Is Blindsight Possible Under Signal Detection Theory? Comment on Phillips (2020)

Matthias Michel[1,2], Hakwan Lau[3,4,5,6]

1. Centre for Philosophy of Natural and Social Science, London School of Economics and Political Science, London, UK
2. Consciousness, Cognition & Computation Group, Université Libre de Bruxelles, Belgium
3. Department of Psychology, UCLA, Los Angeles, 90095, USA
4. Brain Research Institute, UCLA, Los Angeles, 90095, USA
5. Department of Psychology, University of Hong Kong, Pokfulam Road, Hong Kong
6. State Key Laboratory of Brain and Cognitive Sciences, University of Hong Kong, Hong Kong

Abstract: Phillips argues that blindsight is due to response criterion artefacts under degraded conscious vision. His view provides alternative explanations for some studies, but may not work well when one considers several key findings in conjunction. Empirically, not all criterion effects are decidedly non-perceptual. Awareness is not completely abolished for some stimuli, in some patients. But in other cases, it was clearly impaired relative to the corresponding visual sensitivity. This relative dissociation is what makes blindsight so important and interesting.

Keywords: blindsight, signal detection theory, consciousness

Residual visual abilities have long been reported after damages to the primary visual cortex (V1). The term 'blindsight' was introduced by the late Larry Weiskrantz, to highlight that these abilities sometimes come with little or no acknowledged subjective awareness. Since its introduction, the phenomenon has been controversial. But many of the issues raised by critics have been methodically addressed (Cowey, 2004; Weiskrantz, 2009a, 2009b), earning the phenomenon the status of standard textbook knowledge (Cowey, 2010; LeDoux et al. 2020).

It is in this context that we welcome Phillips' latest critical evaluation of the phenomenon (Phillips, forthcoming). While his arguments have historical origins (Campion et al. 1983), they helpfully pinpoint a few unresolved issues in a novel way. These issues, especially those concerning psychophysics, remain commonly misunderstood. Once they are clarified, we think blindsight cannot be interpreted in the ways Phillips suggests.

Little or no awareness?

Phillips argues that blindsight patients consciously see visual stimuli. Such experiences may be difficult to describe because the perceptual process is impoverished and qualitatively different from vision in the intact field. As such, the patients may not acknowledge these experiences under a conservative reporting strategy.

We do not doubt that awareness occurs for some stimuli, in some patients diagnosed as having 'blindsight'. For example, 'type 2 blindsight' is common for high-contrast, fast-moving stimuli (Weiskrantz et al. 1995; Zeki & ffytche 1998); patients may be aware of the presence of some stimulus while the experience lacks specific content, such as movement direction (Weiskrantz, 2009a).

There are debates about the exact nature of these impoverished experiences (Brogaard, 2015; Kentridge, 2015; Macpherson, 2015; Zeki & ffytche, 1998). But the relevant issue is whether there are *any* cases under which awareness is truly dissociated from perceptual sensitivity – as reflected by one's ability to perform well in visual tasks. For well-studied patients like GY, the case for dissociation is strong for low contrast, static (or slow-moving), monochrome stimuli (e.g., Sahraie et al. 1997, 2010; Stoerig et al. 2002; Weiskrantz et al. 1995). We will focus on these cases here.

The argument cannot be that these are exceptional cases, such that a single account accommodating more stimuli types and patient cases is better. True blindsight is a rare phenomenon. To account for blindsight is to account for the specific and exceptional cases. That's why we study these rare patients carefully.

Phillips argues that even for these stimuli, there may still be some degree of awareness. The complete absence of any kind of awareness may be difficult to ascertain. But even assuming that blindsight patients do have some visual experiences in their blind field, it is an important question whether these patients perform visual tasks above chance *because* of their having those experiences.

Phillips writes that in some cases such awareness could be “feature-agnostic” (p.49). But for our purposes, a non-specific kind of awareness seems irrelevant. If their experiences do not represent specific visual features, or provide relevant clues as to *what* features are visually presented, the patients’ experiences cannot account for their ability to discriminate between *specific visual features* (Cowey, 2004; Weiskrantz, 2009).

The evidence cited by Phillips as indicating weak conscious experiences in the blind field does not vindicate the much stronger claim that patients are always conscious of the specific *visual features* that they use to perform visual tasks.

For instance, Phillips cites Mazzi et al. (2016) as supporting the claim that blindsight subjects report awareness when using the right scale, and that “awareness will, all else equal, correlate with performance” (p.34). He does not mention that the subject performed at chance level in four of the five tasks, and yet reported “awareness” more than 50% of the time. Contrary to Phillips’ claim, this suggests that blindsight patients’ occasional reports of awareness are often unrelated to the specific features that they perceive, or are simply tied to the fact that *something* was presented. In some cases, as in patient D.B, performance could sometimes *increase* “when conditions were arranged to abolish any acknowledged experience whatever” (Weiskrantz, 2009, p.134).

