Translating cognitive insights into effective conservation programs: Reply to Schakner et al.

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Our Opinion Piece [1] aimed to promote conversation about cognition in behaviourally-based conservation solutions, and to spark further research into the field. We welcome Schakner et al.'s comments as part of this dialogue.

Their response mainly critiqued our decision to emphasize 'why' cognition is important in animal conservation, asserting that we do not explore 'how' it should be applied in sufficient detail. We agree with Schakner et al. that our paper is not a comprehensive instruction manual for all animal conservation problems. However, we offer broad guidelines to highlight the cognitive processes that need be considered for different classes of problems, and provide examples where cognition has been successfully applied. We chose this focus for two reasons. Firstly, our goal was to make comparative cognition accessible to a wide audience; therefore explaining the 'why' was crucial for those unfamiliar with cognitive mechanisms. Without laying a general foundation of cognitive theory, examples where cognition is effectively applied would seem like isolated cases of insight rather than applications of a widely studied discipline.

Secondly, it would be unfeasible to offer readers a detailed solution to every conceivable conservation problem in the space of one manuscript. The behavioural manipulations that conservationists and wildlife managers seek span widely different contexts. We agree that tailored solutions are most likely to be successful and wholeheartedly support Shakner et al's calls for further research into the conservation applications of cognitive theory. However, until a greater number of species-specific guidelines are developed—such as the step-by-step reinforcement schedules that Schakner et al. mention—the fundamentals of perception and learning can still help guide efforts to alter animal behaviour. As more detailed, empirically-tested guidelines are developed, it is critical that these be consolidated and made widely available in a format such as a freely accessible online database that allows researchers and managers to search for solutions based on their

specific species or conservation issue. The website conservationevidence.com [2] provides an excellent example of how this might be achieved.

Several points made by Schakner et al illustrate some of the priority areas for conservation-minded cognitive research, such as specifying species' cognitive biases, and doing so in the context of animal communities. The authors mention that the sterile laboratory is divorced from the noise of a natural environment. Careful laboratory studies should not be dismissed as irrelevant, as they helped develop the laws of associative learning, revealing widely applicable patterns that most animals share. Since the ability to learn associatively did not evolve in a laboratory, we know animals are able to make associations despite imperfect cue presentations. Learning rules govern responses in nature through the lens of cognitive biases that define what is perceptually salient and biologically relevant for any given species. Adapting fundamental learning rules to wild settings through careful use of salient stimuli allows one to tap into these biases to ensure animals make the correct associations. We cover the fundamentals in our discussion of general learning tendencies, but agree that these principles can be more effectively applied when translated into concrete conservation guidelines that incorporate species' cognitive biases.

Additionally, the authors make a valid point that the use of deterrents needs to be developed within the context of the larger animal community, as deterrents may potentially impact non-target species. While we do mention some of the problems that can arise if reinforcement schedules of deterrents offer unexpected rewards, (e.g. the dinner bell effect [3]), there is still much to be explored in their usage on entire ecosystems. Documenting and learning from unintended consequences that occur because of the implementation of cognitive insights is an equally important part of developing effective methods.

Our paper and Schakner et al.'s response are both advocating the same ultimate goal: increased research into the intersection of cognition and conservation, with the focus on directly applicable solutions to conservation problems. Our framework provides a unifying foundation to this type of research, but the details of species-specific solutions require further investigation. We invite continued dialogue into the subject, but also hope that innovative solutions for communicating and consolidating these details can be broadcast though an accessible, database-like platform where researchers and managers can collaborate.

1 Greggor, A.L. *et al.* (2014) Comparative cognition for conservationists. *Trends Ecol. Evol.* 29, 489–495

2 Sutherland, W.J. (2014) , ConservationEvidence.com. [Online]. Available: http://www.conservationevidence.com/

3 Carretta, J. V and Barlow, J. (2011) Long-term effectiveness, failure rates, and “dinner bell” properties of acoustic pinners in a gillnet fishery. *Mar. Technol. Soc. J.* 45, 7–19