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1 Great white pelicans (*Pelecanus onocrotalus*) fail to use tools flexibly  
2 in problem-solving tasks

3 **Running title:** Tool use in pelicans

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27 **Abstract**

28 Although reports of animal tool-use are phylogenetically widespread, it remains rare in the  
29 wild. From the perspective of human evolution, this rarity was first explained by the  
30 cognitive demands associated with tool use. Recently, an alternative assumption, ‘the tools  
31 are not often useful’ hypothesis, proposes that tool use is rare, because it is seldom more  
32 useful than the species’ anatomical adaptations. At the same time, several species that do not  
33 use tools in the wild have shown the capacity for tool use in experimental problem-solving  
34 settings, which suggests a certain level of cognitive flexibility. Investigating whether  
35 habitually non-tool using species are able to use tools flexibly is crucial to evaluate the  
36 predictions of existing theories on the evolution of cognition. In this study, we tested whether  
37 great white pelicans (*Pelecanus onocrotalus*), morphologically specialised fishers, for whose  
38 natural foraging tools are unlikely to be of use, were able to use tools in two problem-solving  
39 situations. In two tasks, the subjects were required to drop tools into an apparatus to gain  
40 access to a food reward. In Tool-use task 1, we tested the capacity of pelicans to show  
41 spontaneous tool-use behaviour. In Tool-use task 2, we assessed the birds’ tool-using  
42 performance, before and after providing them with different kinds of information about the  
43 task’s solution, that is experience with the functional features of the apparatus (‘platform-  
44 pushing group’) and trial-and-error learning of tool-dropping behaviour (‘stone-nudging  
45 group’). All subjects failed in using tools in Tool-use task 1 and only one individual in the  
46 stone-nudging group learnt to use a tool in the training phase of Tool-use task 2. Despite  
47 previous experience with the functional properties of the task, birds from the platform-  
48 pushing group did not exhibit tool-use behaviour or increased motivation towards the  
49 apparatus and the tools during the test phase. Although pelicans were not inhibited by  
50 morphological constraints to carry out the required tool behaviours, whether they lack the  
51 cognitive prerequisites for flexible tool-use remains to be further tested.

52

53 **Keywords:** adaptive specialization; foraging ecology; *Pelecanus onocrotalus*; physical  
54 cognition; problem solving; tool use

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## 61 Introduction

62 Initially considered a core feature of human evolution and intelligence (Washburn, 1959),  
63 tool use is now reported in various animals, ranging from invertebrates to apes (for a review,  
64 see Shumaker, Walker, & Beck, 2011). A widely used, standard definition of tool use is “The  
65 use of an environmental object ... to alter more efficiently the form, position, or condition of  
66 another object, another organism, or the user itself, when the user holds and directly  
67 manipulates the tool during or prior to use” (Shumaker, Walkup, & Beck, 2011). For  
68 instance, a capuchin monkey (*Cebus apella*) uses a tool when hitting the ground with a stone  
69 in search of insects, but does not use tools when engaging in object manipulations with no  
70 apparent purpose (e.g. object play). Furthermore, according to this definition, tool use does  
71 not include nest building as the manipulation of nest components involves *static* relations  
72 (Visalberghi, Sabbatini, Taylor, & Hunt, 2017). In birds, numerous tool-use examples have  
73 been reported (Boire, Nicolakakis, & Lefebvre, 2002), with ever-growing evidence in the  
74 wild (e.g. Camacho & Potti, 2018; Fayet, Hansen, & Biro, 2020, but see Farrar, 2020; Van  
75 Leeuwen, Cronin, & Haun, 2017). However, tool use remains rare in the animal kingdom  
76 (Biro, Haslam, & Rutz, 2013; Visalberghi, Sabbatini, Taylor, & Hunt, 2017). Traditionally,  
77 this rarity was associated with the cognitive demands of exhibiting tool use i.e. the ‘tools,  
78 animal intelligence’ hypothesis (Bird & Emery, 2009a; Brosnan, 2009; Van Schaik, Deaner,  
79 & Merrill, 1999). In this context, numerous experimental studies have focused on large-  
80 brained accomplished tool users (e.g. chimpanzees, *Pan troglodytes*: Kühl et al. 2016, Pruetz  
81 & Bertolani, 2007; New Caledonian crows, *Corvus moneduloides*: Hunt, 1996), and revealed  
82 sophisticated cognitive capacities (e.g., Taylor, Hunt, Medina, & Gray, 2009; Povinelli, 2000;  
83 Wimpenny, Weir, Clayton, Rutz, & Kacelnik, 2009).

84 Nevertheless, as highlighted by Shumaker et al. (2011) in their second ‘Myth’, tool use  
85 does not always predict advanced cognition (Emery & Clayton, 2009; Hansell, 2000, 2007;  
86 Mc Grew, 1993). Indeed, many instances of tool use or manufacture in animals possess a  
87 significant inherited component (e.g. Kenward, Weir, Rutz, & Kacelnik, 2005; Tebbich,  
88 Taborsky, Fessl, & Blomqvist, 2001). Tool use seems also not directly associated with better  
89 general cognitive capacities: woodpecker finches (*Cactospiza pallida*) and New Caledonian  
90 crows do not outperform closely related, non-tool-using species in physical and general  
91 cognitive tasks (Teschke, Cartmill, Stankewitz, & Tebbich, 2011; Teschke et al., 2013).

