Unfolding Conscious Awareness from Non-Conscious Perception in Non-Human Animals

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Animal Conscious Awareness

Conscious awareness to the events and stimuli around us is a central part of our everyday experience. Yet, are humans the only species that experiences conscious awareness? Since non-verbal species cannot report their internal states, philosophers and scientists have long debated whether the question of animal consciousness is empirically testable, and it still remains a topic of speculation (Dawkins, 2015; Gutfreund, 2017). In the large spectrum of views, some advocate that consciousness may require complex processes like language, a capacity that is unique to adult humans (Dennett, 1995) or a human-like theory of mind (Carruthers, 1998), which may extend to only a few selected species such as great apes (e.g., Krupenye, Kano, Hirata, Call, & Tomasello, 2016; but see Horschler, MacLean, & Santos, 2020). In contrast, others have used neuroanatomical similarities to argue that a number of species (including some birds and octopuses) are likely to be capable of generating conscious experience (see, for example, the Cambridge declaration on consciousness, 2012). Others argue that non-human animals are conscious on the basis of intelligent behaviors which, at least in humans, seem to coincide with conscious awareness as supporting evidence for animal consciousness. These include behaviors such as planning (Osvath & Osvath, 2008), or metacognition (Hampton, Engelberg, & Brady, 2020; Rosati & Santos, 2016), for review see Boly et al., 2013; Griffin & Speck, 2004. Yet, since many complex human behaviors and high-level functions can be performed outside of conscious awareness (i.e., Hassin, 2013), it is difficult to determine whether non-human animals that display intelligent behaviors are indeed conscious or not (Carruthers, 2018). Furthermore, given the ambiguity and difficulty in disentangling conscious from non-conscious processes in non-verbal species, many consider the question of animal consciousness as far from having been resolved (Dawkins, 2015; Gutfreund, 2017). For many, the gap in evidence needed to unambiguously infer animal consciousness is considered "as wide as ever" (Dawkins, 2012).

In our recent paper (Ben-Haim et al., 2021) we departed from all previous attempts to study consciousness and developed a novel empirical approach that can allow disentangling the two modes of processing. Specifically, we harnessed a well-established double dissociation between non-conscious and conscious visual awareness in humans. In special circumstances, humans show characteristically *opposite* performance signatures when processing consciously accessible stimuli versus stimuli that are just below the threshold of conscious detection. Using this paradigm, we tested whether rhesus monkeys (*Macaca mulatta*) also show these same opposite double dissociation signatures of visual awareness. Because this approach predicts that completely *opposite* signatures of performance would emerge only if there are both conscious and non-conscious processing modes, this framework can be used to reliably disentangle the two levels of processing in non-human species. Crucially, this approach can provide evidence for the presence of non-conscious processing in non-human animals, and the immediate corollary of conscious visual awareness (or a similarly characterized processing mode) in animals.

A Double Dissociation of Awareness

To establish a double dissociation between conscious and non-conscious visual processing in humans, we first presented participants (n = 36) with a novel **forced guessing task** where a reward was hiding within one of two treasure chests presented on a computer screen. On each trial, one of the two chest locations was cued with an image displaying a star. The cue predicted the location of the reward but in an incongruent manner - the reward was always hidden in the opposite chest. Note that in order to find the reward with more than 50% accuracy (chance level), participants must use this cue and choose the treasure chest presented in the opposite side of the cue location. We also varied whether the cue was always consciously accessible or presented

unconsciously (i.e., subliminally masked after 17/33 milliseconds thus it escaped awareness in naive participants). We hypothesized that participants will quickly learn to choose the opposite chest of the cue when the cue is consciously accessible (*supraliminal* conscious condition). Yet, in the non-conscious *subliminal* condition, we anticipated that participants would perform significantly ***worse than chance*** (<50%), as they will be more likely lured to choose the flashed cue location without being aware of it.

Indeed, our results indicated that participants easily learned to choose the chest opposite of the cue when it was consciously accessible, but performed significantly *worse* than chance in the *subliminal* condition ($\chi(1)=5.33$, $P=0.021$). Although our participants were not aware of the cues as evident by their self-reports, their performance was clearly affected by the subliminal cue as it was worse than random guessing. This consistent non-random below-chance performance suggests that the cues were processed non-consciously and influenced participants' behavioral choices. Importantly, the clear above-chance performance with consciously accessible cues, together with an opposite pattern of worse-than-chance performance with subliminal cues represents a canonical human double dissociation of visual awareness.

