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

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11 **Abstract**

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

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

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

## 30 **Introduction**

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

41 While there is on-going debate about appropriate definitions of tool-use,  
42 most researchers agree that tool-use constitutes the use of a freely manipulable  
43 object to modify the physical properties of a target object through a complex  
44 mechanical interaction (e.g., Alcock 1972; Beck 1980; Bentley-Condit and Smith  
45 2010; St Amant and Horton 2008). Possible target objects may include other  
46 organisms (e.g., conspecifics; Nishida 2003, or prey; Levey et al. 2004; McGrew  
47 et al. 1979) or even the tool-user's own body (Beck 1980; Seed and Byrne 2010;  
48 St Amant and Horton 2008). St Amant and Horton (2008) argued that tool-use  
49 does not need to be directed at an object, but additionally can also have the effect  
50 of modifying the information flow in the environment. Animals may therefore use  
51 tools to obtain sensory information (e.g. a gorilla apparently using a stick to test  
52 water depth; Breuer et al. 2005), to avoid painful stimuli (e.g., dolphins covering  
53 their rostrums with sponges during benthic foraging; Krützen et al. 2005) or  
54 detection (e.g., an orang-utan hiding behind a detached branch; van Schaik et al.  
55 2003), or for communicative purposes (e.g. using branches in gestures or displays;  
56 Nishida 2003; Pika et al. 2003; van Schaik et al. 2003).

57 The vast majority of animal species do not use tools, and those that do come  
58 from a diverse taxonomic background (Alcock 1972; Beck 1980; Bentley-Condit  
59 and Smith 2010). Tool-using behaviours are often highly stereotyped, but some  
60 species exhibit the ability to modify tools and their use depending on the task at  
61 hand (e.g., Hunt and Gray 2004; Sanz and Morgan 2009; Tebbich and Bshary  
62 2004). Such behavioural flexibility may be a better indicator of physical

63 intelligence than the use of tools alone (Emery and Clayton 2009). Several species  
64 that do not use tools in the wild can be taught their use in captivity and show  
65 comparable aptitude at tool-using tasks as tool-using species (e.g., Bird and  
66 Emery 2009; Tebbich et al. 2010). Among the invertebrates, antlions  
67 (*Myrmeleontidae*; Alcock 1972) and veined octopus (*Amphioctopus marginatus*;  
68 Finn et al. 2009) are known to use tools. Fishes known to use tools include archer  
69 fishes (*Toxotes spp.*; Alcock 1972; Bentley-Condit and Smith 2010) that use a jet  
70 of water to dislodge insects from vegetation and show surprising behavioural  
71 flexibility related to tool-use (Schuster et al. 2006). Tool-use has been  
72 documented in a few tens of species of birds including buzzards and old-world  
73 vultures (*Accipitridae*), owls (*Strigidae*), herons (*Ardeidae*), Galápagos finches  
74 (*Thraupidae*) and corvids (*Corvidae*; summarised by Alcock 1972; Beck 1980;  
75 Levey et al. 2004; Emery and Clayton 2009). Particularly corvids and Galápagos  
76 finches show significant levels of behavioural flexibility when using tools (e.g.,  
77 Bird and Emery 2009; Hunt & Gray 2004; Tebbich and Bshary 2004; Tebbich et  
78 al. 2010).

79         Among mammals tool-use is comparatively common in primates and has  
80 been documented in the wild for chimpanzees (*Pan troglodytes*; e.g., Boesch and  
81 Boesch 1990; McGrew et al. 1979; Sanz and Morgan 2009; Whiten et al. 2005),  
82 bonobos (*Pan paniscus*; e.g., Ingmanson 1996), gorillas (*Gorilla gorilla*; Breuer  
83 et al. 2005), orang-utans (*Pongo spp.*; van Schaik et al. 2003), capuchin monkeys  
84 (*Cebus spp.*; e.g., Ottoni and Izar 2008), as well as humans. Some great apes  
85 exhibit the ability to use tools flexibly depending on the task at hand (e.g., Hall  
86 1963; Sanz and Morgan 2009; Sanz et al. 2009) and show evidence for imitation  
87 and cultural transmission (Call and Tennie 2009; Whiten et al. 2005; Whiten et al.  
88 2009). However, there is little evidence that any non-human primates understand  
89 causal relationships underlying complex tool-use tasks (Emery and Clayton 2009;  
90 Visalberghi and Limongelli 1994).