92 In their ‘tools are not often useful’ hypothesis, Hansell and Ruxton (2008) propose that  
93 *ecological utility* determines the emergence (or absence) of tool use in animals (Hunt, Gray,  
94 & Taylor, 2013). The anhinga (*Anhinga anhinga*), for instance, forages in southern swamps

95 where it engages in a particular type of fishing, by using its specialized pointed bill as a  
96 ‘harpoon’ to spear prey (Davis, 2015). From an ecological perspective, foraging with a tool  
97 does not seem to provide any selective advantage to this species, which already possesses a  
98 tool-like morphological adaptation. Thus, according to this hypothesis, tool use is induced  
99 when it is beneficial and practicable for the species in question given its morphological,  
100 ecological, and/or behavioural features (Hansell & Ruxton, 2008; see also Bräuer, Hanus,  
101 Pika, Gray, & Uomini, 2020). However, circumstances in which tool use is advantageous  
102 may be actually more numerous than believed, suggesting that constraints, other than the lack  
103 of ecological need, prevent tool use in birds and mammals in the wild (the ‘excess-of-  
104 opportunity’ problem: Hunt, Gray, & Taylor, 2013). Moreover, recently, an increasing  
105 number of habitually non tool-using species (the ‘facultative tool users’) has been reported to  
106 employ novel foraging tools flexibly in captivity (reviewed in Bentley-Condit & Smith, 2010;  
107 Shumaker, Walkup, & Beck, 2011). This has led to the hypothesis that flexible tool-use - “the  
108 production of innovative solutions to respond to challenging or new situations” (Call, 2013;  
109 from Visalberghi, Sabbatini, Taylor, & Hunt, 2017) - is derivative of general-purpose  
110 cognition in some species (e.g. Bird and Emery, 2009; Deaner, Van Schaik, & Johnson,  
111 2006; see also the commentary of Kacelnik, 2009).

112 Providing a more complete taxonomic picture of tool-use skills in animals under  
113 controlled conditions may significantly help elucidating *why* tool use is rare (Biro, Haslam, &  
114 Rutz, 2013; Hunt, Gray, & Taylor, 2013). Among birds, for instance, in contrast to the  
115 multifarious tool-use reports in the wild, captive Passeriformes have received considerable  
116 attention, with much focus on habitual tool-users (e.g. corvids: reviewed in Kacelnik,  
117 Chappell, Weir, & Kenward, 2006; Tebbich, Seed, Emery, & Clayton, 2007; finches:  
118 Tebbich & Bshary, 2004; Teschke, Cartmill, Stankewitz, & Tebbich, 2011). Assessing tool-  
119 related capabilities in non-tool-using foragers that possess features generally associated with  
120 flexible tool-use (e.g. brain size and innovation in birds: Lefebvre, Nicolakakis, & Boire,  
121 2002; Lefebvre, 2013) is essential to comprehend to what extent ecology, cognition, and  
122 morphology, influence species differences in tool use (Cheke, Bird, & Clayton, 2011;  
123 Johnsson & Brodin, 2019).

124 The great white pelican (*Pelecanus onocrotalus*) is a highly specialised piscivorous  
125 forager (Bowker & Downs, 2008; Hatzilacou, 1996; Megaze & Bekele, 2013; Sibley, 2000)  
126 that possesses a beak functionally very similar to humans’ hoop nets (Meyers & Myers, 2005;  
127 Mwema, de Ponte Machado, & Ryan, 2010; Redrobe, 2014). This sensitive feeding apparatus  
128 fulfils different functions (e.g. catching fish, stocking rain water, or ventilating the body

129 during heat; Elliott, 1992; Johnsgard, 1993; Wirtz, 1986) and has not changed during more  
130 than 30 million years, probably as a result of highly efficient adaptation to fishing (Louchart,  
131 Tourment, & Carrier, 2011). Despite its seemingly unwieldy beak, this species shows basic  
132 object manipulation outside the foraging domain. For instance, during the breeding season,  
133 pelicans normally nest directly on the ground, from which they pile up natural materials  
134 (grass, sticks, reeds, etc.) in order to form a nest (Brown & Urban, 1969). Object  
135 manipulation is common in some captive populations, where one or more individuals take  
136 and throw wood sticks on the ground, repeating this action sequence several times without  
137 apparent purpose (SD, personal observation). Although this bird, and Pelecaniformes more  
138 generally, is largely understudied in behavioural and cognitive sciences, we nevertheless  
139 know that pelicans possess a large relative brain size (the Lefebvre's 'seventh group':  
140 Lefebvre, Whittle, Lascaris, & Finkelstein, 1997) associated with slow life history including  
141 late sexual and physical maturity, long incubation period, and longevity (Ricklefs, 2004).  
142 Moreover, cognitive capacities, such as learning, flexibility, and innovation, are crucial to  
143 learn important social aspects of foraging (Anderson, 1991; Danel et al., 2020) or to find new  
144 feeding opportunities (de Ponte Machado & Hofmeyr, 2004). The great white pelican may  
145 thus represent a relevant biological model to evaluate the predictions of theories on the  
146 evolution of tool use.

147 In this study, we aimed to assess the capacity of twelve great white pelicans to use tools in  
148 two problem-solving tasks. Nest building involves specific behaviours in this species, ranging  
149 from collecting, pouch storing, and disgorging materials on the ground (Brown & Urban,  
150 1969; Elliott, 1992). We therefore built two devices that required a similar range of tool-  
151 manipulation behaviours (i.e. touch, pick up, drop), with a restricted need to orientate the  
152 tools towards the apparatuses' relatively large apertures. During Tool-use task 1, we assessed  
153 spontaneous foraging tool use. Subjects had to drop a tool inside an apparatus to get access to  
154 an out-of-reach reward. As for the second experiment, Tool-use task 2, our goal was to  
155 evaluate whether pelicans could use tools after being given experience with the functional  
156 features of the apparatus ('platform-pushing group') or trial-and-error learning of tool-  
157 dropping behaviour ('stone-nudging group'). We administered a slightly modified replica of  
158 the experimental design initially created by Bird & Emery (2009a) with rooks (*Corvus*  
159 *frugilegus*), which also possess morphological constraints (Matsui et al., 2016), and further  
160 employed using different methods with several other non-tool-using birds (e.g. Eurasian jays,  
161 *Garrulus glandarius*: Cheke et al., 2011; great-tailed grackles, *Quiscalus mexicanus*: Logan,  
162 2016; keas, *Nestor notabilis*: Auersperg, Gadjon, & Huber, 2010; Auersperg, von Bayern,

163 Gadjon, Huber, & Kacelnik, 2011; and Goffin cockatoos, *Cacatua goffiniana*: Laumer,  
164 Bugnyar, & Auersperg, 2016) and one habitually tool-using species (New Caledonian crow:  
165 Auersperg et al., 2011; von Bayern, Heathcote, Rutz, & Kacelnik, 2009). As material  
166 manipulation occurs in some specific contexts, and regarding aspects of this species'  
167 cognition and behaviour, our first hypothesis predicts that pelicans will be able to use  
168 spontaneously novel tools to reach an out-of-reach reward (Tool-use task 1). Our second  
169 hypothesis also predicts that this species will use tools, and show increased motivation to  
170 interact with the apparatus and the tools, after experience with the task is provided (Tool-use  
171 task 2).