Critically, we then used this same approach in **rhesus monkeys** (*Macaca mulatta*) to test whether a non-human species showed the same double dissociation between conscious and non-conscious visual processing. Monkeys strikingly mimicked exactly the double dissociation we observed in humans, showing significant learning and correct performance in the *supraliminal* conscious condition, but performing significantly below-chance in the *subliminal* condition with no signs of learning through hundreds of trials (M=43.5% correct, with a combined binomial probability of $P=0.00018$). While the observation that monkeys can learn the task well with consciously accessible cues is not very surprising, the fact that monkeys performed below-chance on the *subliminal* trials suggests that monkeys may perceive the cues much like humans do - non-consciously. The combined results showing both non-conscious influence with *subliminal* cues, and in contrast successful learning with consciously accessible *supraliminal* cues, strongly suggests that monkeys too may experience two modes of visual awareness as humans do. These striking results, which we replicated in two different dissociation tasks, demonstrate that monkeys show the same double dissociation that humans exhibit across conscious and non-conscious processing, thus providing robust empirical support for conscious awareness in a non-human animal. Taken together, these results strongly support the existence of both non-conscious processing as well as functional human-like visual awareness in non-human animals.

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References

Ben-Haim, M., Dal Monte, O., Fagan, N. A., Dunham, Y., Hassin, R. R., Chang, S. W. C., & Santos L.R. (2021). Disentangling perceptual awareness from non-conscious perception in rhesus monkeys (macaca mulatta), *PNAS,* 118 (15), e2017543118

Boly, M., Seth, A. K., Wilke, M., Ingmundson, P., Baars, B., Laureys, S., . . . Tsuchiya, N. (2013). Consciousness in humans and non-human animals: Recent advances and future directions. *Frontiers in Psychology, 4*, 625.

Cambridge declaration on consciousness. July 7, 2012, P. Low, Ed. (Francis Crick Memorial Conference on Consciousness in Human and non-Human Animals, University of Cambridge, UK

Carruthers, P. (1998). Natural theories of consciousness. *Eur. J. Philos, 6*, 203.

Carruthers, P. (2018). The problem of animal consciousness. Proceedings and addresses of the APA, San Diego, CA*, 92* 179-205.

Dawkins, M. S. (2012). *Why animals matter: Animal consciousness, animal welfare, and human well-being.* New York.: Oxford University Press.

Dawkins, M. (2015). Animal welfare and the paradox of animal consciousness. *Adv Study Behav, 47*, 5-5-38.

Dennett, D. C. (1995). Animal consciousness: What matters and why. *Soc. Res., 62, 3*, 691.

Griffin, D. R., & Speck, G. B. (2004). New evidence of animal consciousness. *Animal Cognition, 7*(1), 5-18.

Gutfreund, Y. (2017). The neuroethological paradox of animal consciousness. *Trends in Neurosciences, 40*(4), 196-199. doi:S0166-2236(17)30016-4 [pii]

Hampton, R. R., Engelberg, J. W. M., & Brady, R. J. (2020). Explicit memory and cognition in monkeys. *Neuropsychologia, 138*, 107326.

Hassin, R. R. (2013). Yes it can: On the functional abilities of the human unconscious. *Perspectives on Psychological Science, 8*(2), 195-207.

Horschler, D. J., MacLean, E. L., & Santos, L. R. (2020). Do non-human primates really represent others' beliefs? *Trends in Cognitive Sciences, 24*(8), 594-605.

Krupenye, C., Kano, F., Hirata, S., Call, J., & Tomasello, M. (2016). Great apes anticipate that other individuals will act according to false beliefs. *Science, 354*(6308)

Osvath, M., & Osvath, H. (2008). Chimpanzee (pan troglodytes) and orangutan (pongo abelii) forethought: Self-control and pre-experience in the face of future tool use. *Animal Cognition, 11*(4), 661-674.

Rosati, A. G., & Santos, L. R. (2016). Spontaneous metacognition in rhesus monkeys. *Psychological Science, 27*(9), 1181-1191.