News & views

Evolution

Learning from others what cannot be learnt alone

Alex Thornton

It has been argued that human culture rests on a unique ability to learn from others more than we could possibly learn alone in a lifetime. Two studies show that we share this ability with bumblebees and chimpanzees. **See p.572**

You and I are both, biologically speaking, African apes, but I am writing this on a laptop in Cornwall, and you might be reading it in Colombo, Caracas or Canberra. This reflects one of the most remarkable attributes of the human species – the progressive improvement of skills and technologies as innovations spread and are built on, a phenomenon called cumulative culture. Studies by Bridges *et al.*[1] on page 572 and van Leeuwen *et al.*[2] in *Nature Human Behaviour* shed light on the capacity of other animals to demonstrate the type of skill that might be needed to achieve cumulative culture.

Improvements in the products of human culture, such as tools and technologies, have enabled humanity to spread across the globe, transform ecosystems and probe the farthest reaches of space. Other animals show modest forms of cumulative culture – for example, homing pigeons (*Columba livia*) refine the efficiency of their flight routes by learning from each other[3] – but the scope and scale of human cumulative culture clearly outstrips anything observed in the natural world. Why might this be the case? One influential argument[4] states that only humans can learn from others things that are beyond what they could learn independently, exceeding what is called a zone of latent solutions (those that an individual might be able to invent alone). The research by Bridges *et al.* and van Leeuwen *et al.*, examining two notably different species, cast serious doubt on this supposed human exceptionalism.

At a sanctuary in Zambia, van Leeuwen and colleagues presented two groups of chimpanzees (*Pan troglodytes*) with a multi-step task involving an apparatus similar to a vending machine. To obtain a reward of peanuts, a chimpanzee had to retrieve a wooden ball, pull and hold open a drawer on the machine, slot in the ball and then close the drawer to release the peanuts (Fig. 1a). The chimpanzees explored the task, but over a period of 3 months, no individual among the 66 tested solved it. However, after the experimenters trained 2 chimpanzees to solve the task and the animals acted as demonstrators, the solution spread across the apes' social network, resulting in 14 individuals learning how to solve the task.

Hence, chimpanzees seem to join humans in the club of animals that, through observation, can learn skills that are difficult, if not impossible, to learn alone. This might, in principle, enable cumulative culture because many could learn from advances made by rare innovators. But perhaps the result of this experiment is not so surprising given that chimpanzees have large brains and rich cultural lives, including the ability to develop traditions of foraging techniques and tools that differ between communities[5].

Bridges and colleagues' study is all the more remarkable because it focuses not on humanity's primate cousins, but on the humble bumblebee (*Bombus terrestris*) – an animal with a brain that is barely 0.0005% of the size of a chimpanzee's. These authors used a two-step puzzle box in which a bee first had to move a blue tab out of the way to

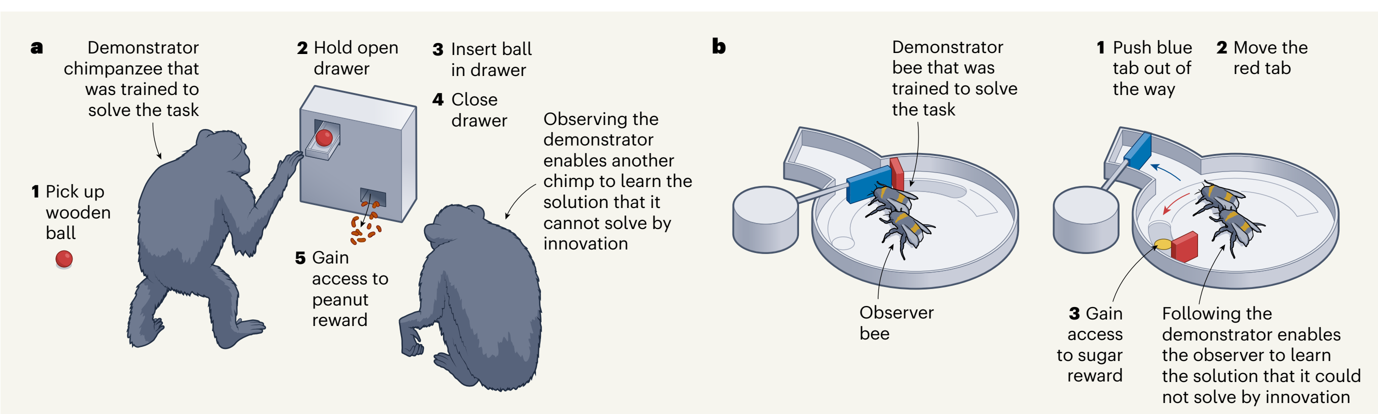

Figure 1 | Animals other than humans can learn skills that one individual could probably not achieve in their lifetime. Scientists examined the ability of chimpanzees and bees to solve a complex task through innovation over an extended period of time. **a**, van Leeuwen *et al.*[2] reveal that chimpanzees can learn to complete a task that they could not solve by innovation alone over the course of three months. Chimpanzees gained the ability to complete the task by watching an individual demonstrator that had been trained to solve the task. **b**, Bridges *et al.*[1] show that this capacity is also present in invertebrates, because bumblebees can socially learn to solve a task that individuals could not solve by innovation over the course of up to 24 days — longer than most bumblebees spend foraging during their lifetime. The bee has to move two tabs to solve the task. The red tab is attached to an opening in the upper layer of the plastic that provides access to the sugar treat when the opening is moved above the reward.

reach a red tab, which could then be pushed to access a sugar treat (Fig. 1b). Over periods of 12 or 24 days, no bee across 3 colonies tested worked this out. Then, through a painstaking process, the authors used rewards to train nine bees to learn the solution and thus become demonstrators for the other bees. Strikingly, 5 of the 15 bees that were then exposed to demonstrators learnt the task themselves. These are small sample sizes, but the point is clear – the task was exceptionally hard to learn alone, yet some bees could solve it through social learning.

