COMMENTARY

Extraordinary elephant perception

Joshua M. Plotnik[a,b,1] and Frans B. M. de Waal[c,1]

[a]*Division of Biological and Natural Resource Sciences, Mahidol University, Sai Yok, Kanchanaburi 71150, Thailand;* [b]*Think Elephants International, Stone Ridge, NY 12484; and* [c]*Living Links, Yerkes National Primate Research Center, and Department of Psychology, Emory University, Atlanta, GA 30322*

When it comes to people, elephants can be very discriminating, especially those under human care in Southeast Asia. There is the story of the orphaned elephant who, at the age of 10, pulled her drowning mahout out of a lake after hearing his cries for help a kilometer away, or the dangerous 3-m-tall bull who would charge anyone who approached except the 160-cm wife of the village elder, who he would caress with his trunk as she fed him. This behavioral connection between elephants and ourselves is not the product of domestication—in the sense of artificial genetic selection—but born from individual life histories involving near constant human contact (1).

Elephants have a very interesting past with humans, but the future is significantly more foreboding. In Africa, where human/elephant coexistence was possible due to a balanced use of land by humans and wild elephants alike, the latter are now faced with a dire situation. With some estimates suggesting that 100 elephants/d are being slaughtered for their ivory (largely due to an increasing demand from China), extinction in under a century is inevitable without substantial intervention. In Asia, loss of natural habitat, conflict with humans over land and food, and the endangered species trade are all contributing to a loss of wild elephant numbers. How is this possible for a family long regarded as a member of the animal kingdom's "cognitive elite?" The obvious answer is that human culture (which has led to a growth in wealth and resource acquisition) and rapid population expansion (which has led to massive habitat destruction) are severely curtailing elephant numbers.

With such damage being done to elephants, there is an urgent need to find ways to protect the remaining wild populations. One unique way to address this need is to attempt to understand how they navigate their physical and social worlds. Their perspective is quite different from our own. Specifically, they live in a world that is largely acoustic and olfactory (2–5) rather than visual, which means any mitigation efforts aimed at protecting wild populations from poaching or human/elephant conflict will require special techniques that may not be immediately obvious.

The study of how animals first identify threats from other species constitutes a growing body of literature, including the different alarm calls for different predators in vervet monkeys (6) and prairie dogs (7) and the ability of wild corvids to recognize individual humans by their faces (8, 9). Such fine discriminatory abilities may help distinguish dangerous from nondangerous encounters with one of the most threatening species on the planet: ours. This is precisely the task that McComb et al. set for themselves using the highly social African elephant as their test subject (10).

McComb et al. studied how wild African elephants in Amboseli National Park, in Kenya, reacted to potential threats posed by two different human ethnic groups. The cattle-herding Maasai sometimes attack or otherwise threaten elephants that challenge their livestock for water or food, and thus the elephants have regularly negative experiences with them. The Kamba, on the other hand, are agriculturalists with little reason to threaten elephant herds. Previous research has shown that elephants react more negatively to the color and smell of clothing worn by Maasai than that worn by Kamba (11). McComb et al., however, focus here on what is probably the elephants' most acute sensory modality, sound, to assess the elephants' evaluation of human threats. The authors played back human voices from a concealed loudspeaker; the voices would say a single phrase in the Maasai's or Kamba's respective languages, "Look, look over there, a group of elephants is coming." It is hard to imagine that the precise words carry any meaning for the elephant audience, but the investigators compared the utterance made by adult men, adult women, and boys. They also

Fig. 1. Elephant matriarch raises her head in alarm in response to playback while her family bunch defensively behind. Photograph by Karen McComb.

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[1]To whom correspondence may be addressed. E-mail: josh@thinkelephants.org or dewaal@emory.edu.

looked at how vocal stimuli digitally altered to switch the vocalizers' sex affected the elephants' behavior when other acoustic features were maintained.

McComb et al. found that the elephants more often and more intensely retreated and "bunched" together in defense (i.e., formation of a tight circle, usually with their young in the center for protection) and smelled the air more following playbacks of Maasai male voices than Kamba male voices (Fig. 1). They further found that Maasai adult male voices triggered more defensive reactions than those of Maasai females or boys. Even if these natural stimuli were adjusted for sex—making the adult male voices sound more female and vice versa—the results remained the same in that the elephants were most vigilant after hearing the transformed adult male voices. This was surprising because these stimuli now had the opposite sex's fundamental frequencies and formant values. The authors argue that the elephants may be identifying age and sex while using less conventional acoustical information.

This study provides evidence that elephants have, most likely through individual and social learning, the ability not only to identify human voices but also to identify specific cues in human vocalizations that signal age, sex, and ethnic identity. This ability allows the elephants to identify specific components of voices—or differentiate between different languages, as the authors suggest—that signal a potential threat. The elephants' discriminations and differentiated responses fit with the authors' assessment of the perceived threat from each of these groups of individuals.

This study suggests that an animal species has adapted its natural behavior to include humans as a dangerous predator. Considering recent research on the impact of an elephant matriarch's experience and age on her herd's survivability (12, 13), it is not surprising that individual life experience might also influence how elephants react to different potential threats. McComb et al. (10) provide suggestive data that the age of the herd's matriarch affects their response to Maasai boys, with older matriarchs less likely to retreat from their voices than younger matriarchs. In another study, herds led by older matriarchs reacted more appropriately to threats from male lions than those led by younger, less experienced females (12). Typical responses to lions—offensive, mobbing behavior that drives lions away—differed strikingly from the defensive retreat in response to humans. As the authors note, to mob men carrying spears is not likely to be successful.

McComb et al. suggest that elephants develop this ability to recognize and respond to different threats through experience. Although we agree that individual learning during development may be responsible for anti-predator behavior, substantial changes to the consistency of wild African and Asian elephant herds due to poaching and habitat loss that have occurred within a single generation may affect the way in which young elephants experience their environment. The alternative view to individual learning is social learning in which young elephants learn to respond to Maasai men differentially by following the behavior of older, adult individuals, such as their mother or the herd's matriarch. It is becoming increasingly more important to try to determine how the ontogenetic development of animal behavior is affected in environments where, largely due to human impact, family group experiences are changing rapidly. With an increasing number of older elephants being killed for their ivory or family groups being affected by human-elephant conflict, changes in natural elephant behavior are inevitable.

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The importance of this sort of research cannot be overstated. Despite the great public interest in elephants, we know remarkably little about their cognition. Most studies have concerned elephant social behavior and interactions with the environment without subjecting the species to the controlled experiments needed to map their brainpower. The 4-kg elephant brain is remarkably complex, and in many ways, mirrors our own (14, 15). Recent studies put elephant social complexity on a par with that of the great apes, including findings of their capacities for mirror self-recognition, cooperation, empathy, and problem-solving (16–20). It is then of little surprise that they are learning to adapt to their changing natural environments, but quite disturbing that we are forcing them to do so.

Studies such as the one by McComb et al. suggest that elephants are learning to adapt to human threats quickly, but this flexibility in their behavior, which is often linked to discussions of intelligence (21), also suggests that we still have much to learn about how elephants make decisions within their physical and social environments. If elephants primarily interact with the world using their nonvisual senses, the "human perspective" for solving conservation problems will not be enough. The more we understand about how elephants navigate their physical and social worlds using nonvisual sensory modalities such as sound and smell, and how their behavior continues to adapt to ever-changing threats, the better able we will be to effectively work to protect them in the wild.

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