Visual perception and decision making in cuttlefish

Abstract

Recent research on the visual mechanisms of rapid adaptive camouflage in cuttlefish (Cephalopoda; Mollusca) will be presented. These neurophysiologically complex marine invertebrates can camouflage themselves against almost any background, a feat well appreciated by Aristotle, and one never mastered by any land animal. Yet their ability to quickly (0.5-2 sec) alter their body patterns on different visual backgrounds poses a vexing challenge: how to pick the correct body pattern amongst their repertoire. The ability of cuttlefish to change appropriately requires a visual system that can rapidly assess complex visual scenes and produce the motor responses - the neurally controlled body patterns - that achieve camouflage. Using specifically designed visual backgrounds (both natural and artificial) and assessing the corresponding body patterns quantitatively (akin to visual psychophysics with human participants), we and others have uncovered several aspects of scene variation that are important in regulating cuttlefish patterning responses. We also investigated the visual processing of the cuttlefish, including visual equivalence and amodal completion. Our results showed that cuttlefish were able to treat the training images of reduced size and sketches as the visual equivalence. Cuttlefish were also capable of recognizing partially occluded versions of the training image. Finally, we also examined whether cuttlefish have number sense, and whether their valuation of food reward is satiation state dependent. We found that cuttlefish showed a preference for a larger quantity when faced with two-alternative forced choice tasks. However, cuttlefish preferred the small quantity when the choice was between one live and two dead shrimps. More importantly, when the choice was between one large live shrimp and two small live shrimps (a prey size and quantity trade-off), the cuttlefish chose the large single shrimp when they felt hunger, but chose the two smaller prey when they were satiated. These results demonstrate that cuttlefish are capable of number discrimination and that their choice of prey number depends on the quality of the prey and on their appetite state.