

requirements of the predatory lifestyle of many species have led to complex and interesting abilities.

The group of Jayne Gardiner from the University of South Florida at Tampa, US, together with researchers from the University of South Florida and Boston University, recently described how several shark species can combine input from multiple sensory channels and switch between them if necessary (PLoS ONE (2014) 9, e93036). The researchers note that signal dispersal under water in natural conditions is seriously inhibited by disturbances such as light scattering. Therefore, they created naturalistic settings for controlled experiments to test the prey-finding behaviour of sharks in the presence of such difficulties.

Sharks can use combinations of olfactory, turbulence, visual, electrical and tactile signals to detect their prey. The relative importance of these signals varies with the distance of the prey and the specific requirements of the general situation. The experiments showed that the sharks can respond flexibly if one information channel is blocked. While the initial olfactory tracking of prey from a distance appears to be a stereotyped, species-specific behaviour, the animals showed greater plasticity in their behaviour on approaching the prey, making the best use of whatever sensory channels were available. Due to this flexibility, they can also overcome various kinds of camouflage.

“Our findings may explain why previous attempts to use chemical deterrents or visual camouflage to prevent shark bites haven’t been very successful. In many cases, the loss of one sensory signal generally doesn’t inhibit feeding behavior, as sharks can switch to alternate sensory cues to locate and capture prey,” notes Gardiner.

Better understanding of these processes may ultimately also lead to additional strategies to make shark attacks on humans even less likely than they currently are. Given the efficiency of the predators’ sensory strategy, we can just be grateful that, in contrast to their bad reputation, they’re not really interested in us.

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## Book review

### Group-mindedness

Cecilia Heyes

*A Natural History of Human Thinking*  
Michael Tomasello  
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From the late middle ages until early in the twentieth century, ‘Skimmingtons’ gave English villagers a highly effective instrument of social control, and a fun day out for all the family. In a Skimmington, couples who had broken the social rules — typically the wife was a ‘scold’ or the husband a ‘cuckold’ — were ridiculed by a ludicrous cavalcade (Figure 1). In the lead was a horse carrying grotesque effigies of the offending pair, back-to-back, with the woman wielding a (skimming) ladle. Close behind were barking dogs and all the righteous of the parish, hooting, blowing horns and beating pans to let the offending couple, cowering in their hovel, know exactly how they felt about failure to conform. The Skimmington ritual was both a punishment and a warning. On its way to the home of the victims, the procession brushed the door steps of other anomalous couples. Toe the line or next time it will be you.

Skimmingtons are one manifestation of the kind of hypersociality that distinguishes our species, modern humans, from all other animals. We don’t just happen to live in groups that include unrelated and distantly related individuals, we have to live this way. We depend on cooperation with others, alive and dead, not just for the higher things in life — art, justice, spirituality, prosperity — but for the satisfaction of basic bodily needs. Most of us would starve if we didn’t cooperate with others to find and prepare food. Given this dependence, it’s not surprising that we’re ‘group-minded’. Each of us identifies with the groups and cultures to which we belong, tries to conform to their norms, and participates in rituals that reinforce group identity — singing or dining together, watching our team try to win the cup — or, as in the case of Skimmingtons, in rituals that shame and punish those who have failed to conform. Courts of law are less

colourful and usually more humane than Skimmingtons but they fulfil a similar function.

In his book, *A Natural History of Human Thinking*, the distinguished developmental psychologist Michael Tomasello lays out his latest views on the evolution of group-mindedness. Compared with his previous monograph on the same subject, *The Cultural Origins of Human Cognition* (Harvard, 1999), the current story gives more cognitive credit to our closest living relatives, the great apes, and has more twists in the plot. The new ‘shared intentionality hypothesis’ suggests that, rather than one giant leap, there were two major transitions in the evolution of human thinking: the first, from the ‘individual intentionality’ of the ancestors we share with great apes, living six million years ago, to the ‘joint intentionality’ of early humans, emerging about 400 thousand years ago, and the second, 200–300 thousand years later, from joint intentionality to the ‘collective intentionality’ of modern humans. Curiously, Tomasello doesn’t unpack his key term, ‘intentionality’, but the *Stanford Encyclopedia of Philosophy* defines it as ‘the power of minds to be about, to represent, or to stand for, things, properties and states of affairs’.