We share Cowey’s (2004) view that reports of awareness might often result from learned correlations between the presentation of stimuli and the sensori-motor results of sensory processing, such as eye movements. This could allow blindsight subjects to know when something is presented, without consciously knowing *what* is presented. Such mechanism can account for Stoerig & Barth’s (2001) finding, cited by Phillips, that visual fields are practically full when “aware” instead of “seen” reports are required. It is also consistent with their failure to find a phenomenal match between the blind and intact fields for static stimuli: “Whenever the contrast was high enough for anything at all to be visible, GY pronounced [the stimulus in the intact field] as simply ‘‘visual’’ and thus as ‘‘no match at all’’ for what he was aware of in the impaired field.” (p. 581).

So, what remains is the drastic discrepancy between acknowledged awareness and visual abilities in blindsight. It is this dissociation between awareness and sensitivity that makes blindsight so special (Weiskrantz, 2009). Whatever feeble level of awareness there might be in well-studied blindsight patients, it seems to lack specific content. As such it is incongruent with the patients’ striking ability to discriminate stimuli – sometimes at up to above 90% correct.

Performance matching

The discrepancy between awareness and performance is most evident in cases of performance matching (Morales et al. forthcoming; Sahraie et al., 1997; Weiskrantz et al. 1995). In patient GY, damage to the primary visual cortex mainly affected his right visual field. By presenting weaker stimuli on the left, Persaud et al. (2011) made sure that the patient was equally able to discriminate stimuli in both the ‘normal’ and ‘blind’ fields. But GY reported awareness much more frequently on his ‘normal’ field (43% vs. 3%).

Interestingly, GY was just as willing to bet money on discriminations in his ‘blind’ field, indicating that he was, in a sense, ‘aware’ of his overall good performance. But across trials, high bets did not correlate as well with his accuracy in the ‘blind’ field, as it did for his ‘normal’ field.

Phillips suggested that this betting behavior may not reflect unawareness, because it was not analyzed using signal detection theoretic measures. But the point of these measures – some which only developed after the study was initially conducted (Maniscalco & Lau, 2012) – was primarily to remove the effects of bias. Because GY was just as willing to bet on his ‘blind’ field, we can rule out this issue.

Likewise, Phillips argued that Persaud et al.’s finding may reflect loss aversion or use of suboptimal strategy. Again, the fact that GY placed high bets just as often in his ‘blind’ field suggests that he was no more loss averse, nor was he using an overall different strategy. Instead, what the results show is that GY lacked the ability to directly introspect on his performance in the ‘blind’ field. He had overall general knowledge as well as confidence for his ‘blind’ field performance, but could not directly assess when this performance was good or bad, in a trial-by-trial manner.

As such, for the awareness ratings in blindsight, a conservative bias due to personality, tiredness, motivation, or general strategy, is unlikely; the comparison was within the same person during the same experiment. Nor can this result be explained by an appeal to the Neyman-Pearson objective (Macmillan & Creelman, 2005), since performance was matched between both visual fields.

In response, Phillips remarks that blindsight patients could apply different response criteria in the two visual fields, because the relevant experiences might involve different contents (Kahneman, 1968). Compared to the ‘normal’ field, experiences in the blind field may be too degraded to be subjectively appreciated as “visual”. Another possible explanation could be that GY selectively set a conservative criterion for stimuli presented in the blind field because he felt expected to do so, or because he believed that his blind field was less sensitive than his intact field.

It is true that GY knew about his own condition, and this might have influenced his expectations. But it is unclear how this would have only affected his awareness ratings but not his wagering, and only for specific stimuli but not others. Indeed, changes in reported awareness can happen *within* the blind field when stimulus parameters are manipulated. In these cases, a change in contrast (Weiskrantz et al. 1995), spatial frequency (Sahraie et al. 2010; Stoerig et al. 2002), movement speed (Sahraie et al. 1997, 1998; Zeki & ffytche, 1998), or presentation location (while holding stimulus constant) (Kentridge et al. 1997; Sahraie et al. 2006), was sufficient to lead to a change in awareness, in ways unmatched by task performance.

Why would blindsight patients apply radically different response criteria, both across visual fields, and within the blind field? Empirical studies have shown that normal observers are not so flexible in adopting different response criteria for stimuli presented in different locations (Gorea & Sagi, 2000), nor are they very quick in adjusting these criteria (Brown & Steyvers, 2005).

Phillips insists that in all of these instances of reported unawareness, the content somehow became qualitatively different and less “visual”. But in what sense was the content more visual when the stimulus was presented in one location compared to another? Why would there be any difference, given that performance was also matched? We know that there is a difference in reported awareness. It would be *ad hoc* to hypothesize unacknowledged non-visual experiences just to account for that difference. Merely *saying* that such experiences exist does not help – unless one can pinpoint additional and meaningful functional differences.

If Phillips is correct that experience in blindsight is merely impoverished and atypical, one may expect that patients may be able to learn to monitor and make use of these experiences more effectively over time (Cleeremans, 2020). After all, as sensory substitution experiments have shown (Macpherson, 2018), with training people are able to learn to make use of highly unusual experiences. Instead, in GY, even after years of living with the condition, as well as participating repetitively in similar studies, he could not introspect correctly on his performance in a trial-by-trial manner (Persaud et al. 2011). This suggests that blindsight is more than the mere unfamiliarity of atypical experiences. Instead there seems to be fundamental limitations as to how much experience there is for one to learn to introspectively monitor, even with prolonged exposure.