It is possible that some individuals in the studies might have innovated the task solution had they been given more time. After all, 3 months is not that long a time frame for a chimpanzee that might live for 40 years or more. By contrast, the average bumblebee spends only 8 days of its life foraging, so the 12–24 days in Bridges and colleagues' study might be as close as scientists will ever get to testing what animals are capable of in their lifetimes.

But what if more individuals had participated in the experiments? This demonstrates a general difficulty in testing the hypothesis based on the zone of latent solutions. How can a researcher ever be satisfied that a task is too difficult to solve alone? And can we really define the zone of latent solutions for a particular species, given that cognitive abilities, skills and knowledge vary widely between individuals in that species, depending on their genes and developmental experiences[5,6]?

Of course, the social transmission of behaviours acquired through human training does not show that bumblebees or chimpanzees socially learn such complex skills in the wild. Moreover, both studies involved a single episode of social learning, so they cannot explicitly test the potential for the progressive improvements in skills that characterize cumulative culture. The chimpanzee research has intriguing parallels with natural behaviours such as nut-cracking – a multi-step skill that some suggest is too complex for chimpanzees to learn alone and so must be an outcome of cumulative culture[7]. However, rather than telling us about cumulative culture in bumblebees and chimpanzees, a strength of these studies might be what they reveal about humans.

People habitually overestimate their abilities relative to those of other animals and are drawn to 'silver bullet' explanations of human cognition and culture[8]. This research suggests that the ability to learn from others what cannot be learnt alone should now join tool use, episodic memory (the ability to recall specific past events) and intentional communication in the scrapheap of discarded silver bullets[8]. There is also no need to appeal to specialized forms of social learning, such as imitating others' body movements – the bumblebees learnt simply because by following closely behind knowledgeable demonstrators, they gained experience of the task. Many researchers studying humans are reaching similar conclusions. For instance, experiments show that the imitation of body movements is not necessary to achieve cumulative improvements in tool designs[9,10].

If chimpanzees and bumblebees can learn from others what cannot be learnt alone, then this ability is unlikely to be an explanation for humanity's distinctive cumulative culture. Rather than an explanation, it might instead be an outcome — cumulative culture produces products, such as the laptop I am using now, that are much too complex for any one of us to invent alone. Perhaps it is time to abandon silver bullets and focus instead on unravelling how the co-evolutionary web of feedback between innovation, social learning and social structure gives rise to the complex culture on which humans all depend[5,8,10].

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In retrospect

Epstein–Barr virus at 60

Lawrence S. Young

The 1964 discovery of Epstein–Barr virus shed light on factors that contribute to human cancer. Subsequent studies set the stage for finding ways to diagnose and treat cancer, and revealed how immune defences control viral infection.

This month marks the 60th anniversary of the discovery of Epstein–Barr virus (EBV), the first virus shown to cause cancer in humans. In March 1964, Anthony Epstein, Yvonne Barr and Bert Achong presented findings[1] in *The Lancet* which reported the identification of these virus particles in cancer cells, grown *in vitro,* that were taken from an aggressive type of blood cancer (lymphoma) found in children living in central Africa.

The possibility that an infectious agent might cause cancer originated with Peyton Rous's discovery in 1911 that a virus – called Rous sarcoma virus – caused soft-tissue tumours (known as sarcomas) in chickens[2]. Although this report was met with much scepticism, the observation initiated a series of studies confirming that viruses can cause cancer in animals, but such a role for viruses in humans remained elusive.

The identification of EBV, 53 years later, was a landmark discovery in the understanding of human cancer, providing key insights into processes that can drive tumour formation. The finding also encouraged further interest in the field of tumour virology resulting in the identification[3] of other human-cancer-associated viruses, including human papillomaviruses and hepatitis B virus. It is now estimated that viruses cause between 10% and 15% of human cancers worldwide[3,4]. These viruses provide crucial targets for diagnosis, therapy and prevention.

The discovery of EBV owes much to serendipity[5,6]. During the 1950s, Epstein had been working on Rous sarcoma virus – an unfashionable topic at the time – because he was convinced that viruses would also have a role in human cancer. By chance, Epstein, who was then working at the Middlesex Hospital in London, attended a lecture on 22 March 1961 by Denis Burkitt, a surgeon who had been working in Africa. Burkitt showed that the distribution of a type of lymphoma that affected children across Africa was dependent on climatic factors. Epstein concluded that the connection to climate noticed by Burkitt might mean that an insect was involved in spreading a tumour-promoting virus.

Burkitt agreed to send biopsy samples of the tumour, now known as Burkitt lymphoma, from Kampala for analysis in Epstein's