The picture of stage one, individual intentionality, comes from experiments with extant great apes, most of them conducted by Tomasello’s group in Leipzig. Chimpanzees, gorillas and orang-utans are seen as physically and socially manipulative creatures. They use limited forms of imagination, inference and self-monitoring — thinking about thinking — to get their own way in competition for food, mates and other valued resources. They can assess whether a stick is rigid enough to scrape food out of a tricky spot, use rattling as a sign that a solid object is in a sealed container, and, when competing with others for food, keep track of who was looking when a juicy morsel was hidden. They also use simple gestures for communication, raising an arm to initiate play-hitting, slapping the ground to attract attention, and reaching toward objects they want a human to deliver. But great apes don’t go in for cooperation. When given a choice of acquiring food cooperatively or independently, or simply between eating with a groupmate or in isolation, chimpanzees go it alone. So, Tomasello argues, great apes are smarter than



Figure 1. Social norms.

A 'Skimmington riding' maintained social norms by punishing licentious behaviour with ridicule, and warning potential culprits to conform to their society's values. Skimmingtons were one of the less-than-benign consequences of the group-mindedness that Michael Tomasello regards as the unique feature of human cognition. Image courtesy of Trinity Hall, Cambridge. Engraving by James Mynde after William Hogarth.

other mammals, they have some understanding of causal and intentional relations, but their intentionality is individualistic. Mostly they think about what *I* want and know, and occasionally, when it serves their selfish purposes, about what *you* want and know, but never about what *we* are thinking.

That changed with the advent of joint intentionality at stage two. Common ancestors of modern humans and Neanderthals, perhaps the elusive *Homo heidelbergensis*, began to find that they couldn't get their daily bread without working in pairs, and consequently to face dilemmas of coordination. If I can catch a hare by myself, but I need to work with you to fell a stag, it's in my interests to give up on the hare and go for the stag only if you're going to do the same thing. So, how do I work out what you're going to do? Tomasello's answer is that early humans dealt with this kind of problem by evolving a new form of cooperative communication, combining pointing and pantomiming, and, 'internalizing'

this communication, a new way of thinking. In the new 'second-personal' mode of thought, each party in a collaborative pair represents joint goals and joint attention — what we want, and what we perceive — as well as each of our roles in the task and perspectives on the situation. With the dawn of this joint intentionality, agents became able and motivated to inform rather than manipulate their social partners. Imagine that you and I are gathering honey together, and I point to a stick. I'm not trying to make you use it. Rather, I'm letting you know about the stick's location because I realise that you may not be able to see it from your perspective, and you may want to use the stick given your role in our task.

A lot happens in the transition to stage three, collective intentionality. Due to increases in population size and competition between groups, humans now need to cooperate with strangers in their group, provoking the emergence of both culture and language. Individuals begin to regard

group membership as a fundamental part of their identity, and to decide who belongs in which group — and therefore who is a potential cooperation partner — using shibboleths. The kind of container you use to transport your honey isn't just a matter of what works, it defines who you are. Consequently, there is now a premium on high fidelity cultural inheritance of skills, which is achieved through norm-guided teaching. Novices are taught to make the honey pot *this* way because that's how *we* do it. To further assist cultural inheritance, and to enable cooperation among strangers, communication becomes vocal and conventional; it became language. You don't just cobble together some gestures that might get me to notice the stick, you use words in sequences that all members of our group will understand. And with the conventionalisation of communication, modern humans began to think in a torrent of new ways — to use logical operations; to connect beliefs into an encompassing inferential 'web'; to

assess their own thought processes in an internal dialogue similar to reasoned debate among group members; and to represent features of the world, not just as your perspective or my perspective, but as objectively true, as facts.

Evolutionary psychology is a crowded market. There's no shortage of books telling a story about how chimp-like ancestors turned into modern humans. *A Natural History of Human Thinking* is part of a sub-genre that sees the problems and solutions as fundamentally social. It was the demands of dealing with other agents, rather than technological problems, that were the primary drivers of human evolution, and these demands were met, not by expanding and adjusting general-purpose cognitive mechanisms, but by evolving distinctively social ways of thinking. Within this sub-genre, Tomasello's book has two major selling points. First, following Sterelny's *The Evolved Apprentice* (2012), it makes a serious attempt to bridge the gap — to explain the kind of cooperation that must already have been in place to enable the evolution of language and culture. This is the crucial 'joint intentionality' stage of Tomasello's model. Second, it is more cognitive than other, similar stories — it tries hard not only to reconstruct the behaviour of our forebears, but to explain what was going on inside their heads. Both of these ambitions are fulfilled only in part.