## 172 **Methods**

### 173 **Subjects**

174 Twelve captive great white pelicans were tested at the Bird Park in Villars-les-Dombes,  
175 France. Five were males (Cra, Cro, Hyd, Jac, Jee), and seven were females (Asa, Bal, Coo,  
176 Her, Jan, Jgo, Jyw). All subjects were adults and their age varied between 3 to 16 years.  
177 Pelicans belonged to the free-flight bird show and were brought down to 85-90% of their *ad*  
178 *libitum* weight during the park's high season (from Mar-Nov), which was also the  
179 experimental period. All birds were maintained within an outdoor enclosure of two  
180 compartments (1<sup>st</sup> compartment: 17.97 x 5.88 x 2.26m, including an indoor room: 2.34 x 2.34  
181 x 2.26m; 2<sup>nd</sup> compartment: 24.74 x 17.91 x 2.26m). Tests took place in the first compartment  
182 each early morning from 8 a.m. to 1 p.m.

183 Statement about the STRANGEness of the test sample (based on the STRANGE  
184 framework: Rutz & Webster, 2021; Webster & Rutz, 2020): all subjects initially selected  
185 lived in the same social group and contributed data (original sample). Thus, no pelican was  
186 excluded due to specific "personality" types. Our sample may have been biased with at least  
187 four of the seven STRANGE factors: first, most of our pelicans were hand-reared and  
188 originated from the gene pool of the park avian collection ("Rearing history" and "Genetic  
189 make-up"). Subjects' participation to the free-flight bird show also required some degree of  
190 cooperation between birds and avian keepers. Second, subjects had prior experience with one  
191 cognitive study ("Acclimation and habituation" and "Experience"): they had been previously  
192 tested on a social-learning task conducted by Danel et al. (2020), who investigated their  
193 capacity to acquire a novel behaviour by watching experienced conspecific demonstrators.

### 194 **Apparatus**

195 **Tool-use task 1.** The apparatus consisted of an inclined rectangular box with a transparent  
196 top that was opened at both ends. The reward was presented in the centre of the apparatus

197 inside an empty cardboard tissue box (24 x 12.5 x 7.5cm), which was held in position by a  
198 wooden protrusion (**Figure 1**). In the pre-test phase, the apparatus was shortened (40 x 38 x  
199 12.5cm), so the pelican could push out the tissue box directly by inserting its beak into the  
200 apparatus's upper end. In the test phase, the apparatus was longer (85.7 x 38 x 12.5cm), so  
201 that the tissue box containing the reward was out-of-reach. In order to retrieve the reward, the  
202 subject had to pick up one of the tools provided on the ground (20 sticks: from 17.7 to 51cm  
203 in length; 20 stones up to 11cm large, each stone weighted about 50g and was heavy enough  
204 to collapse the tissue box), and to drop it into the box's upper end.

205 < Insert Figure 1 about here >

206 **Tool-use task 2.** The apparatus consisted of a long transparent square-formed tube (95 x  
207 12 x 15cm) fixed on the centre of a board (1.5 x 59 x 40cm; **Figure 2a & c**). The out-of-  
208 reach reward was presented in the centre of a collapsible platform held up by magnets 15cm  
209 above the ground. The subject had to pick up a tool on the ground (20 sticks: from 17.7 to  
210 51cm long; 20 stones up to 9.5cm large) and to drop it into the mouth of the tube in order to  
211 collapse the platform and get the reward. In the experience phase, two apparatuses were  
212 created: for the stone-nudging group, a rimmed square plank was mounted around the mouth  
213 of the tube (45.5 x 42.5 x 2.7cm), upon which a stone was placed (5cm in diameter; **Figure**  
214 **2b1**). To reach the reward, the subject had to push – ‘nudge’ – the stone with its beak towards  
215 the mouth of the tube so the tool would ultimately fall into it (**Video 1**, see **Supplementary**  
216 **Materials**). For the platform-pushing group, the transparent square-formed tube was  
217 considerably shortened (20 x 12 x 15cm; **Figure 2b2**). Here, the subjects had to learn about  
218 the mechanism of the collapsing platform, by pushing it down directly with the beak (**Video**  
219 **1**, see **Supplementary Materials**). The recording equipment consisted of a camera (Samsung  
220 camera HMX-F90) and a tripod, which were removed from the aviary after each trial.

221 < Insert Figure 2 about here >

222 Procedure

223 **Tool-use task 1.**

224 *Habituation phase.* Subjects were familiarized with the recording equipment and the  
225 unrewarded apparatus during two 30 min sessions (one session per day on two consecutive  
226 days).

227 *Pre-test phase.* Pelicans were first trained to take the tissue box from the shortened  
228 apparatus, by pushing it down with the beak. Once they had obtained the reward eight times  
229 in a row, they were considered qualified to proceed to the test phase.



230           *Test phase.* Fifteen 12 min trials were administrated (usually two trials per day). On  
231 each test day, the experimenter entered the aviary and closed the door separating the first  
232 compartment from the second compartment in order to set up the experiment. To prevent any  
233 visual contact between the first compartment (the test bird) and the second compartment (the  
234 rest of the group), the grid wall in between the two compartments was covered with an  
235 opaque fabric. After having triggered the camera and baited the tissue box in the apparatus,  
236 the experimenter allowed the subject to enter the first compartment. Participation was made  
237 on a voluntary basis, so the order in which subjects participated changed randomly from day  
238 to day.

239           ***Tool-use task 2.***

240           *Pre-test phase.* Birds were presented with the apparatus and the tools (i.e. sticks and  
241 stones) available on the ground during eight trials of 20 min each. This was carried out in  
242 order to establish whether tool-use behaviour was already part of the species' behavioural  
243 repertoire (i.e., any behaviour consisting of manipulating, displacing, and dropping one of the  
244 tools provided into the mouth of the tube).