One plausible functional difference between blindsight and normal vision is detectability. Perhaps the patients deny awareness when the stimuli are not so *detectable*. Theoretically, two visual stimuli can be highly discriminable from each other, and yet both could be poorly detectable; detection and discrimination rely on different information (or signal dimensions). An undetected but discriminable stimulus may not be subjectively appreciated as “visual”. There is a good sense in which it has a qualitatively different content from a highly detectable stimulus.

There is in fact some evidence for the dissociation between detection and discrimination sensitivities in blindsight (Azzopardi & Cowey, 1997; Yoshida & Isa, 2015). So matching discrimination performance alone, as Persaud et al. did, is arguably not enough. But as we will see, Phillips cannot accept this interpretation.

Impaired detectability?

Theoretically, one’s sensitivity for a two-alternative forced-choice (2AFC) task is related to one’s sensitivity for a corresponding yes-no (YN) detection task, by a factor of $\sqrt{2}$ (Macmillan & Creelman, 2005). Phillips pointed out that this theoretical relationship does not always hold empirically (see Yeshurun et al. 2008). But in instances where the theoretical expectation is reportedly violated, one may question whether detection d' was always estimated correctly. In particular, the equal-variance assumption of signal detection theory does not always hold for detection tasks (Macmillan & Creelman, 2005; Mickes et al. 2007), which means that parametric d' estimates are often inaccurate. To deal with this issue one should collect multiple levels of responses and conduct a full ROC (Receiver Operating Characteristics) analysis to estimate detection sensitivity.

When this was done correctly by Azzopardi & Cowey (1997), the theoretical relationship between detection and 2AFC *d′* was found to be robustly held for GY's intact visual field, as well as for motion stimuli in the blind field (Azzopardi & Cowey, 1998). It did not hold, however, for static stimuli presented in GY's blind field (Azzopardi & Cowey, 1997). So empirically, there was a very selective breakdown that called for an explanation. Yoshida & Isa (2015) also found the breakdown of this theoretical relationship between YN and 2AFC sensitivities following V1 damage in monkeys.

This finding has been taken to mean that blindsight is a genuine *perceptual* phenomenon (Azzopardi & Cowey, 1997; Cowey, 2004, 2010; Ko & Lau, 2012; Yoshida & Isa, 2015). Detection sensitivity was selectively impaired, which seems conceptually relevant to awareness. However, Phillips attempts to write off this effect (Azzopardi & Cowey, 1997) as the result of criterion "jitter": criterion setting may be particularly unstable for the YN task, leading to underestimation of true YN sensitivity.

But what caused this criterion jitter? According to Phillips, part of the explanation could be that blindsight patients were "unable to draw on any reservoir of traces from prior *experience* to project into their current trace pool and thereby help stabilize their current criterion." (p.54; italics ours). But this cannot be true for the blind field in general. Indeed, there was no such effect for motion stimuli (Azzopardi & Cowey, 1998). Incidentally, GY was aware of motion in the blind field in some instances (e.g., Weiskrantz et al. 1995; Zeki & ffytche, 1998).

One way to explain criterion jitter is that in the absence of conscious experiences of the task-relevant features, patients multiply their attempts to correctly set their response criterion (Figure 1D). When patients are conscious of those features – as when they have to detect a moving stimulus – it is easier for them to adjust their response criterion, thus leading to a more stable criterion. According to this view, the 'experience' highlighted above refers precisely to *conscious* experience.

This explanation is not available to Phillips, since according to QDC patients are conscious of static stimuli as well. An alternative hypothesis – compatible with Phillips' account – is that criterion is more stable for motion stimuli because the reservoir of traces is larger for motion contents compared to static contents. This could be the case if motion perception is more preserved than perception of motionless stimuli in the blind field, and if blindsight subjects do use motion perception in the blind field in everyday life, thus leading to a larger reservoir of traces for motion contents. While this is a plausible hypothesis, it is currently speculative, given that there is no evidence that blindsight patients do use blind field contents in everyday life, and also no evidence for an asymmetry between their use of static contents compared to motion contents.

Putting this disagreement on the source of criterion jitter aside, Phillips maintains that GY's lower-than-expected detectability was entirely due to the 'artefact' of criterion jitter, which has little to do with awareness. This would mean that, whenever 2AFC performance was matched, the actual underlying signals in the blind and good fields were probably also matched in detectability.

In that case, why does Phillips think the content in blindsight is qualitatively different from normal vision? If it was less “visual”, it is unclear how. And why would patients not acknowledge awareness, if detectability was actually preserved? Presumably the answer is that the content, though detectable, is somehow not taken as visual. But the discrimination performance reflects specific visual contents. If the patients are unaware of these very contents, awareness of other forms is beside the point. The dissociation between awareness and sensitivity remains just as paradoxical.

Are all criterion effects non-perceptual?

