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# Context-dependent tool use in New Caledonian crows

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**Humans and chimpanzees both exhibit context-dependent tool use. That is, both species choose to use tools when food is within reach, but the context is potentially hazardous. Here, we show that New Caledonian crows used tools more frequently when food was positioned next to a novel model snake than when food was positioned next to a novel teddy bear or a familiar food bowl. However, the crows showed no significant difference in their neophobic reactions towards the teddy bear and the model snake. Therefore, the crows used tools more in response to a risky object resembling a natural predator than to a less-threatening object that provoked a comparable level of neophobia. These results show that New Caledonian crows, like humans and chimpanzees, are capable of context-dependent tool use.**

**Keywords:** context-dependent tool use; New Caledonian crow; neophobia response

## 1. INTRODUCTION

The Mahabharata, the Sanskrit epic of ancient India, tells the story of the sage Chayvana [1]. This saint meditated in the Vira posture for so long that ants enveloped him and gave him the appearance of an ant-hill. The daughter of the King, Sukanya, on seeing the eyes of the sage enclosed within the ant's nest, was overcome with curiosity and poked them with a thorny branch. The story of Chyavana is, therefore, one of the earliest recorded demonstrations of *Homo sapiens*' capacity for context-dependent tool use: the ability, in risky situations, to preferentially use tools rather than the body to interact with objects that are within reach. This behaviour is likely to have been highly important during the evolutionary history of hominins because it allows the use of tools in ways that would be risky for the body, such as when cooking or hunting [2]. Recently, chimpanzees have also shown the capacity to perform context-dependent tool use [2].

It is currently unknown whether non-primate animals that have convergently evolved the ability to use and manufacture tools are capable of context-dependent tool use. A recent study on New Caledonian crows (*Corvus moneduloides*), a species that has sophisticated tool use and manufacture [3–6], showed that they occasionally made initial contact with novel objects by probing them with a tool [7]. This behaviour raises the possibility that New Caledonian crows prefer to use tools, rather than their bodies, in risky situations. However, the study failed to rule out alternative explanations for the crows' behaviour. First, a previously learnt association between interacting with novel objects using tools and obtaining food may have triggered tool use. Second, the crows' tendency to carry tools while performing non-tool behaviours [8,9] may have caused them to coincidently hold a tool while investigating the novel objects. Third, this species may use tools when faced with novel objects that provoke neophobic reactions, rather than objects that are actually risky. Thus, we do not know at present whether New Caledonian crows are capable of context-dependent tool use: when faced with hazardous situations do they prefer to risk their head or their tool?

## 2. MATERIAL AND METHODS

We carried out the experiment with 11 wild crows captured on the island of Maré, New Caledonia. Three of the crows were adults over 2 years old and eight were sub-adults under 2 years old. Based on sexual size dimorphism [10], five were females. The crows were housed in an outdoor aviary; the cages were all 8 $m^2$ in area and 3 m high. Individuals were tested separately in a visually isolated cage. All crows were released at their site of capture three months after their capture date.

Pre-testing was first conducted to examine whether crows used tools only when food was out of reach. The crows were presented with a toolbox (see Taylor *et al.* [5] for a detailed description) with a range of stick tools (size 10–25 cm) in front of it. A meat block was placed either 1 cm inside the bars (so crows could extract the meat with their bill) or 15 cm inside the bars (so crows needed a tool for extraction). The position of the meat was pseudorandomised (no more than two trials in any one position) across the five trials that each crow was given in each condition.

During the actual experiment, the crows were presented with blocks of eight trials where meat was always placed 1 cm inside the bars next to either: a familiar food bowl (which the crows had fed from daily for the last two months), a novel teddy bear or a novel model snake. Four tools (size 10–25 cm) were placed in front of the box to see if crows preferred to use a longer stick for any of the stimuli presented inside the box. The position of the tools and contents of the box were pseudorandomised across trials. A trial started when the bird landed on the table and ended when the bird obtained the food or flew to the back of the cage. For each of the three stimuli inside the box, we analysed a crow's behaviour (i) in the first trial, and (ii) across the first three trials. Trials were scored for frequency of: tool pick-ups, tool length picked up, touches of tool tip to box/box contents, startles and retreats. For the tool length preferences in pre-testing, data were only available for six crows. All other tests used the data from all 11 crows.

## 3. RESULTS

In pre-testing, all 11 crows used their bills in the five trials where food was positioned 1 cm inside the box. In the five trials where food was placed 15 cm into the box, all crows used a tool to extract the meat. The crows also showed a preference to use the two longer, rather than the two shorter tools (Binomial choice, $p = 0.044$).