91         Interestingly, for mammalian taxa other than primates evidence for tool-use  
92 in the wild is surprisingly rare – to date true tool use has only been described for  
93 four species. Sea otters (*Enhydra lutris*) habitually use rocks to break the shells of  
94 sea urchins and clams (e.g.: Kenyon 1959). Some Asian elephants (*Elephas  
95 maximus*) modify tree branches and use them to repel flies (Hart et al. 2001). A  
96 small number of bottlenose dolphins (*Tursiops sp.*) in Shark Bay, Australia cover

97 their rostrums with sponges while foraging, presumably to protect themselves  
98 from stingrays (Krützen et al. 2005). Finally, humpback whales (*Megaptera*  
99 *novaeangliae*) in several areas exhale curtains of bubbles and use them to trap  
100 schools of fish (e.g., Jurasz and Jurasz 1979).

101 In this paper I report an incident of tool-use by a wild North American  
102 brown bear (*Ursus arctos*). Although brown bears have been studied extensively  
103 in the wild (e.g., Gilbert 1999; Green and Mattson 2003; Fagen and Fagen 2004)  
104 and are commonly kept in captivity, little is known about their cognitive abilities.  
105 While there has been limited cognitive research on other species of bears (family  
106 *Ursidae*) investigating basic aspects of colour perception, learning, and spatial  
107 memory (e.g., Bacon and Burghardt 1973; Mazur and Seher 2008; Perdue et al.  
108 2011) no studies have investigated cognitive aspects in brown bears to date.

109 Brown bears show many ecological and life-history traits that have been  
110 used to explain the evolution of advanced cognitive abilities in other species.  
111 They have a long life span, and an extended period of maternal dependency  
112 (Pasitschniak-Arts 1993) providing opportunities for both individual and social  
113 learning (Gittleman 1986). Brown bears are omnivorous with a high metabolic  
114 demand and live in highly seasonal environments requiring them to exploit a  
115 variety of food sources effectively. Brown bear diets vary regionally and some  
116 feeding strategies exhibit considerable complexity and may be learned (Gilbert  
117 1999). Environmental variability has been implicated as a force selecting for  
118 behavioural innovations and increased brain size (Lefebvre et al. 2004).

## 119 **Materials and Methods**

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

## 128 **Results**

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

141 At 15:20 the second bear temporarily returned to the carcass to feed, while  
142 the animal first observed on the beach remained in water estimated to be 1.5m  
143 deep close to shore. The animal picked up a small (approximately 25cm x 25cm x  
144 15cm) rock in its forepaws (Fig 1A and B). It used both forepaws to re-orient the  
145 rock and dropped it one minute later. It immediately picked up another rock of  
146 similar size, and, after re-orienting it, rubbed the rock against its muzzle and face  
147 for one minute (Fig 1C-E) before dropping it (Fig 1F). During the rubbing, the  
148 bear used its left paw to press the rock against its face and muzzle and supported it  
149 from below using the claws of the right paw. The bear repeated the action with a  
150 third rock, rubbing its muzzle, face and neck for another two minutes. Close  
151 examination of the photographs taken during the encounter showed that all three  
152 rocks had barnacles growing on them (presumably *Balanus sp.*, see Fig. 1B-C).  
153 The animal then spent two minutes cleaning/grooming its right forepaw using its  
154 teeth before joining the other bear at the whale carcass.