Why then does Phillips hold that a criterion explanation trivializes the result of Azzopardi & Cowey, that GY had selective detection sensitivity impairment? It was Azzopardi & Cowey themselves who first suggested criterion jitter as an account of their findings. But they did not interpret it as a trivializing account. The difference is that for Phillips, criterion effects observed in blindsight are non-perceptual. Indeed, a common assumption in the interpretation of Signal Detection Theory is that criterion effects do not have a perceptual source (Peters et al. 2016). This view has a somewhat confusing history.

Decades ago, researchers believed that there were absolute perceptual thresholds. Perception does not happen for a stimulus presented below this threshold intensity. The advent of signal detection theory (SDT) made the case that there is no ‘hard’ threshold. With enough trials, even a very small increment in stimulus intensity can be detected statistically *above chance*.

Importantly, the lack of a ‘hard’ threshold means that if a stimulus of some positive intensity is consistently reported as ‘unseen’, conservative detection criterion is likely the culprit. Some degree of underlying perceptual sensitivity would be revealed if the subject used a more neutral criterion and were tested on many trials. This leads to the common wisdom that criterion effects may ‘contaminate’ true sensitivity. SDT can be used to remove such artefacts.

But a stimulus detectable at some degree of perceptual sensitivity isn’t necessarily *perceived* on *every single trial*. Sensitivity concerns the statistical behavior of the perceptual system *over many trials*. Above-chance detection over many trials does not mean that a very weak stimulus is perceived in all instances. Otherwise, wouldn’t one have to posit weak conscious experiences even for correct rejection trials?

The above point is admittedly controversial. Many do assume that even on correct rejection trials there may be some minimal degree of experience. In the case of memory, this view may be particularly plausible. For example, when we meet a new person, it is likely that we have a minimal sense of familiarity even in cases where we correctly reject that we have visual memory of having seen that person before. In addition, this conscious sense of familiarity may vary from trial to trial, between different instances of correct rejections.

This interpretation is also compatible with the influential view that the very internal signal on which detection decisions are made is expressed in terms of the likelihood that there is a target, e.g. a face that we have seen before (Macmillan and Creelman, 2005; McClelland & Chappell, 1998). This view assumes that the decision was not made on the scale of some raw physiological units, but rather on a scale that already affords representational meaning. So whatever amount of internal signal there is, it reflects a precise degree to which a meaningful memory trace or percept is likely. As such, it may be plausible to assume that this meaningful signal always reflects at least some minimal degree of experience, regardless of whether it falls above or below some criterion.

But in the case of perception, there is a case to be made that for a specific visual object, there are clear cases in which we just have no corresponding experience. For example, neurons coding for specific objects are known to show spontaneous activity. As the readers are reading this, neurons coding for an elephant may fire periodically. But such neuronal noise does not get confused as hallucinations. When we correctly reject that there is an elephant in front of us – which is most of the time – there are just no elephant-related experiences in most instances whatsoever. This is to say, when the raw physiological signal is below a certain level, it may not imply any meaningful degree of likelihood for the presence of the relevant stimuli at all.

These considerations motivate the possibility that there may be a perceptual criterion, placed on this scale of raw sensory signal rather than likelihood, that is independent of whatever we decide as a response to a task. In other words, not all sensory activities lead to conscious experiences, because most of the time they fall below this perceptual criterion, regardless of how we set our response criterion (Lau, 2019). As Witt et al. (2015) pointed out, SDT does not in itself distinguish between response, and perceptual criterion effects (Figure 1A, 1B). To do so, we need additional evidence.

