Tool-use in the brown bear (*Ursus arctos*)

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Abstract

This is the first report of tool-using behaviour in a wild brown bear (*Ursus arctos*). Whereas the use of tools is comparatively common among primates and has also been documented in several species of birds, fishes and invertebrates, tool-using behaviours have so far been observed in only four species of non-primate mammal. The observation was made and photographed while studying the behaviour of a subadult brown bear in southeastern Alaska. The animal repeatedly picked up barnacle-encrusted rocks in shallow water, manipulated and re-oriented them in its forepaws, and used them to rub its neck and muzzle. The behaviour probably served to relieve irritated skin or to remove food-remains from the fur. Bears habitually rub against stationary objects and overturn rocks and boulders during foraging and such rubbing behaviour could have been transferred to a freely movable object to classify as tool-use. The bear exhibited considerable motor skills when manipulating the rocks, which clearly shows that these animals possess the advanced motor-learning necessary for tool-use. Advanced spatial cognition and motor skills for object manipulation during feeding and tool-use provides a possible explanation for why bears have the largest brains relative to body size of all carnivores. Systematic research into the cognitive abilities of bears, both in captivity and the wild is clearly warranted to fully understand their motor learning skills and physical intelligence related to tool-use and other object manipulation tasks.

KEYWORDS: *tool-use, cognition, motor learning, brown bear*

SHORT TITLE: *Tool-use in the brown bear*

Introduction

The use of tools by non-human animals to solve tasks not easily achieved using the body alone has received much attention in comparative cognition research (reviewed by Alcock 1972; Beck 1980; Bentley-Condit and Smith 2010; Seed and Byrne 2010), because it can teach us about their physical intelligence, motor learning skills and behavioural flexibility. While the cognitive foundations underlying the use of tools are probably diverse and differ between species and tasks performed, tool-using has been used as evidence for cognitive faculties such as goal-directedness (e.g., Bird and Emery 2009; Sanz and Morgan 2009; Sanz et al. 2009), forward planning (e.g., Osvath and Osvath 2008), or the presence of culturally transmitted norms (Call and Tennie 2009; Whiten et al. 2005).

While there is on-going debate about appropriate definitions of tool-use, most researchers agree that tool-use constitutes the use of a freely manipulable object to modify the physical properties of a target object through a complex mechanical interaction (e.g., Alcock 1972; Beck 1980; Bentley-Condit and Smith 2010; St Amant and Horton 2008). Possible target objects may include other organisms (e.g., conspecifics; Nishida 2003, or prey; Levey et al. 2004; McGrew et al. 1979) or even the tool-user's own body (Beck 1980; Seed and Byrne 2010; St Amant and Horton 2008). St Amant and Horton (2008) argued that tool-use does not need to be directed at an object, but additionally can also have the effect of modifying the information flow in the environment. Animals may therefore use tools to obtain sensory information (e.g. a gorilla apparently using a stick to test water depth; Breuer et al. 2005), to avoid painful stimuli (e.g., dolphins covering their rostrums with sponges during benthic foraging; Krützen et al. 2005) or detection (e.g., an orang-utan hiding behind a detached branch; van Schaik et al. 2003), or for communicative purposes (e.g. using branches in gestures or displays; Nishida 2003; Pika et al. 2003; van Schaik et al. 2003).

