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Understanding Human Gaze

Rosemary Bettle and Alexandra G. Rosati
Department of Human Evolutionary Biology,
Harvard University, Cambridge, MA, USA

Introduction

The ability to detect the focus of an individual's visual attention can provide rich information about the location of important objects in the larger environment, as well as about that individual's internal psychological states. Detecting and using such information about gaze direction is a foundational component of human social behavior. For example, even young infants are sensitive to the direction of other's gaze (Flom et al. 2007) and begin to follow gaze geometrically to objects beyond their immediate view in the second year of life. Humans also utilize eye contact as a cue of joint attention – that two individuals are together looking at the same thing. This skill thus allows humans to engage in a variety of potentially species-unique social behaviors, including communication about cultural knowledge (Csibra and Gergely 2009). Finally, our ability to attend to the same stimuli as other individuals is vital to normal social development, providing a scaffold for the development of other abilities such as theory of mind and language acquisition.

Yet despite these links to many complex abilities in humans, sensitivity to gaze is not unique to our species (Rosati and Hare 2009). In fact, gaze-following is widespread across the primate order, as well as in other social mammals and even in some reptiles. Yet these gaze-sensitive behaviors are not necessarily underpinned by the same cognitive processes across species. Comparative cognition researchers are therefore faced with two related questions. First, what are the psychological bases for this skill, and how do they differ across taxa? Second, why does gaze-following appear to contribute to the emergence of complex social cognitive traits in some taxa, such as humans, but not necessarily in others? By answering these questions, we can begin to understand the evolutionary origins of human-unique social cognition.

Psychological Basis of Gaze-Following Across Primate Species

Gaze-following is phylogenetically widespread in primates (Rosati and Hare 2009; Shepherd 2010). Representatives of all major primate groups follow the gaze of others in some situations, including great apes, many Old World monkey species, New World monkey species, and even some lemur species. However, several aspects of gaze-following behavior differ across taxa. A key distinction is the degree to which gaze-following behavior relies upon more reflexive mechanisms that drive individuals to co-orient – looking in the same direction as others without really understanding why – versus whether

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gaze-following stems from the attribution of a mental state to another individual. In the first situation, individuals may learn through trial-and-error experience that they gain useful information when they look in the same direction as others, whereas in the latter individuals actually understand that others are looking somewhere because there is something interesting in that direction to see.

As in humans, gaze-following in apes appears to sometimes involve mental state attribution (Call and Tomasello 2008). One piece of evidence comes from experiments using geometric gaze-following (Okamoto-Barth et al. 2007). Within these paradigms, the object that the actor looks at is not within the subject's immediate line of sight, so the subject must move and reorient their position in order to observe the focus of the actor's gaze. Thus, geometrical gaze-following requires the ability to generalize between their own egocentric perspective and that of the actor. The fact that chimpanzees, bonobos, gorillas, and orangutans (see, e.g., Okamoto-Barth et al. 2007) will move in order to view what the observer is looking at makes it unlikely that the behavior is the result of a simple rule to turn their head when other individuals do. Rather this appears to be a more flexible response where the apes are trying to ascertain what the other can see. Moreover, chimpanzees in particular robustly use information about both humans' and conspecifics' current or past visual perspective in competitive contexts (Call and Tomasello 2008). This provides strong evidence that at least some apes can use information about where others are looking to infer their subjective perceptions and knowledge. Along the same lines, rhesus monkeys seem to use information about other's visual perspective during competitive interactions, as well as to predict how others will act (Martin and Santos 2016).

However, there is increasing evidence that gaze-following may be more reflexive and egocentric in other primate species. First, several monkey species are unable to incorporate gaze information to predict the behavior of humans or conspecifics based on where they were looking previously. Second, unlike chimpanzees or rhesus macaques, several other species do not seem to use information about what others can see in competitive contexts, including capuchins and common marmosets. Finally, while some lemurs have been shown to co-orient with conspecifics during their natural interactions, they may fail to follow the gaze of a human demonstrator in more controlled contexts. However, this may vary across even closely related species: whereas ring-tailed lemurs show a basic gaze-following response to human gazing and also use information about where a human competitor is looking when deciding whether to approach a contested piece of food, several other species of lemur do not (Sandel et al. 2011). Taken together, this suggests that some instances of gaze-following behavior in monkey and strepsirrhine primate species – which can appear behaviorally similar to great ape gaze-following in many respects – might in fact be due to quite different cognitive processes.

A final piece of evidence that the cognitive basis of gaze-following may differ across species comes from studies that compare the ontogeny of these behaviors. In humans, reliable gaze-following emerges within the first year of life. Across nonhuman primates, however, there is quite some variability. In nonhuman apes, gaze-following emerges around 3 to 4 years. In pig-tailed macaques, gaze-following may not emerge until adulthood – leading to the hypothesis that nonhumans require a much longer period of social experience to acquire this behavior. Yet closely related rhesus macaques exhibit gaze-following behavior during infancy, more like humans (Rosati et al. 2016). Overall, this suggests that gaze-following in different species may depend on different social experiences or underlying cognitive mechanisms. Further comparative work examining the ontogeny of social cognition can help elucidate why some species develop social cognitive skills at a different pace and why species may develop certain social cognitive skills but not others.