245           *Experience phase.* After the pre-test phase, pelicans were randomly assigned to two  
246 experimental groups. In the platform-pushing group, six subjects (Asa, Bal, Coo, Hyd, Jgo,  
247 Jee) were trained to retrieve the reward by pushing the collapsing platform with the beak  
248 through the shortened tube. The training process was as follows: initially, the reward was  
249 partly reachable on the platform, so while trying to take the reward the subjects caused the  
250 platform to collapse unintentionally. Progressively, the reward was moved out-of-reach and  
251 subjects were gradually shaped to push the platform with the beak. This phase was  
252 considered completed when the subjects had retrieved the reward sixteen times in a row at  
253 maximum (only birds from the platform-pushing group reached this criterion, see below).

254           The other six individuals in the stone-nudging group (Her, Cro, Jan, Jyw, Jac, Cra) were  
255 trained to nudge a stone into the apparatus from a rimmed square plate with a central hole. At  
256 the beginning of the training process, one stone was placed right on the edge of the tube.  
257 Thus, when the pelican interacted with the apparatus the stone accidentally fell down into the  
258 tube. When the association between the stone falling and the release of the reward was  
259 acquired, the stone was progressively moved to the plate's edge. Here again, subjects met  
260 criterion when they obtained the reward (using the stone located at the border of the plate)  
261 sixteen times in a row at maximum (only one bird from the stone-nudging group reached this  
262 criterion, see below).

263 *Test phase.* After each group had met criterion in the training phase, subjects moved  
264 to the test phase. Here, the procedure was the same as the pre-test phase of *Tool-use task 2*.

265 Coding and data analysis

266 All tests were video recorded, and continuous second-by-second coding of the videos was  
267 performed. For both tool-use tasks, we followed a specific coding scheme including 6  
268 behaviours: 1 = perch on the apparatus, 2 = insert the beak in the apparatus, 3 = interaction  
269 with the apparatus (i.e. touching the apparatus with the beak), 4 = touch a tool, 5 = pick up a  
270 tool, and 6 = insert a tool. Based on this coding scheme, the number of behaviours exhibited  
271 by each bird was counted by assigning a score of 1 when this behaviour lasted at least 1s  
272 (e.g., when a subject interacted with the apparatus during 1 s, this behaviour was coded as 1;  
273 conversely, if no interaction was counted - or behaviour from the coding scheme - this was  
274 coded as 0). We assessed inter-observer reliability by using a sub-sample of the videos,  
275 whereby 36 trials from Tool-use task 1 (180 trials in total) were independently scored by two  
276 observers. Inter-observer reliability was high (percentage agreement: 99%, Cohen's kappa  
277 coefficient: 0.95).

278 ***Model 1: Tool use task 1.***

279 We used a Generalized Linear Mixed model (GLMM) with a negative binomial error  
280 structure (overdispersion score with a Poisson error structure: 9.12). *Time* (i.e. time to  
281 perform each behaviour) was set as dependant variable, *Behaviour* ("Insert beak in the  
282 apparatus" and "Interaction with the apparatus"), *Trial* (1 vs 2 vs ...10), and *Trial\*Behaviour*  
283 as fixed factors, and *Subject* (i.e. subject's identity) as random effect. We limited our  
284 investigation to the behaviours specified above, given the absence or rarity of other  
285 behaviours ("Insert a tool within the apparatus", "Pick up a tool", "Perch on the apparatus",  
286 and "Touch a tool"; see **Results**).

287 ***Model 2: Tool use task 2.***

288 To assess whether the individuals from the platform-pushing group changed their  
289 behaviour after experience with the functional properties of the task, we ran a GLMM with a  
290 negative binomial error structure (overdispersion score with a Poisson error structure: 80.74).  
291 *Time* was set as dependant variable, *Behaviour* ("Insert beak in the apparatus", "Touch a  
292 tool", and "Interaction with the apparatus") and *Phase* (pre-test phase vs test phase) as fixed  
293 factors, and *Subject* as random effect. Here again, we limited our investigation to the  
294 behaviours specified above, given the absence or rarity of other behaviours ("Insert a tool  
295 within the apparatus", "Pick up a tool", and "Perch on the apparatus"; see **Results**).

296 GLMM analyses were conducted using the packages *lme4* (Bates, Mächler, Bolker, &  
297 Walker, 2015) and *multcomp* (Hothorn, Bretz, & Westfall, 2008) in R software (R Core  
298 Team, 2019).

299 Ethics

300 This research conforms to the 'Guidelines for the use of animals in research' as published  
301 in *Animal Behaviour* (1991, 41, 183-186) and the ARRIVE guidelines, and has been carried  
302 out in accordance with the U.K. Animals (Scientific Procedures) Act, 1986 Amendment  
303 Regulations (SI 2012/3039) and associated guidelines, EU Directive 2010/63/EU for animal  
304 experiments, and the National Institutes of Health guide for the care and use of Laboratory  
305 animals (NIH Publications No. 8023, revised 1978). The Bird Park's (Ain, France) scientific  
306 board provided the authorization to perform environmental enrichments through strictly non-  
307 invasive behavioural experiments on captive pelicans.

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315 board provided the authorization to perform environmental enrichments through strictly non-  
316 invasive behavioural experiments on captive pelicans.