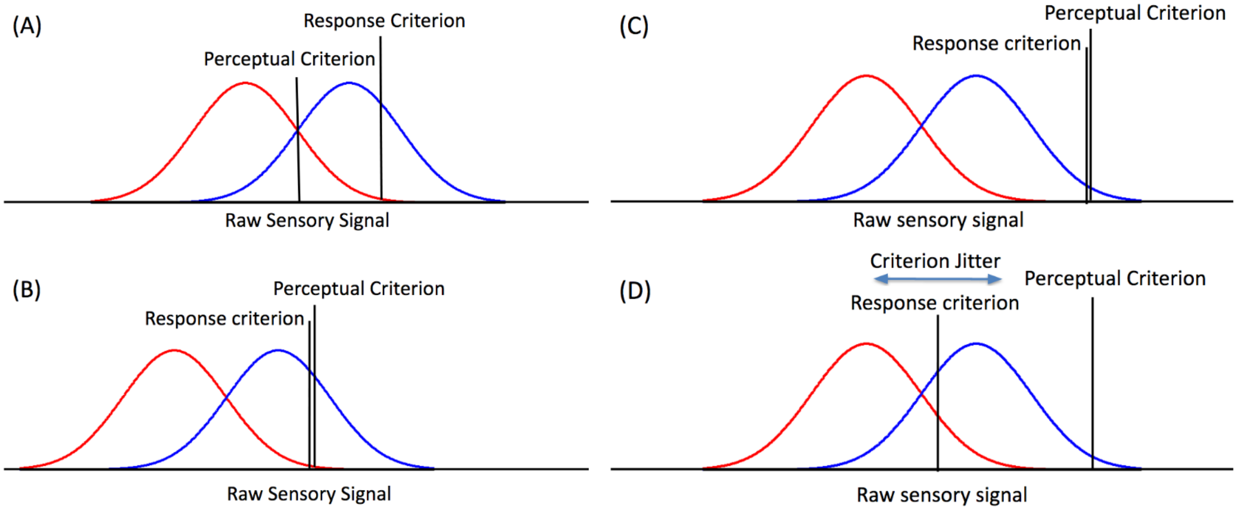

Figure 1. (A) A response bias can be induced experimentally, e.g. by rewarding the subject to say "no" more often. In this case, we do not expect the percept itself to shift; the putative perceptual criterion shall remain in the same location. (B) However, if the raw sensory signals themselves are dampened, and the subject fails

to learn to update the criteria, response bias may appear conservative, just as in A above. In that scenario, we expect a genuine perceptual shift too; the perceptual criterion may also not be updated. Based on the overt behavioral responses alone, one cannot distinguish this from A (Witt et al. 2015). (C) Depicted here is an extreme scenario in which both the response and perceptual criteria are very conservative; this is intended to be a characterization of blindsight. As in B, in natural settings, the response criterion may be placed close to the perceptual criterion. One naturally responds "yes" when one sees a stimulus. (D) As in A we can induce a criterion shift at the response level only, e.g. through instructions. Experimenters often (implicitly) encourage the subject to use a more neutral response criterion. But, as in A, this shift is unlikely to affect the percept itself. Because now the response criterion is set so far away, it cannot use the perceptual criterion as an anchor. So the response criterion may become less stable, as one has to use cognitive strategies to figure out how to maintain the criterion at a suitable level.

As a technical aside: To those who ultimately favor the likelihood view described above over the perceptual criterion view, there is an alternative way to appreciate the matter. The scale on which we conceptualize SDT is up to us, and does not determine objectively how perception works in the brain. The key point is just that not all sensory activities necessarily lead to conscious experience. One can continue to think of the response criterion as being set on a stimulus likelihood scale. But stimulus likelihood does not necessarily map linearly and constantly to neuronal sensory activities; it depends on how the brain *interprets* its own raw sensory activities in terms of stimulus likelihood. So there may exist some range at which sensory activities lead to zero stimulus likelihood, as subjectively represented. In malfunctioning conditions, high levels of otherwise functionally significant sensory activities may also lead to zero subjective stimulus likelihood – as is likely the case in blindsight. We prefer the perceptual criterion view for simplicity and ease of visualization, but in substance the two views can be equivalent, unless one assumes that stimulus likelihood is always optimally and perfectly represented.

The above is not to say that criterion effects always reflect perceptual changes. There are obvious cases where they are likely non-perceptual. For instance, under changes in payoff structure, false feedback, base rate-induced biases, etc (Macmillan & Creelman, 2005). But it would be just as improbable to assume that *all* criterion effects are decidedly non-perceptual.

Empirical cases of perceptual criterion shifts

Phillips holds that a perceptual account of criterion effects in blindsight is less parsimonious than his account, since two criteria are required instead of one. However, as Phillips remarks, providing independent empirical evidence for a perceptual criterion would level the playing field.

Many studies show criterion effects that are much more likely perceptual than response-related only. This is the case for several perceptual illusions such as the sound-induced flash illusion (Rosenthal et al. 2009), the ventriloquist effect (Thurlow and Jack, 1973), the stream-bounce effect (Grove et al. 2012; Sekuler et al., 1997), which manifest as changes in the criterion measure. In the case of the stream-bounce effect, for instance, Rolfs et al. (2013) have demonstrated that the effect can lead to retinotopically specific visual adaptation, which is often considered a sign that an effect is perceptual (see also Meyerhoff & Scholl, 2018). Other perceptual effects, like filling-in of gabor patches by collinear flankers, affect the criterion measure with little effect on sensitivity (Polat & Sagi, 2007).

In addition, the criterion measure can be influenced in opposite directions by perceptual and post-perceptual sources. For instance, studying the 'choice history bias', Fritsche et al. (2017) demonstrated that subjects reported the *appearance* of stimuli as being *repelled away* from previously presented stimuli, while their perceptual decisions were *attracted toward* the previous perceptual decisions (see also Pascucci et al. 2018). The two sources of bias – perceptual and post-perceptual – had different spatio-temporal properties: perceptual bias was sensitive to the location of the stimulus relative to previously presented stimuli, while the decision bias was not, and decision bias significantly increased during a post-perceptual retention period (see also Linares et al. 2019).

Other studies have suggested that perceptual and post-perceptual biases can be distinguished by their different effects on confidence ratings: while perceptual biases typically induce shifts in confidence, response biases (induced for instance by changing the payoff structure of the task) do not necessarily do so (Gallagher et al. 2018, 2019; see also Locke et al. 2020).

