *PC* provide us with better answers to these questions than possible alternative accounts—for example, alternative accounts that are informed by Richard Jeffrey's (1965: Chapter 11) *radical probabilism*, which rejects the assumption that uncertain credences must be based on certain perceptual evidence, or alternative accounts that extend an agent's credal space with an

extra, ‘imaginary’ dimension of possibilities associated with sensory signals to explain how credences are justified and should change under the impact of perceptual experiences (Schwarz 2018)—then we would have good reason to retain the concept of *perceptual confidence*.

The main claim of this paper is that a quantitative notion of subjective probability does not meaningfully apply in the domain of conscious perceptual experiences. If it does not apply, *and* the concept of *perceptual confidence* yields no clear theoretical or practical fruit, then the most reasonable conclusion is that perceptual experiences cannot be probabilistically structured, and so, that *PC* should be abandoned.

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<sup>1</sup> *Tilburg University, the Netherlands*

<sup>2</sup> *Ben-Gurion University of the Negev, Israel*