## 317 **Results**

318 Tool-use task 1

319 No subject was able to solve the task, namely to drop a tool within the apparatus to get  
320 access to the food reward. Indeed, we did not report any behaviour consisting of "Pick up a  
321 tool" or "Insert a tool within the apparatus". Overall, behaviours that involved "Insert the  
322 beak in the apparatus" and "Perch on the apparatus" were rare (respectively: mean = 31.91s,  
323  $SD = 48.20s$ ; mean = 1.16s,  $SD = 2.72s$ ). At least in one of their total test trials, seven birds  
324 tried to obtain the reward by inserting their beak within the apparatus's aperture (Bal, Coo,  
325 Jac, Jgo, Jan, Jee, Jyw), and three by perching on it (Coo, Jani, Jyw). Although most pelicans  
326 rarely touched a tool (Bal, Coo, Hyd, Jac, Jan, Jee, Jgo, mean = 5.91s,  $SD = 7.46s$ ), they  
327 interacted with the apparatus (Asa, Bal, Coo, Cra, Hyd, Jac, Jgo, Jan, Jee, and Jyw, mean =  
328 947.41s,  $SD = 1217.39s$ ). The GLMM analysis revealed a significant effect of the factor  
329 *Behaviour* ( $p < .001$ ; estimated parameters are provided in **Table 1**) and the factor *Trial* ( $p <$

330 .001). The interaction *Trial\*Behaviour* was also significant, suggesting that pelicans  
331 increased their behavioural interactions towards the apparatus ( $p < .001$ ) but decreased their  
332 beak insertions within the apparatus across trials ( $p < .001$ ). As shown in **Figure 3**, subjects'  
333 behaviour was subject to a great inter-individual variability.

334 < Insert Figure 3 and Table 1 about here >

335 Tool-use task 2

336 ***Pre-test phase: stone-nudging group and platform-pushing group.***

337 No subject was able to drop a tool within the device to collapse the platform supporting  
338 the food reward. Here again, behaviours consisting of inserting the beak within the apparatus  
339 were seldom at the group level (platform-pushing group: mean = 14.00s,  $SD = 16.18$ s; stone-  
340 nudging group: mean = 133.25s,  $SD = 183.51$ s). More specifically, in both groups, three  
341 subjects tried to insert their beak within the apparatus (platform-pushing group: Bal, Coo,  
342 Jee; stone-nudging group: Jac, Jan, Jyw), while no one attempted to perch on the device.  
343 Most pelicans touched a tool and interacted with the apparatus in this phase (platform-  
344 pushing group: Bal, Coo, Hyd, Jee, Jgo, mean = 515.60s,  $SD = 524.43$ s for “Interaction with  
345 the apparatus”; and Coo, Jgo, Jee, mean = 27.40s,  $SD = 37.81$ s for “Touch a tool”; stone-  
346 nudging group: Cra, Jac, Jan, Jyw, mean = 1939.5s,  $SD = 1556.22$ s for “Interaction with the  
347 apparatus”, and Jan, Jyw, Jac, mean = 9.25s,  $SD = 9.03$ s for “Touch a tool”). One subject  
348 (Jee) from the platform-pushing group picked up a tool during its first trial without directing  
349 it towards the apparatus, and no one inserted a tool in the device. No subject from the stone-  
350 nudging group picked up a tool on the ground or tried to insert it in the apparatus. As shown  
351 in **Figure 4**, we also noted inter-individual differences.

352 < Insert Figure 4 about here >

353 ***Experience phase: stone-nudging group and platform-pushing group.***

354 Although all subjects in the platform-pushing group rapidly learned to use the beak to  
355 push the platform in this phase, only one subject in the stone-nudging group successfully  
356 moved the stone into the aperture to get the reward (Jac; **Video 1**, see **Supplementary**  
357 **Materials**). Noteworthy, instead of trying to move the stones towards the hole, most subjects  
358 tended to throw the stone on the ground when the experimenter replaced them on the plate.  
359 Consequently, only the platform-pushing group was allowed to proceed to the test phase.

360 ***Test phase: stone-nudging group and platform-pushing group.***

361 The only subject from the stone-nudging group that passed the criterion in the previous  
362 experience phase (Jac) did not pick up a tool on the ground to obtain the reward. Only two  
363 subjects (Bal, Jee) from the platform-pushing group tried to insert their beak in the apparatus,

364 and no perching behaviour was reported. The majority of birds from this group interacted  
365 with the apparatus and touched a tool (Asa, Bal, Coo, Hydra, Jgo, Jee, mean = 807.16s,  $SD$  =  
366 1265.65s for “Interaction with the apparatus”, and Asa, Bal, Jee, Jgo, mean = 61.50s,  $SD$  =  
367 84.59s for “Touch a tool”). According to the GLMM analysis, subjects made significantly  
368 more behavioural interactions with the apparatus than the other behaviours ( $p < .001$ ; “Insert  
369 the beak within the apparatus”:  $p = 0.15$  and “Touch a tool”:  $p = 0.06$ ). However, there was  
370 no significant effect of the factor *Phase* ( $p = 0.46$ ) and *Phase\*Behaviour* ( $p = 0.51$ ). Thus,  
371 behavioural interactions with the apparatus did not increase significantly after experience  
372 with the functional properties of the task (pairwise post-hoc test comparisons are provided in  
373 **Table 2**).

374 < Insert Table 2 about here >

### 375 **Discussion**

376 Overall, most pelicans were unable to spontaneously use the tools provided (Tool-use task  
377 1), even after they had been gradually shaped to produce the stone-dropping behaviour (Tool-  
378 use task 2: stone-nudging group). Knowledge of the collapsing-platform mechanism of the  
379 apparatus had also no effect on the subjects’ motivation or capacity to use tools (Tool-use  
380 task 2: platform-pushing group). Cognitive requirements of flexible tool use, notably the  
381 initial difficulty of perceiving objects as tools, are discussed as the main constraints for the  
382 emergence of tool-use skills in this species.

383 Before delving into explanations of the absence of tool-related competence in pelicans,  
384 methodological biases must be ruled out so as to ensure that the reported experiments truly  
385 reflected the subjects’ failure to understand the task. For instance, although similar devices  
386 have been appropriate to ground foragers such as corvids (e.g. rooks: Kasprzykowski, 2003),  
387 they may have created constraints regarding our species’ physical abilities. Pelicans indeed  
388 frequent a quite different foraging niche, consisting of a wide variety of aquatic habitats  
389 (Elliott, 1992). Nevertheless, object manipulation and transportation have been reported to  
390 often occur on land in captive (SD, personal observation) as well as wild individuals (e.g.  
391 Brown & Urban, 1969), and some free-ranging populations are efficient ground-foragers  
392 (Mwema, de Ponte Machado, & Ryan, 2010; de Ponte Machado, 2004, see also Danel et al.,  
393 2020 for a social foraging task carried out on land). Furthermore, all subjects from the  
394 platform-pushing group learned rapidly through associative learning/operant conditioning  
395 how to obtain the reward when the platform could be reached directly with the beak. Whether  
396 these subjects understood causality (that the platform collapsed if they applied a physical  
397 force on it), however, remains unlikely.