## 155 **Discussion**

156 The stone-rubbing behaviour fulfils all commonly accepted criteria for animal  
157 tool-use (e.g., Alcock 1972; Beck 1980; St Amant and Horton 2008): the bear  
158 used freely manipulable objects (barnacle-encrusted rocks) in a complex  
159 mechanical interaction (rubbing behaviour) to effect a physical change in a target

160 object (in this case the tool-user itself). The behaviour is analogous to non-human  
161 primates using sticks to scratch parts of their bodies (e.g., van Schaik et al. 2003)  
162 or Asian elephants using branches as fly switches (Hart et al. 2001). While the  
163 precise nature of the physical change remains unclear, it is likely that the bear was  
164 using the rock and rough carapaces of the attached barnacles to relieve itching  
165 skin. Brown bears moult during the summer (Green and Mattson 2003;  
166 Pasitschniak-Arts 1993) and both individuals showed clear signs of moulting.  
167 Moulting brown bears commonly rub against trees or rocks (Green and Mattson  
168 2003), but the use of unattached objects for rubbing and scratching has not  
169 previously been reported. Alternatively, the bear may have been attempting to  
170 remove bits of whale blubber and oil from its fur using the rock. A similar use of  
171 an object for body maintenance has been described for giant pandas (*Ailuropoda*  
172 *melanoleuca*): a captive individual apparently rubbed its belly using a clod of soil  
173 (Eisenberg and Kleiman 1977).

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

184         Using tools as an extension of the body changes the periphery between body  
185 and environment and thus has consequences for psychological processes such as  
186 perception, motor learning, attention, and cognition (Seed and Byrne 2010).  
187 Because tool-use requires advanced cognitive and perceptual faculties, it is  
188 commonly used as an indicator for advanced physical intelligence (Emery and  
189 Clayton 2009; Seed and Byrne 2010), and has been linked to increased brain size  
190 in several taxa (e.g., Reader and Laland 2002; Lefebvre et al. 2004). Bears are  
191 largely solitary, but have the largest brain weight and size in relation to their  
192 bodies of all carnivores, larger than far more sociable canids, felids and hyenids  
193 (Gittleman 1986). This appears to contradict theories about sociality as an

194 evolutionary force promoting increased brain size and advanced cognition (e.g.,  
195 Reader and Laland 2002). A possible explanation for the large brain size of bears  
196 in the light of their apparent lack of sociality may be that their high metabolic  
197 demand, especially during the months before hibernation selects for particularly  
198 efficient feeding strategies. The selective advantage of being able to track a  
199 variety of high-calorie food sources in space and time could have led to the  
200 evolution of advanced spatial and temporal cognition (Gilbert 1999) and  
201 manipulative and extractive foraging tasks may promote the evolution of physical  
202 cognition and motor learning skills. A comparative analysis of the brain anatomy  
203 of bears and other carnivores would be helpful to identify which brain regions  
204 have undergone evolutionary change.

205         But the asociality of bears itself may be something of a red herring: brown  
206 bears have an extended period of maternal dependency with cubs remaining with  
207 the mother for 2-4 years (Pasitschniak-Arts 1993; Gilbert 1999). Even after  
208 independence, siblings often remain together for several additional years and adult  
209 individuals are often found associated at sites of high food abundance (Gilbert  
210 1999). Such prolonged social interactions could provide ample opportunity for  
211 social transmission of complex feeding strategies and other behaviours – vertical  
212 transmission from mother to offspring and horizontal transmission between  
213 siblings. However, social learning may not be necessary to explain the spread of  
214 stone-rubbing even if this form of tool-use was found to be common: brown bears  
215 frequently turn over rocks in search of food and feed on intertidal barnacles  
216 (*Balanus spp.*; Smith and Partridge 2004) both of which would provide ample  
217 opportunity for the acquisition of stone-rubbing behaviour through individual  
218 learning alone.

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



228 how wide-spread stone-rubbing and other tool-using behaviours are in this  
229 species.

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

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## 352 **Figure Legend**

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