At the neurophysiological level, criterion shifts can be induced by changes in baseline activity in sensory areas. For instance, high-prestimulus excitability – indexed by α and β power – induces a liberal bias in detection tasks, as well as higher confidence and visibility ratings, without affecting sensitivity in discrimination tasks (Samaha et al. 2017; Benwell et al. 2017; see also van Vugt et al. 2018). This effect has been shown to be perceptual in nature (Iemi & Busch, 2018), and likely operates by modulating sensory evidence accumulation (Kloosterman et al. 2019).

Finally, there is also causal evidence for perceptual influences on the criterion measure. Jin & Glickfeld (2019) could induce either liberal or conservative criterion shifts in a go/no-go task, with little effect on sensitivity, by optogenetically manipulating V1 neurons in mice. The effect was unlikely due to changes in the animals' post-perceptual decision criterion, because the manipulations were induced unpredictably on a presentation-by-presentation basis; changes in decision criterion are known not to be flexible and fast enough to accommodate this (Brown & Steyvers, 2005). In a similar way, Crapse et al. (2018) induced liberal detection criteria by manipulating activity in the superior colliculus in monkeys, thus indicating again that the criterion measure is sensitive to manipulations in areas not thought to be 'higher cognitive'.

This is why Azzopardi & Cowey's findings were not supposed to be explained away by the criterion jitter account. Sometimes criterion effects meaningfully reflect awareness. This is not to say, of course, that blindsight never *involves* response criterion effects. Outside of experiments, blindsight patients most likely adopt a conservative response criterion *because* of their conservative perceptual criterion; it is natural to respond according to what one sees (Figure 1C). When required to adopt a less conservative response criterion in experiments, they cannot adopt the same strategy to anchor the response criterion to the perceptual criterion in the blind field (Figure 1D). This may be why the response criterion is unstable. As such, showing that there is a response criterion effect does not rule out a perceptual criterion effect. To the contrary, the latter may well be what accounts for the former.

Broader perspective

Despite the evidence reviewed above, some may insist that criteria effects just aren't ever perceptual, as a matter of definition. The historical confusion about response criteria runs deep (Peters et al. 2016). To this we can only ask: what would it take for them to accept that blindsight is a genuine phenomenon of selective impairment of awareness? Assuming that SDT is roughly correct, is there any way for awareness to differ between two conditions that are sensitivity-matched? If all criterion effects are by definition non-perceptual, we fear there is just no such possibility. It will be up to the working vision scientists to reflect on whether such a view is too restrictive for empirical progress.

Overall, we applaud Phillips for presenting a well-argued and provocative perspective. Precisely because blindsight is such an important classic phenomenon, the details need to be revisited and challenged. The same happened for other class patient cases, such as the amnesic patient HM (Stanley & Krakauer, 2013).

However, as we learn from these studies, patient cases are hardly ever decisive on their own. Every patient is different. For example, GY has a small lesion in the right parietal cortex (Rees, 2008), the functional significance of which remains unclear. As such, a globally plausible interpretation inevitably leaves some weak openings.

Regardless of the interpretation of these details, the original studies of blindsight opened up the possibility that awareness and visual sensitivity may be dissociated (LeDoux et al. 2020). This in turn inspired decades of studies using many other methods, confirming one and another in different ways. We should be careful not to throw the baby out with the bathwater.

References

Azzopardi, P., & Cowey, A. (1997). Is blindsight like normal, near-threshold vision? *Proceedings of the National Academy of Sciences of the United States of America*, *94*(25), 14190–14194.

Azzopardi, P., & Cowey, A. (1998). Blindsight and Visual Awareness. *Consciousness and Cognition*, *7*(3), 292–311.

Benwell, C. S. Y., Thut, G., Tagliabue, C. F., Veniero, D., & Cecere, R. (2017). Prestimulus EEG Power Predicts Conscious Awareness But Not Objective Visual Performance. *ENeuro*, *4*(6), 1–17.

Brogaard, B. (2015). Type 2 blindsight and the nature of visual experience. *Consciousness and Cognition*, 32, 92-103.

Brown, S., & Steyvers, M. (2005). The dynamics of experimentally induced criterion shifts. *Journal of Experimental Psychology: Learning Memory and Cognition*, *31*(4), 587–599.

Campion, J., Latto, R., & Smith, Y. M. (1983). Is blindsight an effect of scattered light, spared cortex, and near-threshold vision? *Behavioral and Brain Sciences*, *6*(3), 423–448.

Cleeremans, A., Achoui, D., Beauny, A., Keuninckx, L., Martin, J. R., Muñoz-Moldes, S., Vuillaume, L., de Heering, A. (2020). Learning to Be Conscious. *Trends in Cognitive Sciences*, *24*(2), 112–123.

Cowey, A. (2004). The 30th Sir Frederick Bartlett lecture: Fact, artefact, and myth about blindsight. *Quarterly Journal of Experimental Psychology Section A: Human Experimental Psychology*, *57*(4), 577–609.

Cowey, A. (2010). The blindsight saga. *Experimental Brain Research*, *200*(1), 3–24.

Crapse, T. B., Lau, H., & Basso, M. A. (2018). A Role for the Superior Colliculus in Decision Criteria. *Neuron*, *97*(1), 181–194.

