Is cortex unnecessary?

Commentary on **Klein & Barron** *on Insect Experience*

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Abstract: A key contention of Klein & Barron (2016) is that consciousness does not depend on cortical structures. A critical appraisal suggests they have overestimated the strength of their evidence.

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Klein & Barron's (2016) argument by analogy can be paraphrased as follows:

> (1) Cortex isn't necessary for phenomenal "what it is like" consciousness, since a cognitive information processing system that functions very much like the vertebrate midbrain suffices.
>
> (2) The insect nervous system functions very much like the vertebrate midbrain.
>
> So,
>
> (3) Insects are conscious.

Assuming this interpretation is basically right and the premises are true, this seems to be a strong argument. Are the premises correct? I will defer to others when it comes to assessing the second premise and confine my remarks to the first. Is (1) true, and do Klein & Barron offer a compelling case for thinking it is true? My answers are: "probably not" and "certainly not."

Rather than commit to a full-blown philosophical theory, or even definite criteria for ascribing consciousness, Klein & Barron direct the reader to research they claim shows that "[e]mergence from anaesthesia … and coma or vegetative state" is "predicted by the reengagement of subcortical structures" (p. 3). They also offer Merker's (2007) account of the specific processing mechanisms in conscious awareness and cite assurances lent by other authorities that "the basic capacity for subjective awareness is supported by subcortical structures" (p. 3). Yet *supporting*

subjective awareness is not the same as *being minimally sufficient*. These points accordingly call for more scrutiny and reflection.

Some of the works Klein & Barron cite are at best irrelevant to assessment of the first premise, and actually seem to establish its negation! Consider Schiff (2010), who certainly attends to subcortical structures in recovery from brain injury, but does not completely dismiss the cortex. Cortical regions, especially the anterior cingulate, posited to "play an essential role" (p. 4), are included by Schiff within a proposed "mesocircuit" which is granted "central importance" (p. 7) in understanding improved awareness and responsiveness (p. 4; fig. 3). I do not necessarily wish to endorse Schiff's view, but only to note that he makes no suggestion that subcortical mechanisms on their own are sufficient for phenomenal consciousness and cautions about "significant ambiguity" when diagnosing its presence or absence in seemingly vegetative patients (p. 1). The case studies mentioned by Schiff, and indeed Schiff's own work with minimally conscious patients all attest to the contribution of cortical structures (Schiff et al. 2005). Similarly, Långsjö et al. (2012) found that "minimal cortical activity is necessary" (p. 4940) and that *linked* subcortical and cortical regions, including "the anterior cingulate cortex … and portions of the lateral orbital frontal and parietal lobes" (p. 4938) constitute the "minimal neural correlates required for a conscious state to emerge" (p. 4935). Herbet et al. (2014, p. 241) found that experimental interference with the posterior cingulate cortex resulted in loss of responsiveness and awareness of the external environment, with the patient reportedly undergoing an altered dream-like state. Mashour et al.'s (2013) review of current research proposes that the "neural core for primitive consciousness" (p. 10361) depends at least in part on cortical activity, especially from the anterior cingulate, and perhaps "limited neocortical involvement" in the form of frontal-parietal network activity (Ibid.).

Making sense of all these results is not my aim, and I agree that it is unclear how exactly consciousness, in all its various forms, depends on the cortex. But by these evidentiary standards we ought to infer that subcortical structures *merely* provide support and reject Klein & Barron's premise.

Klein & Barron's *PNAS* article, Barron & Klein (2016), does provide a fuller treatment of their first premise. Some of those arguments once again conflate the midbrain on its own with activity of "frontocorticostriatopallidal-thalamocortical loop frontal systems" (Schiff, 2010, p. 5). I will focus, however, on other sources they mention, including Merker (2005) — who is claimed to provide "evidence of preserved consciousness even in patients who lack a cortex" — and various other authors in support of the view that "even massive cortical damage seems to spare subjective experience" (Barron & Klein, 2016, p. 4901). An overview and assessment of this evidence comes next.

Although Merker (2005) points to certain cortically blind patients reporting "bare awareness" despite the absence of normal visual consciousness (p. 101), the inference that only midbrain structures are implicated is unwarranted. Such "type 2" blindsight (Weiskrantz, 1986/98) either depends on preserved islands of striate cortex (Radovea et al., 2008), or if not V1, then other regions of visual cortex, such as V5/MT (Ffythche & Zeki, 2011; see also Brogaard, 2015, pp. 93-

4). Either way, the neuroanatomical basis of blindsight cannot be mistaken for evidence that midbrain structures alone are sufficient for conscious awareness.