The vast majority of animal species do not use tools, and those that do come from a diverse taxonomic background (Alcock 1972; Beck 1980; Bentley-Condit and Smith 2010). Tool-using behaviours are often highly stereotyped, but some species exhibit the ability to modify tools and their use depending on the task at hand (e.g., Hunt and Gray 2004; Sanz and Morgan 2009; Tebbich and Bshary 2004). Such behavioural flexibility may be a better indicator of physical intelligence than the use of tools alone (Emery and Clayton 2009). Several species that do not use tools in the wild can be taught their use in captivity and show comparable aptitude at tool-using tasks as tool-using species (e.g., Bird and Emery 2009; Tebbich et al. 2010). Among the invertebrates, antlions (*Myrmeleontidae*; Alcock 1972) and veined octopus (*Amphioctopus marginatus*; Finn et al. 2009) are known to use tools. Fishes known to use tools include archer fishes (*Toxotes spp.*; Alcock 1972; Bentley-Condit and Smith 2010) that use a jet of water to dislodge insects from vegetation and show surprising behavioural flexibility related to tool-use (Schuster et al. 2006). Tool-use has been documented in a few tens of species of birds including buzzards and old-world vultures (*Accipitridae*), owls (*Strigidae*), herons (*Ardeidae*), Galápagos finches (*Thraupidae*) and corvids (*Corvidae*; summarised by Alcock 1972; Beck 1980; Levey et al. 2004; Emery and Clayton 2009). Particularly corvids and Galápagos finches show significant levels of behavioural flexibility when using tools (e.g., Bird and Emery 2009; Hunt & Gray 2004; Tebbich and Bshary 2004; Tebbich et al. 2010).

Among mammals tool-use is comparatively common in primates and has been documented in the wild for chimpanzees (*Pan troglodytes*; e.g., Boesch and Boesch 1990; McGrew et al. 1979; Sanz and Morgan 2009; Whiten et al. 2005), bonobos (*Pan paniscus*; e.g., Ingmanson 1996), gorillas (*Gorilla gorilla;* Breuer et al. 2005), orang-utans (*Pongo spp.*; van Schaik et al. 2003), capuchin monkeys (*Cebus spp.*; e.g., Ottoni and Izar 2008), as well as humans. Some great apes exhibit the ability to use tools flexibly depending on the task at hand (e.g., Hall 1963; Sanz and Morgan 2009; Sanz et al. 2009) and show evidence for imitation and cultural transmission (Call and Tennie 2009; Whiten et al. 2005; Whiten et al. 2009). However, there is little evidence that any non-human primates understand causal relationships underlying complex tool-use tasks (Emery and Clayton 2009; Visalberghi and Limongelli 1994).

Interestingly, for mammalian taxa other than primates evidence for tool-use in the wild is surprisingly rare – to date true tool use has only been described for four species. Sea otters (*Enhydra lutris*) habitually use rocks to break the shells of sea urchins and clams (e.g.: Kenyon 1959). Some Asian elephants (*Elephas maximus*) modify tree branches and use them to repel flies (Hart et al. 2001). A small number of bottlenose dolphins (*Tursiops sp.*) in Shark Bay, Australia cover their rostrums with sponges while foraging, presumably to protect themselves from stingrays (Krützen et al. 2005). Finally, humpback whales (*Megaptera novaeangliae*) in several areas exhale curtains of bubbles and use them to trap schools of fish (e.g., Jurasz and Jurasz 1979).

In this paper I report an incident of tool-use by a wild North American brown bear (*Ursus arctos*). Although brown bears have been studied extensively in the wild (e.g., Gilbert 1999; Green and Mattson 2003; Fagen and Fagen 2004) and are commonly kept in captivity, little is known about their cognitive abilities. While there has been limited cognitive research on other species of bears (family *Ursidae*) investigating basic aspects of colour perception, learning, and spatial memory (e.g., Bacon and Burghardt 1973; Mazur and Seher 2008; Perdue et al. 2011) no studies have investigated cognitive aspects in brown bears to date.

Brown bears show many ecological and life-history traits that have been used to explain the evolution of advanced cognitive abilities in other species. They have a long life span, and an extended period of maternal dependency (Pasitschniak-Arts 1993) providing opportunities for both individual and social learning (Gittleman 1986). Brown bears are omnivorous with a high metabolic demand and live in highly seasonal environments requiring them to exploit a variety of food sources effectively. Brown bear diets vary regionally and some feeding strategies exhibit considerable complexity and may be learned (Gilbert 1999). Environmental variability has been implicated as a force selecting for behavioural innovations and increased brain size (Lefebvre et al. 2004).

