Published in Current biology 18, issue 11, R453-R455, 2008
which should be used for any reference to this work

Gaze following

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What is gaze following? Gaze following occurs if an individual perceives another's gaze and, as a result, comes into contact with the object or event the other is attending to.

Why is this interesting? Trying to understand how other minds work, particularly those of non-human, non-linguistic animals, is not a trivial task. Researchers are limited to a small set of behaviours from which to interpret mental states, and 'gaze following' is one of particular interest. Gaze usually indicates attention, and one important question is how and why an individual is motivated to find the object of that attention. Is this due to a simple automated response, or is it the result of a mental calculation about the underlying cause?

How widespread is gaze following? Gaze following probably occurs in most primates, from prosimians to humans, but it is not a uniquely primate behaviour. The behaviour has been documented in some domesticated animals, for example dogs and goats, and has recently also been demonstrated in ravens. One hypothesis, therefore, is that gaze following is a general behavioural feature of social species, although empirical data are still lacking for most animal groups.

Why follow gaze? Monitoring another individual's gaze is adaptive for various reasons, particularly during foraging or for detecting predators. Individuals capable of gaze following enjoy a selective advantage over non-gaze-followers because they can benefit from discoveries made by others. For example, in chimpanzees and marmosets, gaze can signal possession, and animals avoid food that others are looking at, presumably to avoid competition. Gaze following also increases the probability of witnessing rare but important social interactions, such as rank reversals, thus helping animals to keep track of other group members and their relationships. As mentioned, chimpanzees can discriminate what others can and cannot see in competition over food, but it remains to be seen if this ability extends to social interactions. Gaze following may be particularly important during cooperation. For instance, dogs prefer objects that are socially marked by a gaze cue, a useful predisposition for social carnivores that must decide on one particular prey individual prior to group hunting.

What is the neurobiological basis of gaze following? Primate brains contain groups of cells in the parietal and temporal cortex that respond specifically to changes in gaze direction. In humans, gaze following is impaired in individuals suffering from autism and similar effects can occur after certain brain lesions, suggesting that gaze following in primates is governed by shared neural circuitry.

What cognitive mechanisms are involved? Should we conclude from the neurobiological studies that gaze following is a cognitively low-level automatic process? Not necessarily. Although animals generally follow gaze because they are biologically endowed to do so, some species display additional cognitive processes during gaze following: they facilitate their own gaze following, they 'check-back', and they can project sight past distracters. To facilitate gaze following, great apes sometimes reposition themselves to follow an experimenter's gaze around a barrier. When 'checking-back', chimpanzees that fail to encounter anything interesting when tracking someone's gaze tend to look back at the gazer's face in order to track the gaze for a second time. Lastly, many primates are able geometrically to project an imaginary line of sight to search for the gazer's focus of attention, even if irrelevant objects interrupt this line. Similar results have also been obtained from ravens, which do not just orient to a target following another's gaze, but appear to take visual perspectives into account. In humans, finally, gaze following provides much of the foundations for a variety of higher cognitive achievements, including 'theory of mind' and language.

Why is gaze following relevant for language? During language acquisition, one productive strategy is to acquire novel word-reference links by following a speaker's gaze after hearing a novel utterance. In these instances gaze following cannot be automatic, but is guided by a selective process that picks out utterances of unknown referential significance. Similarly, infants only follow gaze if the speaker has an intention to inform, rather than being engaged in other sorts of communication. From the start of their second year of life, infants begin to converge with others on interesting phenomena for the purpose of sharing attention. Such 'joint attention' goes beyond automated co-orienting to an external object. Instead, a triadic relationship is formed between the gazer and the gaze follower, allowing them to interact with each other through the external phenomenon. This is a developmental landmark that psychologists grant special status, and it is clear why: many of the higher cognitive abilities unique to humans, such as theory of mind and language, develop during such joint attentional episodes. Gaze following, and joint attention that derives from it, is truly a socio-cognitive hotspot.

How does gaze following develop? Newborn humans already show rudimentary forms of gaze following. The behaviour undergoes elaboration between 6 and 18 months during which infants learn to track gaze in response to eye movements alone, and beyond their immediate visual fields. From about 12 months, infants begin to engage in joint attention. In macaques, gaze following is already seen in juveniles, and performance improves into adulthood. For apes, a 13-month old chimpanzee already shows reliable gaze following to an object indicated by a gaze. Complex geometrical gaze following emerges in chimpanzees before adulthood, although it is difficult to make firm statements about the social insights that young chimpanzees experience during these events, a topic of ongoing research.

What other directional cues are there? Interestingly, although primates are good at following gaze they experience difficulties with

Figure 1. Diana monkeys have evolved a highly contrasting pelage colouration in the neck region, which facilitates gaze following in their natural visually dense rainforest habitat (picture Florian Moellers).

following pointing, much in contrast to some domesticated animals. Primates have forward facing eyes and strongly developed facial musculature, making the eye region particularly useful for providing gaze cues. Non-primates with a more lateralised visual apparatus may be more disposed to attend to other body parts, such as head or torso, to locate the source of another's attentive behaviour. Nevertheless, relying on head and body orientation is also important for primates, particularly in visually difficult habitats, such as dense rainforests. It is interesting that many forest primates have evolved conspicuous visual markers that facilitate gaze following (Figure 1).

What about gaze as a communicative signal? In contrast to other primates, humans have evolved a large white sclera and marked eyebrows, making the eye region highly conspicuous and ideally suited for gaze following, and it has been argued that this is an evolutionary biproduct of the cooperative nature of humans. Not only can humans follow gaze, but they can also use gaze to actively direct each other's attention, or, by eye squinting and lowering eyebrows, to make it more difficult for others to follow gaze (something that is perceived as unfriendly and uncooperative). Non-human primates are clearly sensitive to the directed gaze of others, and therefore they already possess a fundamental prerequisite for using gaze as a communicative signal. Whether or not they are also able to influence the attention of receivers by manipulating gaze cues is currently being investigated.

Where can I find out more?

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