Among the other works Barron & Klein (2016) mention as offering "good evidence" (p. 4901) are Damasio & Carvalho (2013), Philippi et al. (2012), Owen et al. (2002), Klein & Hohwy (2015), and Merker (2007). While this piling on of sources looks impressive, the plasterwork crumbles upon closer examination.

Key (2016) has expressed reservations about the one, possibly anomalous "Patient B" discussed by Damasio et al. (2012) and Damasio & Carvalho (2013), noting that they concede that persisting "cortical regions associated with pain … remain undamaged" and that this might explain the patient's experiences (Key, 2016, p. 10). In reply, Merker (2016, p. 6) counters that this case should be accorded more weight because it involved a rare bilateral lesion. Following Devor et al. (2014), Merker finds it implausible that surviving cortex could stand in for the damaged "major node." Although these points are well taken, the role of cortex in pain is far from settled, and in light of the fact that the observations of Patient B were made in the absence of quantitative testing or imaging (Key, 2016, p. 10), the case remains intriguing, but inconclusive. Meanwhile, Barron & Klein (2016) cite a book chapter as if it offered "evidence of residual conscious awareness" due to "preserved subcortical structures" (p. 4901) in nonresponsive patients, but it offers no data and says almost nothing on the matter (maybe I missed something?). It is at least of some use, however, insofar as it points out that the heterogeneity of individuals and difficulties in interpreting behavior suggest that confidence in one-off patient studies can be inordinate (Klein & Hohwy, 2016, p. 250)!

Barron & Klein's remaining examples are also underwhelming. Concerning Philippi et al. (2012), the authors themselves write that while their findings are compatible with the hypothesis that cortical activity is not needed, they are also compatible with the possibility that persisting regions of cortex "constitute the critical substrate" for aspects of the patient's awareness (2012, p. 14). That the single patient in question had made a recovery through changes in cortical functioning likewise cannot be ignored (Ibid.). As for Owen et al. (2002), they acknowledge that testing revealed significant residual cortical activity in comatose patients in response to visual and auditory stimulation (p. 398). Finally, I consider Merker (2007) alongside Merker (2008) and Aleman and Merker (2014). These articles turn on the issue of certain hydranencephalic infants who, despite the apparent absence of functional cerebral cortex, produce an expressive behavioral repertoire including smiling, laughing, orienting, learning and recognizing.

Key (2016) has responded to Merker, claiming that hydranenephalic children are typically vegetative, with only occasional exceptions. As "most of these children still possess some cerebral cortex" perhaps "those with more overt behaviours could have more functional cortical tissue" (p. 8). Merker (2007) is dismissive of this suggestion, emphasizing that the "physical presence [of cortical tissue] … need not mean … it is even locally functional" (p. 78). Merker (2007) also contests the claim that "incapacity and unresponsiveness" is the norm, noting that with proper care such a child can "survive for years and even decades" (p. 79). In an effort to

address the "lack of formal survivorship data" (Merker, 2008, p. 213), he provides evidence that "quality of care" (Ibid.) may be the decisive factor when it comes to life expectancy.

I am persuaded that we should tread very carefully regarding the question of whether children commonly designated as hydranencephalic can be far more capable than is generally assumed, and in some cases, even phenomenally aware (Merker, 2007; Beshkar, 2008; Aleman & Merker, 2014). What is less certain is whether informal observation can be trusted to deliver judgments about a total absence of cortical resources in specific individuals, as several urged in their *BBS* commentaries on Merker (2007). On this score, Merker agreed that his "summary account is a preliminary one and in no way definitive" (p. 114). While these and other works open up important lines for further inquiry, within the context of justifying Klein & Barron's first premise, they are hugely oversold and I remain skeptical.

Conclusion

Despite these reservations, I look forward to others finding merit in Klein & Barron's arguments for the second premise. It would be a service if they succeeded in building the case for a comparison between insect central complex functioning and the vertebrate midbrain. This work might be of use to philosophers and cognitive scientists on several counts, not least for those interested in "multiple realizability." They might have also strengthened the proposal I made in Allen-Hermanson (2007) that dissociated sensory awareness can be used to argue that insects are "natural zombies." Since then I've worried over whether the analogy between insect sensation and primate blindsight could be based on crude behavioral criteria, since disparities in gross anatomy might suggest that any such comparison is superficial. Klein & Barron might have filled this hole in my argument, though if so they have helped to show that the boundary of consciousness is a bit higher than they intended.

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