Materials and Methods

Observations were made from an 11m diesel-powered vessel in Glacier Bay National Park and Preserve, Alaska, during July 19-26 2011. Bears are protected inside the National Park, habituated to the presence of vessels and showed little or no behavioural response to the boat. Bears were photographed using a digital SLR camera (Nikon D700) with a telephoto zoom lens (Nikkor 28-300mm F5.6 AF-S) and detailed notes on behaviour were taken. Observations were made in compliance with the National Park's wildlife viewing guidelines and under a valid boating permit (Permit # 9152).

Results

On 22 July 2010 at 14:30 ADT, we encountered a single brown bear in the West Arm of Glacier Bay (58°50.7'N 136°37.8'W). The bear, a subadult estimated to be between 3 and 5 years old, was feeding on the carcass of a humpback whale, which had washed ashore at least 2 months earlier. At 14:53 a second bear, also a subadult, emerged onto the beach some 300m distant. After some initial posturing, the two bears joined up at 15:04 approximately 200m from the carcass and spent the next 45min play-fighting interrupted by one short bout of feeding (on the whale carcass, as well as on intertidal barnacles; *Balanus sp.*). Play-fighting showed the characteristics of brown bear play (lack of vocal behaviour, frequent open-mouth grin or play-face; Fagen and Fagen 2004). The behaviour was initiated on shore, but the animals quickly moved into shallow water. The animals remained largely stationary and we observed little running or chasing.

At 15:20 the second bear temporarily returned to the carcass to feed, while the animal first observed on the beach remained in water estimated to be 1.5m deep close to shore. The animal picked up a small (approximately 25cm x 25cm x 15cm) rock in its forepaws (Fig 1A and B). It used both forepaws to re-orient the rock and dropped it one minute later. It immediately picked up another rock of similar size, and, after re-orienting it, rubbed the rock against its muzzle and face for one minute (Fig 1C-E) before dropping it (Fig 1F). During the rubbing, the bear used its left paw to press the rock against its face and muzzle and supported it from below using the claws of the right paw. The bear repeated the action with a third rock, rubbing its muzzle, face and neck for another two minutes. Close examination of the photographs taken during the encounter showed that all three rocks had barnacles growing on them (presumably *Balanus sp.*, see Fig. 1B-C). The animal then spent two minutes cleaning/grooming its right forepaw using its teeth before joining the other bear at the whale carcass.

Discussion

The stone-rubbing behaviour fulfils all commonly accepted criteria for animal tool-use (e.g., Alcock 1972; Beck 1980; St Amant and Horton 2008): the bear used freely manipulable objects (barnacle-encrusted rocks) in a complex mechanical interaction (rubbing behaviour) to effect a physical change in a target object (in this case the tool-user itself). The behaviour is analogous to non-human primates using sticks to scratch parts of their bodies (e.g., van Schaik et al. 2003) or Asian elephants using branches as fly switches (Hart et al. 2001). While the precise nature of the physical change remains unclear, it is likely that the bear was using the rock and rough carapaces of the attached barnacles to relieve itching skin. Brown bears moult during the summer (Green and Mattson 2003; Pasitschniak-Arts 1993) and both individuals showed clear signs of moulting. Moulting brown bears commonly rub against trees or rocks (Green and Mattson 2003), but the use of unattached objects for rubbing and scratching has not previously been reported. Alternatively, the bear may have been attempting to remove bits of whale blubber and oil from its fur using the rock. A similar use of an object for body maintenance has been described for giant pandas (*Ailuropoda melanoleuca*): a captive individual apparently rubbed its belly using a clod of soil (Eisenberg and Kleiman 1977).

Because bears habitually rub against stationary objects and also use their claws to scratch themselves it is easy to see how these behaviours could have been transferred to a freely manipulable object and thus fulfil the criteria for tool-use. In the case of stone-rubbing, sensory feedback from the use of the tool is instantaneous if the intended function of the behaviour is the relief of itchy skin. Such immediate feedback could have facilitated the transfer of rubbing or scratching behaviour from claws or attached objects to a freely manipulable rock. Using intermediate steps towards tool-use such as displacement behaviours (Alcock 1972) is therefore not necessary to explain the evolution of stone-rubbing in brown bears.