In testing, across the first three trials of each condition, crows picked up a tool more when the snake was in the box rather than the teddy bear (figure 1, movie S1; Wilcoxon signed-rank test: $Z = -2.053$, $p = 0.037$) or food bowl (Wilcoxon signed-rank test: $Z = -2.527$, $p = 0.008$). There was no difference in the number of tool pick-ups between the teddy bear and bowl trials (Wilcoxon signed-rank test: $Z = 1.857$, $p = 0.125$). Only the difference in the snake and bowl

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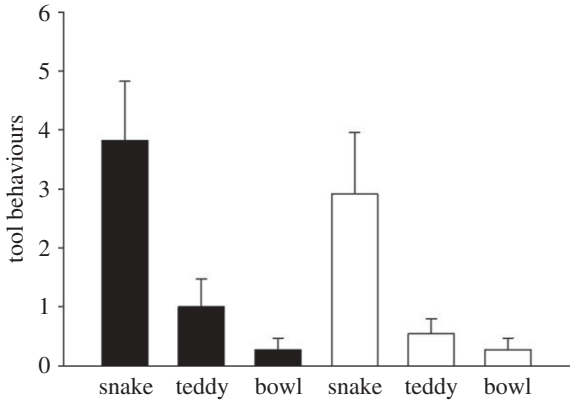


Figure 1. Mean number of times across the first three trials that tools were picked up (black bars) and used to probe the box or its contents (white bars). The mean ± s.e. is given.

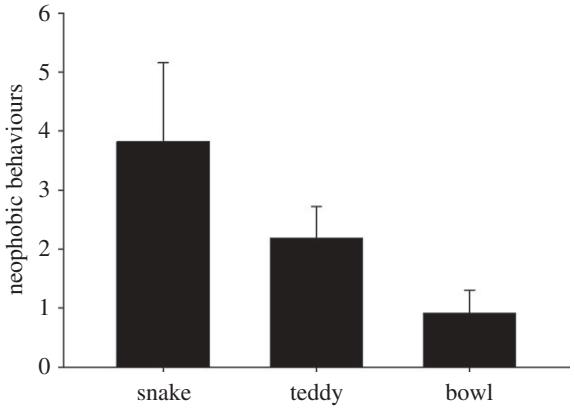


Figure 2. Mean number of neophobic responses across the first three trials. The mean ± s.e. is given.

conditions was present from the first trial (Wilcoxon signed-rank test: $Z = -2.136$, $p = 0.031$). Across the first three trials, the crows touched the box or its contents with the tool tip more in the snake condition than in the teddy bear (Wilcoxon signed-rank test: $Z = -2.254$, $p = 0.023$) or bowl condition (Wilcoxon signed-rank test: $Z = -2.375$, $p = 0.016$). However, there was no difference in touches with the tool tip between the teddy bear and bowl conditions (Wilcoxon signed-rank test: $Z = -1.414$, $p = 0.500$).

To measure the neophobia of the crows to each of the three stimuli, we examined the time crows took to retrieve food or leave the testing area. Across the first three trials with each stimulus, the crows were slower when the snake (Wilcoxon signed-rank test: $Z = -2.934$, $p = 0.004$) or the teddy bear (Wilcoxon signed-rank test: $Z = -2.934$, $p = 0.004$) was present than when the bowl was present. There was no difference in latency between the teddy bear and snake conditions (Wilcoxon signed-rank test: $Z = -1.423$, $p = 0.175$). This pattern was present from the first trial: snake versus bowl (Wilcoxon signed-rank test: $Z = -2.379$, $p = 0.016$), teddy bear versus bowl (Wilcoxon signed-rank test: $Z = -2.845$, $p = 0.005$) and snake versus teddy bear (Wilcoxon signed-rank test: $Z = 0$, $p = 1$). We also examined neophobia by measuring the number of startle responses (rapid movement away from the box while flapping the wings) and retreat responses (rapid movement away from the box without wing flapping). Across the first three trials, the crows showed more neophobic responses towards the snake than the bowl (Wilcoxon signed-rank test: $Z = -2.12$, $p = 0.031$) and a trend for more neophobic responses towards the teddy bear than the bowl (Wilcoxon signed-rank test: $Z = -1.98$, $p = 0.055$; figure 2). However, they responded similarly to the snake and the teddy bear (Wilcoxon signed-rank test: $Z = -0.973$, $p = 0.375$). The above pattern of neophobic responses was present from the first trial: snake versus bowl (Wilcoxon signed-rank test: $Z = -2.379$, $p = 0.022$), teddy bear versus bowl (Wilcoxon signed-rank test: $Z = -2.46$, $p = 0.018$) and snake versus teddy bear (Wilcoxon signed-rank test: $Z = -0.862$, $p = 0.461$).

