The crafting of hook tools by wild New Caledonian crows

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The ‘crafting’ of tools involves (i) selection of appropriate raw material, (ii) preparatory trimming and (iii) fine, three-dimensional sculpting. Its evolution is technologically important because it allows the open-ended development of tools. New Caledonian crows manufacture an impressive range of stick and leaf tools. We previously reported that their toolkit included hooked implements made from leafy twigs, although their manufacture had never been closely observed. We describe the manufacture of 10 hooked-twig tools by an adult crow and its dependent juvenile. To make all 10 tools, the crows carried out a relatively invariant three-step sequence of complex manipulations that involved (i) the selection of raw material, (ii) trimming and (iii) a lengthy sculpting of the hook. Hooked-twig manufacture contrasts with the lack of sculpting in the making of wooden tools by other non-humans such as chimpanzees and woodpecker finches. This fine, three-stage crafting process removes another alleged difference between humans and other animals.

Keywords: crafting tools; hooks; tool manufacture; goal directedness; cognition

1. INTRODUCTION

A characteristic of early human tool manufacture is the modification of natural resources such as wood into tools such as wooden spears, digging sticks and bows. This ‘crafting’ of tools is a process involving (i) selection of an appropriate section or piece of material, (ii) preparatory trimming and (iii) fine, three-dimensional sculpting (Oakley 1967). Although the artefact record of wooden tools made by early humans is extremely poor, the crafting of stone tools is a relatively recent phenomenon in our evolutionary past. Its appearance around 1.5 Myr ago is thought to be associated with new cognitive skills that allowed the manufacture of distinct tools by imposing form on material (e.g. Donald 1991; Wynn 2002). Tool manufacture by animals such as woodpecker finches *Cactospiza pallida* and chimpanzees *Pan troglodytes* often involves some selection and trimming, but fine sculpting is unknown outside humans (Beck 1980; McGrew 1992).

New Caledonian crows *Corvus moneduloides* have impressive tool manufacturing capabilities (Hunt 1996, 2000; Hunt & Gray 2002, 2003). For example, they appear to have diversified and cumulatively evolved the tools that they shape from the edges of *Pandanus* spp. leaves (Hunt & Gray 2003). Hunt (2000) used the term

‘sculpting’ to describe the making of crows’ tapered, stepped pandanus tools. However, manufacture of pandanus tools involves shaping leaf material in a two-dimensional way and no preparatory trimming is carried out (Hunt & Gray 2003). Although it is a complex behaviour, the manufacture of pandanus tools is not directly comparable to the crafting of tools.

The possibility of three-dimensional modification of raw material exists in the manufacture of crows’ hooked-twig tools (Hunt 1996). Crows make these tools at sites over a large area in the southeast of Grande Terre (Hunt & Gray 2002). The hooked ends are the main working ends and are often pointed. Hunt (1996) mentioned that he saw crows working on the hooked ends with their bills, but gave no details as to what they might be doing. In fact, he suggested that birds formed a hook with a single ‘nip’ that detached the live tool twig from the adjoining side twig; the nip supposedly removed the tool twig in one action along with a small section of side twig that constituted the hook. It remained unclear whether the hooks were imposed features or simply side-effects of tool-twig removal.

In 2002, we observed two wild New Caledonian crows making hooked twigs. Here, we report the first detailed description, to our knowledge, of crow hooked-tool manufacture in the wild. This is the first case of crafting tools outside humans.

2. METHODS

Our observations suggest that crows generally live in family units, which consist of a mated pair and offspring. We fed a crow family in Parc Rivière Bleue, Grande Terre, between 25 May and 7 June 2002 by placing food in vertical holes that we drilled in a dead log. The log was positioned horizontally on a makeshift table 1.2 m above the ground and 2 m from our observation hide. The hooked-twig tools that the crows brought to the site were usually made from *Cunonia vieillardii* twigs, so we selected small, leafy *C. vieillardii* branches and stood them in holes in the feeding log. Each branch had at least several forked twigs on it that could potentially be used to make hooked tools. We stood one branch in the log at a time, replacing it with a new one when the supply of forked twigs was nearly exhausted. We then observed an adult crow (three times) and its dependent offspring (seven times) manufacturing tools from this material to extract the food in the holes. Six out of the seven juvenile tool-manufacturing episodes were captured on video. We collected the discarded material and the resulting tools that the crows did not carry away. We also recorded which end of a hooked tool a crow used after it picked it up from a horizontal position (either from the log or table). As some tools were used on more than one occasion, the sample size for tool use is greater than the number of tools made.

3. RESULTS

Both crows exclusively manufactured hooked-twig tools. In contrast to the suggestion by Hunt (1996), the manufacture of hooked twigs does not involve a single ‘nip’. Instead, both birds followed four basic steps to make the 10 tools, before using them (figure 1a). They (i) selected a fork formed by, usually, two twigs; (ii) broke off one twig just above the junction (side twig), then discarded it; (iii) broke off the remaining twig just below the junction (tool twig); and (iv) carried out fine sculpting of the hook on the tool twig with the bill, in between removing the compound leaves (juvenile examples of each step are in the animation in electronic Appendix A: available at The Royal Society’s Publications Web site). The sculpting removed small pieces of wood from the hook, which refined and sharpened it. We did not have sufficient footage of step (i) to record the time it took for a crow to choose material. We could only record the combined time