Using tools as an extension of the body changes the periphery between body and environment and thus has consequences for psychological processes such as perception, motor learning, attention, and cognition (Seed and Byrne 2010). Because tool-use requires advanced cognitive and perceptual faculties, it is commonly used as an indicator for advanced physical intelligence (Emery and Clayton 2009; Seed and Byrne 2010), and has been linked to increased brain size in several taxa (e.g., Reader and Laland 2002; Lefebvre et al. 2004). Bears are largely solitary, but have the largest brain weight and size in relation to their bodies of all carnivores, larger than far more sociable canids, felids and hyenids (Gittleman 1986). This appears to contradict theories about sociality as an evolutionary force promoting increased brain size and advanced cognition (e.g., Reader and Laland 2002). A possible explanation for the large brain size of bears in the light of their apparent lack of sociality may be that their high metabolic demand, especially during the months before hibernation selects for particularly efficient feeding strategies. The selective advantage of being able to track a variety of high-calorie food sources in space and time could have led to the evolution of advanced spatial and temporal cognition (Gilbert 1999) and manipulative and extractive foraging tasks may promote the evolution of physical cognition and motor learning skills. A comparative analysis of the brain anatomy of bears and other carnivores would be helpful to identify which brain regions have undergone evolutionary change.

But the asociality of bears itself may be something of a red herring: brown bears have an extended period of maternal dependency with cubs remaining with the mother for 2-4 years (Pasitschniak-Arts 1993; Gilbert 1999). Even after independence, siblings often remain together for several additional years and adult individuals are often found associated at sites of high food abundance (Gilbert 1999). Such prolonged social interactions could provide ample opportunity for social transmission of complex feeding strategies and other behaviours – vertical transmission from mother to offspring and horizontal transmission between siblings. However, social learning may not be necessary to explain the spread of stone-rubbing even if this form of tool-use was found to be common: brown bears frequently turn over rocks in search of food and feed on intertidal barnacles (*Balanus spp.*; Smith and Partridge 2004) both of which would provide ample opportunity for the acquisition of stone-rubbing behaviour through individual learning alone.

Creative behaviours such as tool-use are likely to be missed in systematic assessments of behaviour because they occur spontaneously only at low frequencies and may be limited to a few individuals. Anecdotes of such behaviours can therefore provide valuable information about the cognitive abilities of a species, so long as the observations were made by an experienced observer and were recorded immediately afterwards (Bates and Byrne 2007). While this observation of tool-use in a brown bear was documented with photographs and detailed behavioural notes as it occurred, to date it remains an isolated incident. Dedicated research is therefore ultimately required to determine how wide-spread stone-rubbing and other tool-using behaviours are in this species.

The observation establishes brown bears as the fifth non-primate mammal known to exhibit true tool-use. The fact that brown bears are able to use external objects as an extension of their bodies could suggest that the cognitive and perceptive faculties for tool-use have evolved earlier during the mammalian radiation than previously thought. Alternatively, and more likely perhaps, they may have evolved independently and convergently in several mammalian clades. Cognitive research in mammals has focussed disproportionately on primates while other taxa have received comparatively little attention. Data on the behaviour of wild brown bears is limited and their cognitive abilities have not yet been studied systematically. Discovery of tool-use in brown bears illustrates that dedicated research into the behaviour and cognition of bears is clearly warranted so that we can determine how these animals use the largest carnivore brains to make sense of their environment and to interact with it and with each other.