When the crows picked up a tool, they extracted food with it 66.6 per cent of the time in the bowl condition, 27.3 per cent of the time in the teddy bear condition and 7.1 per cent of the time in the snake condition. Tool extraction success varied significantly among the three conditions (Fisher's exact test: $p = 0.038$). However, pair-wise comparisons were not significant ($\chi^2$-test: d.f. = 1 for all tests; snake versus teddy bear, $X = 1.123$, $p = 0.289$; snake versus bowl, $X = 2.381$, $p = 0.122$ and teddy bear versus bowl, $X = 0.048$, $p = 0.828$). As in pre-testing, the crows showed a preference to pick up the two longer, rather than the two shorter tools (Binomial choice, $p < 0.001$). This preference did not change depending on the object in the box (Fisher's exact test: $p = 0.515$).

Responses to the snake were not affected by age or sex. Age did not affect tool pick-ups (Mann–Whitney *U*-test: $U = 10.0$, $p = 0.776$) or tool touches to the box/box contents (Mann–Whitney *U*-test: $U = 11.0$, $p = 0.921$). Age did not affect neophobia (latencies: Mann–Whitney *U*-test: $U = 4.0$, $p = 0.133$; neophobic behaviours: Mann–Whitney *U*-test: $U = 4.0$, $p = 0.133$). Sex did not affect tool pick-ups (Mann–Whitney *U*-test: $U = 11.0$, $p = 0.648$) or tool touches (Mann–Whitney *U*-test: $U = 11.5$, $p = 0.648$). Sex did not affect neophobia (latencies: Mann–Whitney *U*-test: $U = 13.0$, $p = 0.927$; neophobic behaviours: Mann–Whitney *U*-test: $U = 13.0$, $p = 0.927$). The low number of tool-mediated extractions prevented statistical testing of the effect of sex and age on variation in this behaviour.

## 4. DISCUSSION

Our results show that New Caledonian crows are capable of context-specific tool use. The crows picked up tools and used them to make contact with a baited box and its contents more often when a novel snake model was inside than when a novel teddy bear or a familiar food bowl was inside. This difference in response means that we can rule out an association between novel objects and tool use, or the coincidental holding of a tool while investigating novel objects, as explanations for the crows' behaviour. Furthermore, our results show that the greater frequency of tool use with the snake was not because the crows preferred to manipulate objects more when stressed owing to object novelty, as their neophobic

responses to the teddy bear and the snake were not statistically different.

That crows showed similar levels of neophobia to both the snake and the teddy bear, but used tools more in the snake condition, suggests that this species' neophobic reactions do not mirror their evaluation of risk. This may be because crows are scared when objects are a potential threat *and* when they are new. The crows may have assessed the teddy bear as less of a threat than the snake because of one or a combination of the following: its more artificial appearance, the reduced chance of it moving through the bars compared with the snake, their prior experience with snakes present on Maré or a genetic predisposition to avoid snakes [11]. The evaluation of the snake as a greater threat did not generate differential neophobic responses to the snake and the teddy bear probably because the latter provoked heightened neophobia owing to its novelty. That neophobia increased the crows' time near a potential predator could be seen as maladaptive. However, the slow approach time to the box was coupled with a typical corvid neophobic reaction [12]—a very fast retreat, which reduced time spent in close proximity to the snake/teddy bear.

Although pre-testing showed that all crows were competent tool users, they were poor at extracting food in the presence of the snake and teddy bear. Whether this was due to the crows using the tools to gather information about the snake and the teddy bear [7,13], or tool use being disrupted by neophobia, is unclear. Tool choice, however, was not affected by the stimuli in the box because the crows' preference for longer tools was not dependent on condition.

The context-specific tool use shown by New Caledonian crows in our study suggests that this species maintains differently structured representations of body and tool in terms of the value assigned to them. That is, these birds value their body more than a tool and so in risky situations perform context-specific tool use. However, our results do not indicate how these representations differ structurally. The crows may understand the conceptual difference between a tool and their body. Alternatively, this information may be represented at lower cognitive levels, such as through the use of heuristics. Similarly, our findings do not indicate how the representations of body and tool develop and particularly whether past experience with potential predators is needed. Nevertheless, the performance of the crows suggests that this species maintains differently structured representations of body and tool during active tool use, as primates do. Determining how New Caledonian crows form tool representations, and whether they have the same structure as those of primates, will be a focus of future work.

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