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Perceptual Noise and the Bell Curve Objection

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1. Two Views of Perception

In the dim light of a restaurant, your visual experience doesn't settle the precise shade of the tablecloth. Taking your visual experience at face value, you come to believe that it is possibly scarlet, but also that it might be cardinal. Likewise, when you see a stick in the distance and attend to its length, you conclude that it is almost certainly between three and seven inches, probably between four and six inches, and that it might be exactly five inches. What must perception be like to support the assignment of confidences in belief — *doxastic confidences* — in these ways? Two views have been dominant.

According to PERCEPTUAL INDETERMINACY, perceptual content can be more or less determinate (Nanay 2010, 2018, 2020, Stazicker 2011). In daylight, your visual experience represents the tablecloth as having the relatively determinate shade scarlet. In dim lighting, it represents the tablecloth as having the determinable colour red without taking a stand on which precise shade of red it has. Likewise, your visual experience represents the stick as being between three and seven inches without specifying exactly which length it has. On this view, perception supports doxastic confidences without assigning confidences itself.

According to PERCEPTUAL CONFIDENCE, by contrast, your perceptual experience supports doxastic confidences because it assigns confidences too (Morrison 2016, Munton 2017). In daylight your visual experience assigns high confidence to the tablecloth's being scarlet and low confidence to its being cardinal. But in dim restaurant lighting, it assigns low (but non-zero) confidences to its being each of many shades of red, including scarlet and

cardinal. Likewise, your visual experience assigns low (but non-zero) confidences to the stick being each of many possible lengths.

Is there any way to decide between these two views? Morrison (2016) thinks so. He argues that PERCEPTUAL CONFIDENCE has a key advantage over PERCEPTUAL INDETERMINACY: it can explain why our doxastic confidences are bell shaped rather than plateau shaped. For example, when you see the tablecloth in dim lighting, you do not take every shade of red to be equally likely. Rather, you think it's most likely to be scarlet, somewhat less likely to be cardinal, and even less likely to be maroon. Your doxastic confidences thus take a bell-shaped distribution over shades of red, centred on scarlet, rather than a plateau-shaped distribution that treats all those shades as equally likely. Similarly, when you see the stick, your doxastic confidences take on a bell-shaped distribution that peaks at five inches, and then trails off at longer and shorter lengths. You think that the stick is more likely to be five inches than three inches or seven inches. But if your visual experiences merely represented determinables, Morrison claims that there would be no reason for your confidences to take on such a bell-shaped distribution. Instead, we should expect a plateau-shaped distribution in which each determinate value within the distribution is presented as equally likely. Thus, Morrison concludes that PERCEPTUAL CONFIDENCE is preferable to PERCEPTUAL INDETERMINACY. Call this *the bell curve objection* to PERCEPTUAL INDETERMINACY.

Here we show that two recent defences of PERCEPTUAL INDETERMINACY, due to Nanay (2020) and Raleigh and Vindrola (2021), fail to adequately address the bell curve objection. But we don't think things are hopeless for PERCEPTUAL INDETERMINACY. On the contrary, we show how PERCEPTUAL INDETERMINACY can address the bell curve objection by hitching itself to a new view, PERCEPTUAL NOISE, which can explain why doxastic confidences are bell-shaped while rejecting PERCEPTUAL CONFIDENCE. While PERCEPTUAL NOISE doesn't require a commitment to PERCEPTUAL INDETERMINACY, it is compatible with PERCEPTUAL INDETERMINACY. Proponents of

PERCEPTUAL INDETERMINACY can thus help themselves to it. The primary argument that was supposed to favour PERCEPTUAL CONFIDENCE over PERCEPTUAL INDETERMINACY is thus unsound, though for different reasons than others have proposed.

2. Nanay's Defence of PERCEPTUAL INDETERMINACY

Nanay argues that the bell curve objection rests on a misunderstanding of PERCEPTUAL INDETERMINACY. According to Nanay, proponents of PERCEPTUAL INDETERMINACY need not maintain that all determinates of a determinable are equally likely. To illustrate this point, Nanay appeals to an analogy with visualization.