398 Another possibility is that tool use may not easily arise when subjects lack first-hand  
399 manipulative experience with the objects (e.g. their mechanical properties, affordances, and  
400 manoeuvrability: Fayet, Hansen, & Biro, 2020; Taylor et al., 2011). However, Tool-use task  
401 2 was specifically designed to allow the subjects all necessary experience with the apparatus  
402 and the tools and, even after proper training, all pelicans (except one subject: Jac, during the  
403 experience phase) were unable to use tools. Finally, a lack of motivation does not appear to  
404 explain the failure of pelicans in both tool-use tasks. Although we noted a decrease in  
405 specific behaviours during Tool-use task 1 (“Insert the beak within the apparatus” and  
406 “Touch a tool”), pelicans interacted with the apparatus significantly more across trials.  
407 Similarly, there was no significant effect of experience during the test phase of Tool-use task  
408 2 (platform-pushing group).

409 Noteworthy, one subject (Jac) was able to repeatedly drop stones within the apparatus to  
410 release an out-of-reach reward during the experience phase of Tool-use task 2. This bird not  
411 only pushed the stone towards the tube’s aperture, but also had sufficient control over the tool  
412 by lifting it above the hole probably to create an additional force on the platform. During the  
413 experience phase, Jac surprisingly dropped a thin stick that fell from a tree above the  
414 apparatus’s platform. This demonstrates that this subject could also use non-trained tool  
415 items, similarly to other bird species tested in similar tasks (e.g. New Caledonian crows: von  
416 Bayern, Heathcote, Rutz, & Kacelnik, 2009). However, when task properties slightly changed  
417 in the subsequent test phase (when tools were located on the ground), this individual did not  
418 repeat the action sequence required to solve the task. As this subject did not engage in any  
419 attempts to touch the tool in this phase, its failure is unlikely due to motor difficulties in  
420 grabbing tools directly on the ground. This subject’s experience with objects and rearing  
421 history were the same as the other tested pelicans. We suggest that more instances of *learned*  
422 tool-use behaviour may appear in studies with a larger sample size.

423 Our sample, however, may have been affected by certain biases (i.e. captivity and rearing  
424 experience, Webster & Rutz, 2020). For instance, subjects’ participation in the tasks may  
425 have been favoured by low neophobia due to previous experience with humans. Participation  
426 in a previous cognitive experiment may also have represented a bias (Webster & Rutz, 2020),  
427 although the foraging apparatus was dissimilar to the present ones and did not require the use  
428 of environmental objects (Danel et al., 2020).

429 We believe additional insights can be gained by looking at the behavioural pattern of  
430 individuals during the training phase of Tool-use task 2. Rather than trying to move the  
431 stones towards the hole, most subjects tended to throw the stones on the ground when the

432 experimenter replaced them on the plate. This manipulation pattern of pelicans' behaviour  
433 when interacting with tools is reminiscent of a recent study that failed to induce tool-use  
434 behaviour in wild-caught great tits (Johnsson & Brodin, 2019). Instead of directing tools  
435 towards the apparatuses, most tits threw them away after grabbing and tossing them with the  
436 beak. This suggests that both avian species failed at making any link between the tools and  
437 the reward obtained. In other words, although some pelicans possess morphological (the  
438 sensorimotor processes to hold a tool) and behavioural (object manipulation or 'object related  
439 non-tool use': Hunt, Gray, & Taylor, 2013) predispositions required to use tools (Call, 2013;  
440 Visalberghi, Sabbatini, Taylor, & Hunt, 2017), and are able to learn to use tools in a goal  
441 directed manner, they may lack the initial cognitive capacity to perceive *the need* for tools  
442 (how objects work and can be used as tools: Hunt, Gray, & Taylor, 2013). Perceiving that a  
443 familiar object can be exploited as a tool might be cognitively demanding (Hunt, Gray, &  
444 Taylor, 2013), even for species that use tools frequently in the wild (e.g. Sonso chimpanzee  
445 community, *Pan troglodytes schweinfurthii*: Grund, Neumann, Zuberbühler, & Gruber, 2019;  
446 Lamon, Neumann, Gier, Zuberbühler, & Gruber, 2018; New Caledonian crow: von Bayern,  
447 Heathcote, Rutz, & Kacelnik, 2009).

448 Pelicans' behaviours contrast with those of some captive habitually non-tool-using species  
449 that performed the stone-dropping behaviour required in the present study, such as Goffin  
450 cockatoos (Laumer, Bugnyar, & Auersperg, 2016) and keas (Auersperg Gajdon, & Huber,  
451 2010; Auersperg, von Bayern, Gajdon, Huber, & Kacelnik, 2011; see also tool-related studies  
452 on other habitually non-tool-using species e.g. macaws, *Ara ambiguous* and *Ara*  
453 *glaucoocularis*: O'Neill, Picaud, Maehner, Gahr, & von Bayern, 2020; Goffin cockatoos:  
454 Auersperg, Szabo, von Bayern, & Kacelnik, 2012; Eurasian jays, *Garrulus glandarius*:  
455 Cheke, Bird, & Clayton, 2011; and vasa parrots, *Coracopsis vasa*: Lambert, Seed, &  
456 Slocombe, 2015). Rooks, for instance, which have shown surprising tool-related capacities  
457 among non-habitual avian tool users, were able to appreciate their functional properties (e.g.  
458 using large stones over small ones) and to exploit successfully their experience with the tools  
459 and the task (Bird & Emery, 2009a; Bird & Emery, 2009b). Moreover, some subjects seemed  
460 capable of learning rapidly about their physical environment, inhibiting inefficient  
461 behaviours, remembering information, focusing attention, and foreseeing the outcomes of  
462 their actions (e.g. Bird & Emery, 2009a; Bird & Emery, 2009b; Tebbich, Seed, Emery, &  
463 Clayton, 2007). Each of these capacities has been proposed to be involved in flexible tool-use  
464 (Coolidge & Wynn, 2005; Kane & Engle, 2000, 2002).

