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Developing effective tools for conservation behaviorists: Reply to Greggor *et al.*

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Many conservation and management problems can benefit from mechanistic insights into how animals respond to stimuli and learn about biologically important events [1]. The growing attention toward using cognition to solve real world conservation/management issues is exciting and promising. We applaud the thoughtful review of Greggor *et al.* of the relevant cognitive mechanisms that could be applied to current conservation and management issues. While the authors effectively communicate 'why' it is useful to integrate the two fields, we feel that they fall short of providing concrete ideas on 'how' cognitive mechanisms can be applied in the real world. To this end, their most progressive contribution is a generalized conceptual framework/decision-tree that links cue assessment to cognitive mechanisms, and provides a range of approaches for experimental manipulation. However, they omitted explicit examples demonstrating how cognitive mechanisms can be applied in the real world. In so doing, the paper of Greggor *et al.* emphasizes the lack of and dire need to develop evidence-based adaptive management protocols to apply cognitive concepts to conservation/management.

Several recent publications sought to raise the awareness of wildlife managers to the advantages of using existing knowledge of animal behavior and physiology to improve conservation efforts (e.g., [2–4]). However, raising awareness is only the first step toward improved conservation outcomes. As we illustrate below, managers will inevitably experience various constraints and problems when attempting to apply behavioral principles, such as associative learning. Thus, there is a pressing need for reviews and guidelines that will detail (for example) the types of stimuli managers may feasibly use, reinforcement schedules, and specific ways to actually apply these promising cognitive mechanisms (e.g., [5,6]).

Greggor *et al.* clearly describe how cognitive mechanisms such as associative learning may enhance deterrence, but they do not provide feasible suggestions managers can use to implement this approach. They also neglect to acknowledge the potential problems that may arise from their application. We agree that an aversive conditioning approach may be useful in situations where the conditioned response to the target conditioned stimulus (CS) is avoidance. However, managers face a difficult task of effectively manipulating animal behavior by using deterrents to elicit aversion in one species while not simultaneously affecting other non-target species. Managers can choose from a variety of stimuli across sensory modalities that elicit aversion through mechanisms of pain, distraction, or sickness; each evoking unique behavioral responses [7]. Sometimes, but not always, it is possible to target species-specific sensory modalities.

The perceptual environment of an animal contains a suite of stimuli such as landscape features, conspecifics, heterospecifics, and background sounds, which often interfere with conditioning processes. For instance, during exposure to a deterrent stimulus, individuals likely associate features of the environment (such as open space or shadows), along with other cues that precede it. According to the Rescorla–Wagner model of associative learning [8], contextual stimuli compete with the CS to predict the unconditioned stimulus (US). In contrast to simplified experimental conditions in the laboratory where extraneous 'context' is controlled, the natural world is full of stimuli, and individuals may make associations between competing contextual cues and salient deterrent stimuli.

This means that managers should use conditioned stimuli that are obvious, discriminable, and detectable [9] when designing potential repellents. There is evidence that CSs that are natural precursors to USs result in relatively rapid and more durable associations [10]. From this functional perspective, using biologically meaningful stimuli such as predator calls that precede painful stimuli may be particularly effective. The reinforcement schedule (how often to pair CS/US versus CS alone) can be modified depending on the nature of the conflict. More work is needed to provide managers with this vital information.

Managers must be aware of the landscape and potential issues involving non-target individuals or species. Greggor *et al.* have suggested that an auditory warning device may reduce ship strikes of whales. However, such sounds will affect and elicit unwanted behavior in the target species and other species [11]. Such acoustic stimuli could potentially be matched to the spectral sensitivities of species, and tailored to evoke a particular response, while still being outside the sensory range of some non-target animals [12].

It is remarkable that while we have known about the mechanistic processes of habituation, sensitization, and associative learning for over a century, there are relatively few concrete examples of managers effectively applying such theory to address wildlife management problems. We

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applaud Greggor *et al*. for clearly articulating the potential application of cognitive mechanisms in wildlife management. Now is the time to develop realistic and effective guidelines for their application.

References

1 Blumstein, D.T. and Fernández-Juricic, E. (2010) *A Primer of Conservation Behavior*, Sinauer Associates
2 Berger-Tal, O. *et al.* (2011) Integrating animal behavior and conservation biology: a conceptual framework. *Behav. Ecol.* 22, 236–239
3 Candolin, U. and Wong, B.B.M., eds (2012) *Behavioural Responses to a Changing World: Mechanisms and Consequences*, Oxford University Press
4 Cooke, S.J. (2014) Conservation physiology today and tomorrow. *Conserv. Physiol.* 2, cot033
5 Schakner, Z.A. and Blumstein, D.T. (2013) Behavioral biology of marine mammal deterrents: A review and prospectus. *Biol. Conserv.* 167, 380–389
6 Blackwell, B.F. and Fernández- Juricic, E. (2013) Behavior and physiology in the development and application of visual deterrents at airports. In *Wildlife in Airport Environments: Preventing Animal–Aircraft Collisions Through Science-Based Management* (DeVault, T.L. *et al.*, eds), pp. 11–22, Johns Hopkins University Press
7 Mason, J.R. *et al.* (2001) Chemical repellents and other aversive strategies in predation management. *Endangered Spec. Update* 18, 175 Sp
8 Rescorla, R.A. and Wagner, A.R. (1972) A theory of Pavlovian conditioning: variations in the effectiveness of reinforcement and nonreinforcement. In *Classical Conditioning: Current Research and Theory* (2), pp. 64–99, Appleton-Century-Crofts
9 Guilford, T. and Dawkins, M.S. (1991) Receiver psychology and the evolution of animal signals. *Anim. Behav.* 42, 1–14
10 Domjan, M. (2005) Pavlovian conditioning: a functional perspective. *Annu. Rev. Psychol.* 56, 179–206
11 Nowacek, D.P. *et al.* (2004) North Atlantic right whales (*Eubalaena glacialis*) ignore ships but respond to alerting stimuli. *Proc. R. Soc. Lond. B* 271, 227–231
12 Gotz, T. and Janik, V.M. (2013) Acoustic deterrent devices to prevent pinniped depredation: efficiency, conservation concerns and possible solutions. *Mar. Ecol. Prog. Ser.* 492, 285–302

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 the comments of Schakner *et al*. as part of this dialogue.

Their response mainly critiqued our decision to emphasise '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. First, 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. Second, 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 the calls of Shakner *et al*. 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 are 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 [Sutherland, WJ (2014) Conservation Evidence (www.conservationevidence.com)] 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 the cognitive biases of species, 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 have helped develop the laws of associative learning, revealing widely applicable patterns that most animals share. The ability to learn associatively did not evolve in a laboratory, thus, we know that animals are able to make associations despite imperfect cue presentations. Learning rules govern

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