> If I tell you that my armchair is red and I ask you to visualize my armchair, your imaginative episode attributes the determinable property of being red to my armchair. But what does this attribution of [a] determinable property amount to? Does this imaginative episode represent all possible determinates as having [*sic*] equally likely? No. It tends to represent some determinates as more likely than others. I have seen armchairs before and some shades of red are more often represented among them than others. So there is no prima facie reason to assume that representing a determinable property entails that all the determinates of this determinable are represented as equally likely. In fact, there is a prima facie reason to hold that representing a determinable would amount to a Bell shape-like representation of determinates, which depends on our previous exposure (in the case of the present example, our previous exposure to armchairs). (Nanay 2020: 165)

Nanay maintains that what is true of visualization is also true of visual perception:

> [W]hen I see [a] red dress at dusk, not all possible determinate shades of the determinable color property seem equally likely. Some will seem more likely than others — depending on the determinate color of reddish dresses I have been exposed to (Nanay 2020: 165).

He thus concludes that PERCEPTUAL INDETERMINACY can explain why our doxastic confidences are bell-shaped.

There is, however, an ambiguity in Nanay's argument. First, he might be suggesting that when you visualize a red armchair, the visualization *itself* represents the armchair as more likely to be scarlet than cardinal, say. This interpretation is suggested by his claim that 'this imaginative episode… tends to represent some determinates as more likely than others.' Carried over to perception, Nanay's view would then be that visual perception itself represents the perceived dress as being more likely to be scarlet than cardinal. But in that case, Nanay's view would assign confidences in perception, and thus be a recapitulation of PERCEPTUAL CONFIDENCE. Perceptual experience would represent that the dress is more likely to be scarlet than cardinal. This would obviously conflict with Nanay's stated aim of defending PERCEPTUAL INDETERMINACY as an *alternative* to PERCEPTUAL CONFIDENCE by showing 'that perception is indeterminate without appealing to probability either in the attitude or in the content' of perception (2020: 162).

Let us therefore consider an alternative interpretation of Nanay's argument. Perhaps he instead means to claim that when you visualize a red armchair, the visualization itself takes no stand on which shade of red the armchair is most likely to be; it simply represents the determinable red. It's only when you doxastically interpret your visualization that you come to represent some shades as more likely than others. Because your past experiences tell you that armchairs are more likely to be scarlet than cardinal, your doxastic gloss on your neutral visualization is that the armchair is more likely to be scarlet than cardinal. Likewise, when you perceive a red dress at dusk, you represent it as being a determinable colour that does not privilege any determinates that fall under the determinable. But because (according to this interpretation) the red dresses you've seen in the past tend to be scarlet more often than cardinal, you doxastically infer that the dress is more likely to be scarlet than cardinal.

The problem with this interpretation, however, is that it doesn't address the bell curve objection in its full generality. That's because there will be many cases of visual perception in which our past experiences give us no reason to favour one determinate over others, but in which our doxastic confidences are nevertheless bell shaped. This is arguably true of the red dress case. Red dresses come in many shades and it is doubtful that we really have expectations about which shades are most likely. Other cases are even clearer. When you see a stick and come to believe that it is more likely to be five inches long than three inches long, that isn't because your past experiences tell you that five-inch sticks are more common than three-inch sticks. Your past experiences are equally compatible with the stick being either of those lengths. Nevertheless, when you see the stick, you infer that it is more likely to be five inches long than three inches long.

Nanay's defence of PERCEPTUAL INDETERMINACY is thus unsuccessful. It either presupposes PERCEPTUAL CONFIDENCE or else fails to adequately address the bell curve objection.

3. Raleigh and Vindrola's Defence of PERCEPTUAL INDETERMINACY

Raleigh and Vindrola also endorse PERCEPTUAL INDETERMINACY. In reply to the bell curve objection, they claim that bell-shaped doxastic confidences could be a rational response to a perceptual experience that represents a determinable.