465 As pelicans are able to solve novel foraging problems after observation of experienced  
466 conspecifics (Danel et al., 2020), future experiments may assess this species' capacity to use  
467 tools through social learning (Bandini, Motes-Rodrigo, Steele, Rutz, & Tennie, 2020).  
468 Further tests may also investigate whether this ability develops early during ontogeny (e.g. at  
469 juvenile stage: Tan, 2017), and/or when pelicans are given the opportunity to manipulate a  
470 various range of objects (e.g. anthropogenic objects). Additionally, in order to assess the  
471 generalisability of our findings, this experiment should be carried out in wild populations  
472 (Rutz & Webster, 2021; Webster & Rutz, 2020).

473 To conclude, our study demonstrates that captive great white pelicans were unable to solve  
474 novel problems by using the provided tools (i.e. sticks and stones). However, our results must  
475 be interpreted with caution. Indeed, at this stage, we cannot conclude that facultative tool-use  
476 is cognitively demanding in pelicans (Hunt, Gray, & Taylor, 2013; Visalberghi, Sabbatini,  
477 Taylor, & Hunt, 2017). We hope that our experiment encourages future investigations to  
478 assess the cognitive demands of flexible tool-use in a taxonomically various range of non-  
479 habitually tool-using species, in order to test the validity of existing theories on the evolution  
480 of tool use and cognition.

481

#### 482 **Declarations**

483 **Conflict of interest** – the authors declare there is no conflict of interest.

484



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740 **Table 1.** *GLMM Estimates of Model 1 - Tool-use task 1*

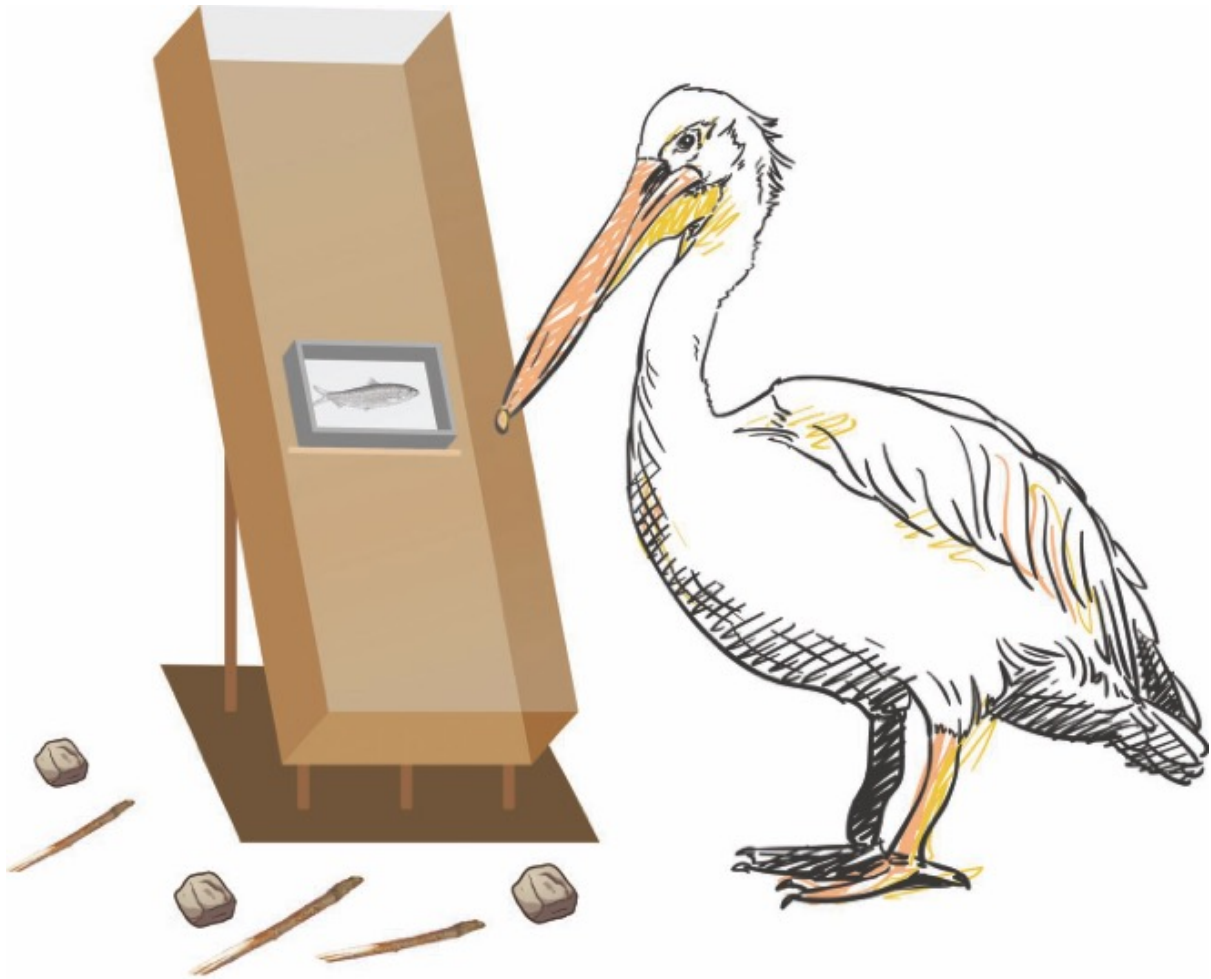
Variable	Estimate	SE	z	Pr( z )
Behaviour - Insert beak in the apparatus (Intercept)	-1.94	0.72	-2.68	< .001
Behaviour - Interaction with the apparatus	4.08	0.31	12.79	< .001
Trial	0.02	0.01	4.13	< .001
Trial: Behaviour - Interaction with the apparatus	1.09	0.32	3.40	< .001

741 **Table 2.** Pairwise comparisons within *Behaviour* and between *Phase x Behaviour of Model 2 - Tool-*  
 742 *use task 2.*