Fendrich, R., Wessinger, C. M., & Gazzaniga, M. S. (1992). Residual vision in a scotoma: Implications for blindsight. *Science*, *258*(5087), 1489–1491.

Fritsche, M., Mostert, P., & de Lange, F. P. (2017). Opposite Effects of Recent History on Perception and Decision. *Current Biology*, *27*(4), 590–595.

Gallagher, R., Suddendorf, T., & Arnold, D. H. (2018). The implied motion aftereffect changes decisions, but not confidence. *BioRxiv*.

Gallagher, R., Suddendorf, T., & Arnold, D. (2019). Confidence as a diagnostic tool for perceptual aftereffects. *Scientific Reports*, 9:7124.

Gorea, A., & Sagi, D. (2000). Failure to handle more than one internal representation in visual detection tasks. *Proceedings of the National Academy of Sciences of the United States of America*, *97*(22), 12380–12384.

Grove, P. M., Ashton, J., Kawachi, Y., & Sakurai, K. (2012). Auditory transients do not affect visual sensitivity in discriminating between objective streaming and bouncing events. *Journal of Vision*, *12*(8), 1–11.

Iemi, L., & Busch, N. A. (2018). Moment-to-moment fluctuations in neuronal excitability bias subjective perception rather than decision-making. *ENeuro*, *5*(3).

Jin, M., & Glickfeld, L. L. (2019). Contribution of sensory encoding to measured bias. *Journal of Neuroscience*, *39*(26), 5115–5127.

Kahneman, D. (1968). Method, findings, and theory in studies of visual masking. *Psychological Bulletin*, *70*(6), 404–425.

Kentridge, R. W., Heywood, C. A., & Weiskrantz, L. (1997). Residual vision in multiple retinal locations within a scotoma: implications for blindsight. *Journal of Cognitive Neuroscience*, 9(2), 191–202

Kentridge, R. W. (2015). What is it like to have type-2 blindsight? Drawing inferences from residual function in type-1 blindsight. *Consciousness and Cognition*, *32*, 41–44.

Kloosterman, N. A., De Gee, J. W., Bergner, M. W., Lindenberger, U., Garrett, D. D., & Fahrenfort, J. J. (2019). Humans strategically shift decision bias by flexibly adjusting sensory evidence accumulation. *ELife*, *8*(e37321), 1–27.

Ko, Y., & Lau, H. (2012). A detection theoretic explanation of blindsight suggests a link between conscious perception and metacognition. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences*, *367*(1594), 1401–1411.

Lau, H. (2019). Consciousness, Metacognition, & Perceptual Reality Monitoring. *PsyArXiv*. https://psyarxiv.com/ckbyf/

LeDoux, J. E., Michel, M., & Lau, H. (2020). A little history goes a long way toward understanding why we study consciousness the way we do today. *Proceedings of the National Academy of Sciences of the United States of America*.

Linares, D., Aguilar-Lleyda, D., & López-Moliner, J. (2019). Decoupling sensory from decisional choice biases in perceptual decision making. *ELife*, *8*(e43994), 1–22.

Locke, S. M., Gaffin-Cahn, E., Hosseinizaveh, N., Mamassian, P., & Landy, M. S. (2020). Priors and payoffs in confidence judgments. *Attention, Perception & Psychophysics*.

Macmillan, N. A., & Creelman, C. D. (2005). *Detection theory: A user’s guide*. Mahwah, NJ: Lawrence Erlbaum Associates, Inc.

Macpherson, F. (2015). The structure of experience, the nature of the visual, and type 2 blindsight. *Consciousness and Cognition*, *32*, 104–128.

Macpherson, F. (2018). *Sensory Substitution and Augmentation*. Oxford University Press.

McClelland, J. L., & Chappell, M. (1998). Familiarity Breeds Differentiation: A Subjective-Likelihood Approach to the Effects of Experience in Recognition Memory. *Psychological Review*, *105*(4), 724–760.

Maniscalco, B., & Lau, H. (2012). A signal detection theoretic approach for estimating metacognitive sensitivity from confidence ratings. *Consciousness and Cognition*, *21*(1), 422–430.

Mazzi, C., Bagattini, C., & Savazzi, S. (2016). Blind-sight vs. degraded-sight: Different measures tell a different story. *Frontiers in Psychology*, *7*(901), 1–11.

Meyerhoff, H. S., & Scholl, B. J. (2018). Auditory-induced bouncing is a perceptual (rather than a cognitive) phenomenon: Evidence from illusory crescents. *Cognition*, *170*, 88–94.

Mickes, L., Wixted, J. T., & Wais, P. E. (2007). A direct test of the unequal-variance signal detection model of recognition memory. *Psychonomic Bulletin & Review*, *14*(5), 858–865.

Morales, J., Odegaard, B., & Maniscalco, B. (Forthcoming). The Neural Substrates of Conscious Perception without Performance Confounds. In Felipe De Brigard & Walter Sinnott-Armstrong (Eds.) *Anthology in Neuroscience and Philosophy*. Cambridge, MA: MIT Press.