> [I]n response to the evidential proposition: 'The shirt is red', it could be entirely natural and rational to form a credence function about the colour of the shirt which is highest around the prototypical red, and which tails away towards less prototypical red shades. I.e. the rational response to this evidence would not be to form a plateau distribution over possible reds, but rather to privilege some regions of the colour space – those that correspond to more prototypical reds. Again, these indeterminate evidential propositions

> do not involve any kind of probability or graded confidence structure. Our suggestion then is that if a perceptual experience represents only a determinable shade of red, an immediate and rational response to that way of looking might be a non-flat credence distribution that favours more prototypical areas of red colour-space over less prototypical areas. (Raleigh and Vindrola 2021: 402)

They maintain, moreover, that this response needn't be based on a background belief about which shades of red the perceived object is most likely to have.

> This need not, we suggest, be based on any kind of inference or further belief. It could simply be the rational credential response to the indeterminate or imprecise nature of the evidence. (Raleigh and Vindrola 2021: 25)

Raleigh and Vindrola thus open up logical space for the possibility that the attribution of a determinable warrants a non-flat distribution of doxastic confidences.

We are in full agreement with Raleigh and Vindrola that this is possible. But to show that it is possible is not yet to show that it is the appropriate characterization of the transition from perceptual experience to belief. For there are also occasions in which the attribution of a determinable warrants a plateaued distribution of confidences. Suppose you know that an integer has been selected between 0 and 10. That knowledge in and of itself provides absolutely no reason for you to think that the integer is most likely to be 5. Nor does it warrant the belief that any one integer between 0 and 10 is more likely to be the selected integer than any other. The attribution of the determinable *an integer between 0 and 10* rationally supports a plateaued distribution of confidences. This is so even if 5 is a more 'prototypical' number than 0.

Raleigh and Vindrola thus do not fully address the bell curve objection because they do not explain why their red shirt example is a better model for perceptual experience than the

random number example. They do not explain why the rational response to experience is a bell-shaped distribution rather than a flat distribution.

Note that the appeal to 'prototypical' values in the red shirt case won't help. For even if some reds are the most prototypical, it is doubtful whether some stick lengths are the most prototypical (at least within a large range of possible stick lengths). Prototypicality thus cannot explain why an indeterminate visual perception of a stick in the distance should lead one to favour certain determinate lengths over others.

Moreover, even if Raleigh and Vindrola could somehow show that the attribution of a determinable in itself warrants a *non-flat* distribution of confidences, it wouldn't follow that it warrants a *bell-shaped* distribution of confidences. There are many other shapes a non-flat distribution might take. An adequate reply to the bell curve objection would thus need to explain why it is rational to distribute doxastic confidences in the specific shape of a bell curve. We will now take up the task of providing such an explanation.

4. Perceptual Noise

Perception is known to be corrupted by noise, factors that influence how a stimulus is perceived but that are unrelated to the stimulus itself. In low light, vision is influenced by photon noise, a product of the quantum nature of light that obeys a bell-shaped Poisson distribution. Under greater illumination, photon noise becomes irrelevant, but other types of external noise are still present, such as interference effects from competing light sources, refraction from particles in the air, and reflections. There are also sources of internal noise, such as random fluctuations in blood flow, temperature, metabolic activity, membrane potentials, and neural firing rates, all of which can influence visual processing.

The idea that noise is bell shaped makes intuitive sense. When you perceive a stimulus, random events are likely to distort your perception. But on the whole, those distortions are

more likely to be small than big. They're more likely to make the stimulus appear a little different than it really is rather than a lot different. Thus, the distortions will take on a bell-shaped distribution. The idea that noise is bell shaped also receives some empirical support. Signal detection theory, which has successfully dominated psychophysics for several decades, posits Gaussian noise. This might be justified by appeal to the central limit theorem in probability theory, which states that the sum of many independent random variables tends toward a normal distribution. But we needn't assume a Gaussian distribution per se. Any distribution that is roughly bell shaped will do.

According to PERCEPTUAL NOISE, perception supports doxastic confidences because it is subject to bell-shaped noise. When your perceptual experience estimates that a quantity takes value *V*, you endorse a bell-shaped distribution of doxastic confidences that reflects the fact that this estimate is noisy.[1] This explanation is independent of PERCEPTUAL INDETERMINACY. Suppose that *V* is a determinate. For example, suppose you visually experience the stick as exactly five inches long. According to PERCEPTUAL NOISE, your doxastic response should assign a bell-shaped distribution of confidence values centred on five inches. PERCEPTUAL NOISE thus does not require the representation of determinables.