The Adaptive Value of Gaze-Following

Gaze-following and other gaze-sensitive behaviors appear to be biologically important, given that this skill has evolved in many taxa. In general, this social response may allow diverse species to engage in several important behaviors such as avoiding predators and locating food items in the environment. Yet the cognitive basis of gaze-following differs between species: in humans and other great apes, the ability to model another individual's mental states seems to drive gaze-following, whereas in other species gaze-following may be more egocentric. There are two main evolutionary hypotheses accounting for this variation, and in particular why mind-reading abilities might emerge in some species but not others.

One influential idea is that social competition drives the evolution of theory of mind abilities. If animals can think about other's visual perspective in competitive contexts, this enables more sophisticated deception and counter-deception. This hypothesis is supported by the fact that many primates seem to show their most sophisticated abilities to think about the direction of other's gaze in competitive situations. In contrast, many nonhuman species have difficulty using gaze cues in more cooperative situations, such as "object choice" paradigms in which a human helpfully looks at the location of a hidden food item to communicate this information. In fact, many diverse primate species fail to use such cues.

Yet gaze-following may hold a different adaptive role in humans (Tomasello and Carpenter 2007). Our species may follow gaze to enable successful *cooperative* behaviors. Humans are especially reliant on eyes in gaze-following situations, and eyes subsequently evolved a new social function in human evolution, to support cooperative (mutualistic) social interactions. The "cooperative eye hypothesis" posits that our species' unique eye morphology is an adaptation allowing individuals to view each other's gaze direction with greater precision, enabling these cooperative behaviors. These morphological changes include a white sclera with high contrast to the iris, along with an enlargement of the visible part of the sclera, and they may explain why humans are especially sensitive to eye direction (compared to face direction or whole-body cues) relative to other species. These changes may allow humans to engage in large-scale cooperative behaviors between non-kin, which appear to be human unique.

More generally, humans appear to be uniquely motivated to participate in "joint attentional interactions," collaborative interactions where the actors usually monitor each other's visual attention in order to better coordinate. Building on this proposal, Csibra and Gergely (2009) have argued that eye contact is a type of cue that humans use to mark the transfer of pedagogical information. In response to such pedagogical cues, infants infer that the information that follows will be culturally relevant information about their social world (Csibra and Gergely 2009). This theory predicts that other species lacking human-like culture and teaching will not respond to such ostensive cues in the way that humans do. However, it remains untested whether other primates do in fact exhibit any similarities with humans in their responses to such cues.

Conclusions

Why are so many species sensitive to gaze direction? Gaze direction information may be useful because other individuals tend to gaze at biologically relevant stimuli, because this information allows an individual to make inferences about another individual's mental state, because gaze is used as an explicitly communicative signal, or because information about gaze direction helps to scaffold the development of other cognitive skills. It is likely that the adaptive purpose of gaze sensitivity varies between taxa, despite the superficial similarity of gaze-following behaviors in many species. Therefore, comparative analysis of the cognitive basis of these skills can illuminate the selective pressures that have resulted in divergent social cognitive skills across taxa. This is of particular importance in light of the hypothesis that the evolutionary origins of human-unique social cognition can be understood as the result of a selective pressure resulting from cooperative interactions or unique patterns of sociocultural learning. If so, human gaze sensitivity might be uniquely adapted to support such behaviors, for instance, via involvement in processes such as joint attentional interactions or pedagogical learning. Gaze sensitivity therefore provides a window into the selective pressures that have characterized social cognitive evolution between taxa, which may enable researchers to begin to uncover the roots of human-unique cognition.

Cross-References

▶ Cooperation and Social Cognition
▶ Evolutionary Social Psychology
▶ Humans as Social Primates
▶ Social Development in Non-human Primates
▶ The Evolution of Human Sociality
▶ The Social Intelligence Hypothesis

References

Call, J., & Tomasello, M. (2008). Does the chimpanzee have a theory of mind? 30 years later. *Trends in Cognitive Sciences, 12*, 187–192.

Csibra, G., & Gergely, G. (2009). Natural pedagogy. *Trends in Cognitive Sciences, 13*, 148–153.

Flom, R. E., Lee, K. E., & Muir, D. E. (2007). *Gaze-following:Its development and significance*. Mahwah: Lawrence Erlbaum Associates Publishers.

Martin, A., & Santos, L. R. (2016). What cognitive representations support primate theory of mind? *Trends in Cognitive Sciences, 20*, 375–382.

Okamoto-Barth, S., Call, J., & Tomasello, M. (2007). Great apes' understanding of other individuals' line of sight. *Psychological Science, 18*, 462–468.

Rosati, A. G., Arre, A. M., Platt, M. L., & Santos, L. R. (2016). Rhesus monkeys show human-like changes in gaze-following across the lifespan. *Proceedings of the Royal Society B, 283*, 20160376.

Rosati, A. G., & Hare, B. (2009). Looking past the model species: Diversity in gaze-following skills across primates. *Current Opinion in Neurobiology, 19*, 45–51.

Sandel, A. A., MacLean, E. L., & Hare, B. (2011). Evidence from four lemur species that ringtailed lemur social cognition converges with that of haplorhine primates. *Animal Behaviour, 81*, 925–931.

Shepherd, S. V. (2010). Following gaze: Gaze-following behavior as a window into social cognition. *Frontiers in Integrative Neuroscience, 4*, 5.

Tomasello, M., & Carpenter, M. (2007). Shared intentionality. *Developmental Science, 10*, 121–125.