Figure 1. (a) The manufacture of tool 4 in figure 2 from a *Cunonia vieillardii* twig (the tool is 13.1 cm long). After selecting the fork, the crow snapped off the side twig just above the junction and discarded it (break I). It then snapped the tool twig off the stem just below the junction (break II) before carrying out fine sculpting of the hook and removing the four compound leaves to the right. (b) Hooks on the five hooked-twig tools that we collected from the juvenile crow at the feeding site (i). The four hooks from left to right are on tools 1, 2, 4 and 5 in figure 2. We were unable to film the manufacture of the unnumbered tool at the far right. (ii) Hooks on the nine hooked twigs brought to the feeding site that we collected from the adult crow are shown.

it took to carry out steps (ii) and (iii) because it was often difficult to determine the finish of step (ii) and beginning of step (iii). However, we were able to record the time it took a crow to complete step (iv). Step (iv) was not just a few seconds work, but a large part of the manufacturing process (mean = 67.8 s, s.d. = 11.6, $n = 5$); the juvenile took significantly longer to complete step (iv) than steps (ii) and (iii) combined (mean = 20.8 s, $n = 4$) (Wilcoxon $Z = -2.33$, $p = 0.02$).

Both crows used the same 'snapping' technique to remove side twigs and tool twigs. They snapped the side twigs off by holding them firmly in the bill near their bases and then sharply rolled their heads sideways. The side twigs then broke in half just below the bill (break I in figure 1a). Stumps did not form when we simply pulled *C. vieillardii* twigs off adjoining twigs. The only time we saw a crow pull a side twig off one of the branches was when the adult made a hooked tool from a three-twig fork.

It first removed an outside twig by pulling it off, which left no stump or potential fork. Then it carried out steps (i)–(iv) above to make a hooked tool out of the remaining two-twig fork. Both crows also snapped the tool twig off very close to the base of the forked junctions. Consequently, the hooks were close to the ends of the tools (break II in figure 1a).

We documented the variation in the juvenile's tool-making from the video footage (figure 2). On two occasions the crow began using a tool with the last compound leaf still attached, but subsequently removed it. It also appeared to start sculpting the hook after breaking off the side twig, but before removing the tool twig. This possible sculpting only lasted a matter of seconds at most so we were uncertain as to whether or not it was more related to removal of the tool twig.

Three differences in the behaviour of the two crows suggested that the juvenile was less experienced than its parent at making and using hooked twigs. First, only the juvenile repeatedly worked on the hook after first use of the tool. This behaviour may have been a reaction to limited success at extracting food combined with the considerable effort spent in trying to do so. The diminished hook on tool 2 (figure 1b) was probably a result of this repeated refining. Second, after picking up tools from a horizontal position the juvenile sometimes used the non-hooked ends as the working ends ($n = 6$), but used the hooked ends significantly more often ($n = 39$) ($\chi^2 = 24.2$, $n = 45$, $p < 0.0001$). The parent never attempted to extract food using the non-hooked end of a tool. Last, the juvenile crow had noticeably more difficulty in snapping off the tool twig than did its parent (see the animation in electronic Appendix A). The wood is wider and strongest at the junction of stems compared to stems themselves either side of the junction, and it often required some skill to snap the tool twigs off. We noticed that there was more stem at the base of hooks on some tools made by the juvenile compared with those made by the adult (figure 1b).

4. DISCUSSION

New Caledonian crows appear to have a rudimentary technology analogous to that of early humans. This rudimentary technology includes the cognitively demanding task of crafting tools. In all 10 manufactures the crows (i) always chose forked twigs when commencing to make tools out of *C. vieillardii*; (ii) initially discarded side twigs that could have made suitable non-hooked tools. More tellingly, by snapping off side twigs near their bases instead of pulling them off, stumps or potential hooks were created; (iii) removed tool twigs by snapping them off just below the junction where the wood was strongest. This was often a difficult task, but it ensured that hooks were positioned at the ends of tools; and (iv) carried out definite sculpting to shape the hooks. This routine of complex manipulations is consistent with the possibility that the crows' goal was the manufacture of a hooked tool. The fact that the crows predominantly used the hooked ends as the working ends is also consistent with this possibility.

The tool manufacture of New Caledonian crows has four features previously thought to be unique to hominids: a high degree of standardization, the use of hooks, 'handedness' and cumulative changes in tool design (Hunt 1996, 2000; Hunt & Gray 2002, 2003). Recent work with

Figure 2. Variation around the four basic steps in the manufacture of six hooked-twig tools by the juvenile crow (described from video footage). Tools are numbered 1–6 in the chronological order that they were made. A cross within a circle indicates that the action was carried out just before data recording ceased. In the case of tool 3, the crow flew off with the tool before manufacture was completed.

a captive New Caledonian crow that bent wire to obtain food (Weir *et al.* 2002) suggests that, in contrast to chimpanzees (Povinelli 2000), these crows may have at least a rudimentary grasp of the physical properties of objects or ‘folk physics’. The crafting of hooked tools that we have reported here further demonstrates that the tool-making capabilities of these crows are surprisingly similar to those of early humans. Recent research (Chou *et al.* 2002) has led to the suggestion (Zimmer 2003) that the development of crafting stone tools in humans was linked to brain expansion initiated by the inactivation of the *CMAH* gene. We still know little about the developmental, neural and cognitive underpinnings of crows’ tool manufacture. Future work needs to address the question of why this particular species of crow can make such sophisticated tools when neither its close avian relatives, nor our primate cousins, appear able to do so.

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