But there are independent reasons to think that perceptual experience represents determinables. One reason has to do with the limited spatial resolution of perception (Stazicker 2011: 172–73). Visual spatial resolution is sharpest in the fovea (though even there it is limited) and degrades at greater eccentricities, suggesting that spatial properties are represented at various levels of determinacy. Another reason derives from categorical perception. Observers are more sensitive to changes across category boundaries than within them. While the light from a rainbow varies continuously, you see it as a series of discrete bands. This suggests that

[1] This is not to deny that the doxastic response may introduce its own sources of 'metacognitive' noise. See Shekhar and Rahnev 2021 for discussion.

we perceive determinables such as red and orange in addition to more determinate colour shades. There is also reason to think that shapes are represented at various levels of determinacy (Green 2017).

Given the independent evidence for PERCEPTUAL INDETERMINACY, it is worth noting that PERCEPTUAL NOISE is compatible with the representation of determinables. If you visually experience the stick as being between three and seven inches long, PERCEPTUAL NOISE maintains that your doxastic response should assign a bell-shaped distribution of confidences that centres on five inches, the midpoint of that determinable. PERCEPTUAL NOISE can thus be combined with PERCEPTUAL INDETERMINACY.

When you see a tablecloth in daylight, you assign a different doxastic confidence distribution than when you see it in the dimly lit restaurant. In daylight, you are highly confident that the tablecloth is scarlet. In the restaurant, you are less confident. According to PERCEPTUAL NOISE, that's because there's greater perceptual noise when there's less light. PERCEPTUAL NOISE thus makes an empirical prediction: the perceptual system knows about its own noise. There is evidence that bears out this prediction. For example, when people are given conflicting evidence about the width of a stimulus from vision and touch, the resulting estimate is a Bayes-optimal compromise that takes into account how noisy each sensory channel is. When noise is added to vision, the estimate places greater weight on haptic cues; and when noise is added to touch, the estimate places greater weight on visual cues (Ernst and Banks 2002).

The thesis that the visual system 'knows' about its own noise need not require an explicit representation of noise. It could be that the visual system simply 'knows' about its own noise in the following sense: when conditions are less favourable (e.g., the light is dim or the stimulus is far away), the visual system's estimates are given less weight (e.g., in cue combination) and generate doxastic confidence distributions with greater variance. This is not

unlike how a jury would discount the testimony of a witness who claimed to identify the defendant at the scene of the crime but then admitted, upon cross-examination, that the suspect was far away and that the night was dark. The totality of the evidence is taken into account (Beck 2020: 183–85). Proponents of PERCEPTUAL INDETERMINACY will also hold that the perceptual estimates themselves become less determinate as the conditions become less favourable.

Like Raleigh and Vindrola, we're proposing that the transition from perception to belief is a transition from one mental state that does not assign confidences (perceptual experience) to a second mental state that does (belief). We also agree that background beliefs needn't be involved (Beck 2020: 185–86). The disposition to transition from determinate or determinable perceptual experiences to bell-shaped doxastic confidences could be built into the mind, as a result of evolution, learning, or both. (By comparison, the visual system's disposition to treat light as though it comes from above does not require the perceiver to have the general belief that light comes from above; the assumption is built into the visual system.) But unlike Raleigh and Vindrola, we have explained why this transition is rational. And we have explained why it should take the shape of a bell.

5. Conclusion

Previous accounts of PERCEPTUAL INDETERMINACY have failed to explain why a bell-shaped doxastic confidence distribution constitutes a rational response to a perceptual experience of a determinable. Consequently, they have failed to provide a satisfactory reply to the bell-curve objection. Accounts that embrace PERCEPTUAL NOISE are more promising. They not only explain

why doxastic confidences are bell-shaped, but also why bell-shaped confidence distributions constitute a rational response to experience.[2]

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