The problem with Tomasello's bridge is that he attempts to support it with studies of young children, who are not a good model of culture-less, language-less early humans. The language of one- to three-year-olds may be limited, but their behaviour and ways of thinking have already been shaped by thoroughly modern humans — their parents and other caregivers. Acknowledging this kind of evidential problem, Tomasello suggests that it is the logic of his stage model that really counts. No matter when or exactly how they did it, our ancestors *must* have gone through something like joint intentionality to get from a chimp-like state to our current way of life. Well, yes and no. Yes if we accept this book's characterisation of the start and end points. No if we doubt, along with many primate researchers, that chimpanzees are quite as smart as Tomasello suggests, or, in the company of some linguists, that modern humans are really so keen to inform rather than manipulate in their use of language.

But even if we embrace the sequence of three stages — which is certainly plausible and clearly drawn — if it's only the logic that counts, the sequence might unfold ontogenetically, wholly in the course of human development. Perhaps we are born competitors with individual intentionality and become pair-wise collaborators with joint intentionality through the enculturation and language learning which give us, in maturity, collective intentionality.

A natural objection to this idea is that there must be some inborn differences between us and our chimp-like ancestors — genetically inherited cognitive adaptations — that make possible enculturation and language learning. That is surely right, but Tomasello's analysis is pitched so high — so preoccupied with intentionality — that some good candidates may be overlooked. Drawing on the work of philosophers and historical figures in developmental psychology, such as Vygotsky and Piaget, but ignoring contemporary cognitive science and neuroscience, this book is resolutely focused on the most complex kinds of thinking. It overlooks the myriad 'subpersonal' processes that go on inside our heads — the perceptual, attentional, motivational and motoric mechanisms that beaver away below the intentional surface. It could be genetically-based changes to these mechanisms — such as the inborn human tendency to look at faces, and to enjoy contingent interaction — that lay the foundations for enculturation.

But these reservations should not detract from Tomasello's achievement. Especially when discussing communication, the breadth of his scholarship and clarity of his analysis are truly impressive. There's a tendency in evolutionary psychology and beyond to see language as the Rubicon — the thing that changed everything — but very few authors are able to lay out in detail the full range of challenges and opportunities that language presents. So, in this respect and many others, this is an important book. It offers a subtle and authoritative contemporary statement of the view that human thinking — which yields both beautiful ideas and nasty Skimmingtons — is naturally and fundamentally social.

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## Q & A

### Jack Horner

*John 'Jack' Horner is Regent's professor of paleontology in the department of earth sciences, and the honor's college, and curator of paleontology at the Museum of the Rockies, Montana State University in Bozeman. Although he attended the University of Montana for seven years studying geology and zoology, he does not have a formal college degree. The University of Montana bestowed him with an honorary doctorate of science the same year he received a MacArthur Fellowship. Most recently, he received the Romer Simpson Lifetime Achievement Medal from the Society of Vertebrate Paleontology. Jack studies dinosaur growth, behavior, and evolution and works almost exclusively in Montana.*

**How did you end up a professor and curator without a college degree?**

I'd like to blame the lack of a college degree on the 60s, but dyslexia was the reason. I graduated last in my class in high school and flunked out of college seven times. I read words letter by letter and have virtually no short-term memory. Reading is still the hardest thing I do in my life. I discovered early in my career that if I worked on subjects others had neglected or simply not thought of, there really wasn't much of anything to read. My first job was at Princeton University as a technician in their natural history museum. My boss, Don Baird, taught me how to write research papers and NSF grants. One of my first papers was in *Nature*, so Princeton promoted me to research scientist status. Shortly thereafter I was hired by Montana State University to be the curator of paleontology at the Museum of the Rockies. I wasn't able to have students, or write NSF grants, or teach classes, but that all changed when I received my honorary doctorate and the MacArthur Fellowship.

**When did you first become interested in biology?**

I was born loving nature, but on the plains of Montana, where I was raised, there was precious little living nature to observe. At a very young age I began collecting