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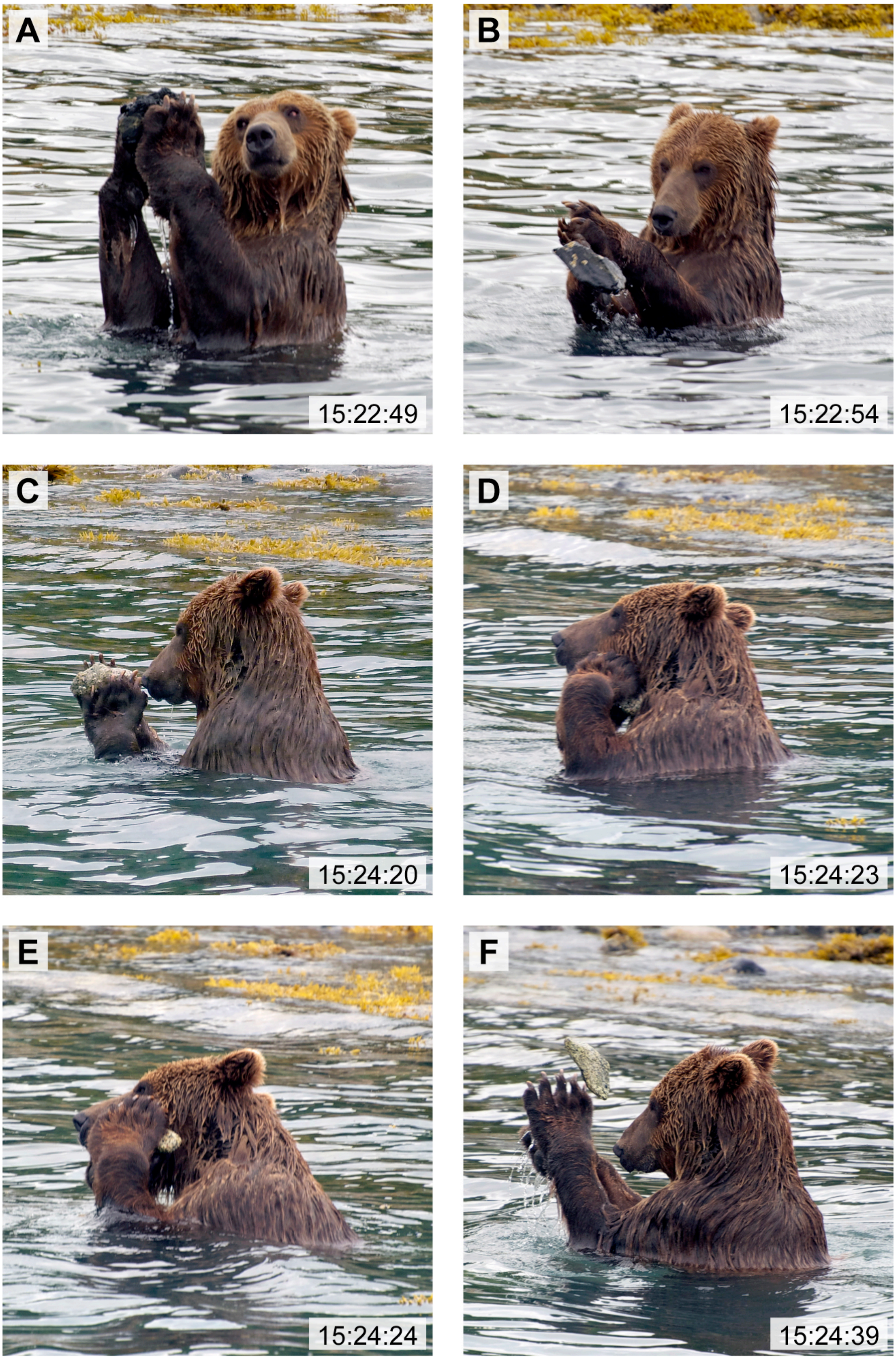
Figure Legend

Figure 1: Photographs showing stone-rubbing behaviour in a subadult brown bear (*Ursus arctos*). The animal picked up a rock from the sea floor and manipulated it (Panels A and B). It then retrieved a second rock, manipulated it, and rubbed it repeatedly against its neck and muzzle (Panels C-E) before dropping it (Panel F). The entire sequence was repeated with another rock (not shown).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