Overgaard, M., Fehl, K., Mouridsen, K., Bergholt, B., & Cleeremans, A. (2008). Seeing without seeing? Degraded conscious vision in a blindsight patient. *PLoS ONE*, *3*(8), 8–11.

Pascucci, D., Mancuso, G., Santandrea, E., Della Libera, C., Plomp, G., & Chelazzi, L. (2018). Laws of concatenated perception: Vision goes for novelty, Decisions for perseverance. *Journal of Vision* 18(10), 1-42.

Persaud, N., Davidson, M., Maniscalco, B., Mobbs, D., Passingham, R. E., Cowey, A., & Lau, H. (2011). Awareness-related activity in prefrontal and parietal cortices in blindsight reflects more than superior visual performance. *NeuroImage*, *58*(2), 605–611.

Peters, M. A. K., Ro, T., & Lau, H. (2016). Who's afraid of response bias? *Neuroscience of Consciousness*, *2016*(1), 1–16.

Phillips, I. (Forthcoming). Blindsight is qualitatively degraded conscious vision. *Psychological Review*.

Polat, U., & Sagi, D. (2007). The relationship between the subjective and objective aspects of visual filling-in. *Vision Research*, *47*(18), 2473–2481.

Rees, G. (2008). The Anatomy of Blindsight. *Brain*, *131*(6), 1414–1415.

Rolfs, M., Dambacher, M., & Cavanagh, P. (2013). Visual adaptation of the perception of causality. *Current Biology*, *23*(3), 250–254.

Rosenthal, O., Shimojo, S., & Shams, L. (2009). Sound-induced flash illusion is resistant to feedback training. *Brain Topography*, *21*(3–4), 185–192.

Sahraie, A., Weiskrantz, L., Barbur, J. L., Simmons, A., Williams, S. C. R., & Brammer, M. J. (1997). Pattern of neuronal activity associated with conscious and unconscious processing of visual signals. *Proceedings of the National Academy of Sciences of the United States of America*, *94*(17), 9406–9411.

Sahraie, A., Weiskrantz, L., & Barbur, J. L. (1998). Awareness and confidence ratings in motion perception without geniculo-striate projection. *Behavioural Brain Research*, *96*, 71–77.

Sahraie, A., Trevethan, C. T., MacLeod, M. J., Murray, A. D., Olson, J. A., & Weiskrantz, L. (2006). Increased sensitivity after repeated stimulation of residual spatial channels in blindsight. *Proceedings of the National Academy of Sciences of the United States of America*, *103*(40), 14971–14976.

Sahraie, A., Hibbard, P. B., Trevethan, C. T., Ritchie, K. L., & Weiskrantz, L. (2010). Consciousness of the first order in blindsight. *Proceedings of the National Academy of Science of the United States of America*, *107*(49), 21217–21222.

Samaha, J., Iemi, L., & Postle, B. R. (2017). Prestimulus alpha-band power biases visual discrimination confidence, but not accuracy. *Consciousness and Cognition*, *54*, 47–55.

Sekuler, R., Sekuler, A. B. & Lau, R. (1997) Sound alters visual motion perception. *Nature,* 385:308.

Stanley, J., & Krakauer, J. W. (2013). Motor skill depends on knowledge of facts. *Frontiers in Human Neuroscience*, *7*(AUG), 1–11.

Stoerig, P., & Barth, E. (2001). Low-level phenomenal vision despite unilateral destruction of primary visual cortex. *Consciousness and Cognition*, *10*(4), 574–587.

Stoerig, P., Zontanou, A., & Cowey, A. (2002). Aware or unaware: Assessment of cortical blindness in four men and a monkey. *Cerebral Cortex*, *12*(6), 565–574

Thurlow, W. R., & Jack C. E. (1973) Certain determinants of the "ventriloquism effect". *Perceptual and Motor Skills*. 36:1171–84.

van Vugt, B., Dagnino, B., Vartak, D., Safaai, H., Panzeri, S., Dehaene, S., & Roelfsema, P. R. (2018). The Threshold for conscious report: Signal loss and response bias in visual and frontal cortex. *Science*, *360*, 537–542.

Weiskrantz, L., Barbur, J. L., & Sahraie, A. (1995). Parameters affecting conscious versus unconscious visual discrimination with damage to the visual cortex (V1). *Proceedings of the National Academy of Sciences of the United States of America*, *92*(13), 6122–6126.

Weiskrantz, L. (2009a). *Blindsight. A case study spanning 35 years and new developments.* Oxford University Press.

Weiskrantz, L. (2009b). Is blindsight just degraded normal vision? *Experimental Brain Research*, *192*(3), 413–416.

Witt, J. K., Taylor, J. E. T., Sugovic, M., & Wixted, J. T. (2015). Signal detection measures cannot distinguish perceptual biases from response biases. *Perception*, *44*(3), 289–300.

Yoshida, M., & Isa, T. (2015). Signal detection analysis of blindsight in monkeys. *Scientific Reports*, *5*, 1–11.

Zeki, S., & ffytche, D. H. (1998). The Riddoch syndrome: insights into the neurobiology of conscious vision. *Brain*, *121*(1), 25.