Contrast	Estimate	SE	z	Pr( z )
<i>Behaviour</i>				
Insert beak - Interaction	-4.09	0.31	-12.7	< .001
Insert beak - Touch tool	1.10	0.32	3.40	< .001
Interaction - Touch tool	5.19	0.32	16.07	< .001
<i>Phase x Behaviour</i>				
Insert beak pre test - Insert beak test	-0.52	0.71	-0.73	0.97
Interaction pre test - Interaction test	0.05	0.57	0.10	0.84
Touch tool pre test - Touch tool test	0.13	0.67	0.20	0.49

743 **Figures**

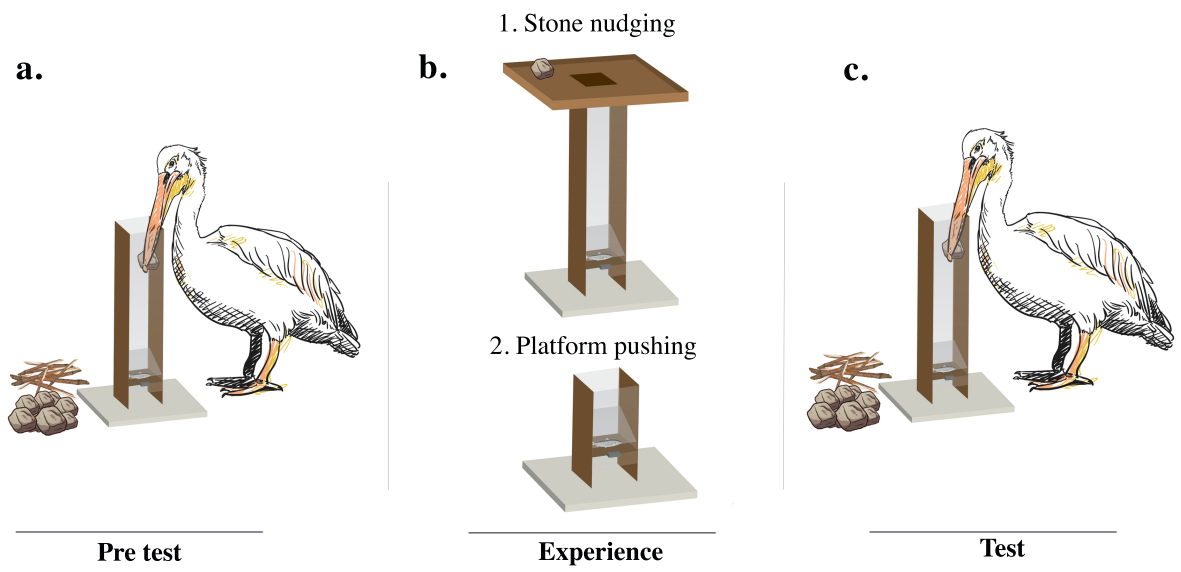
744 **Figure 1.**



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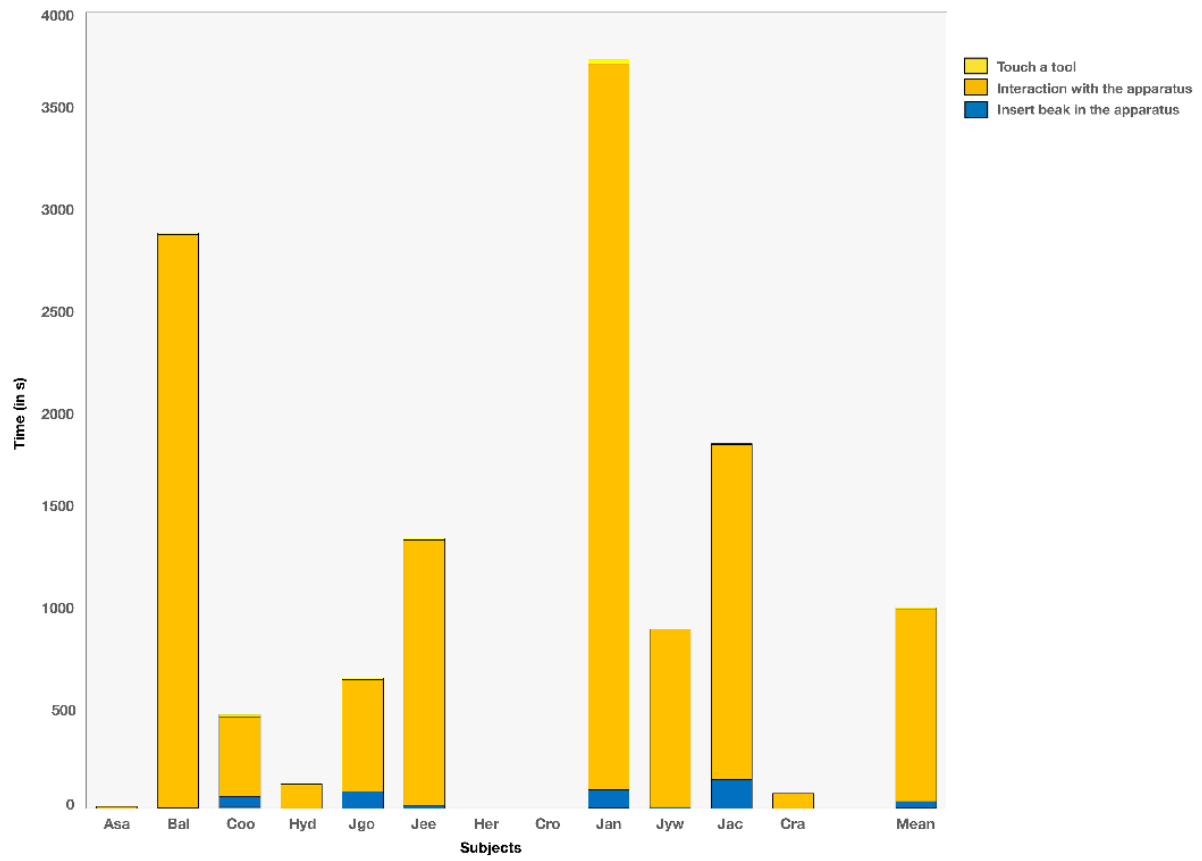
747 **Figure 2.**



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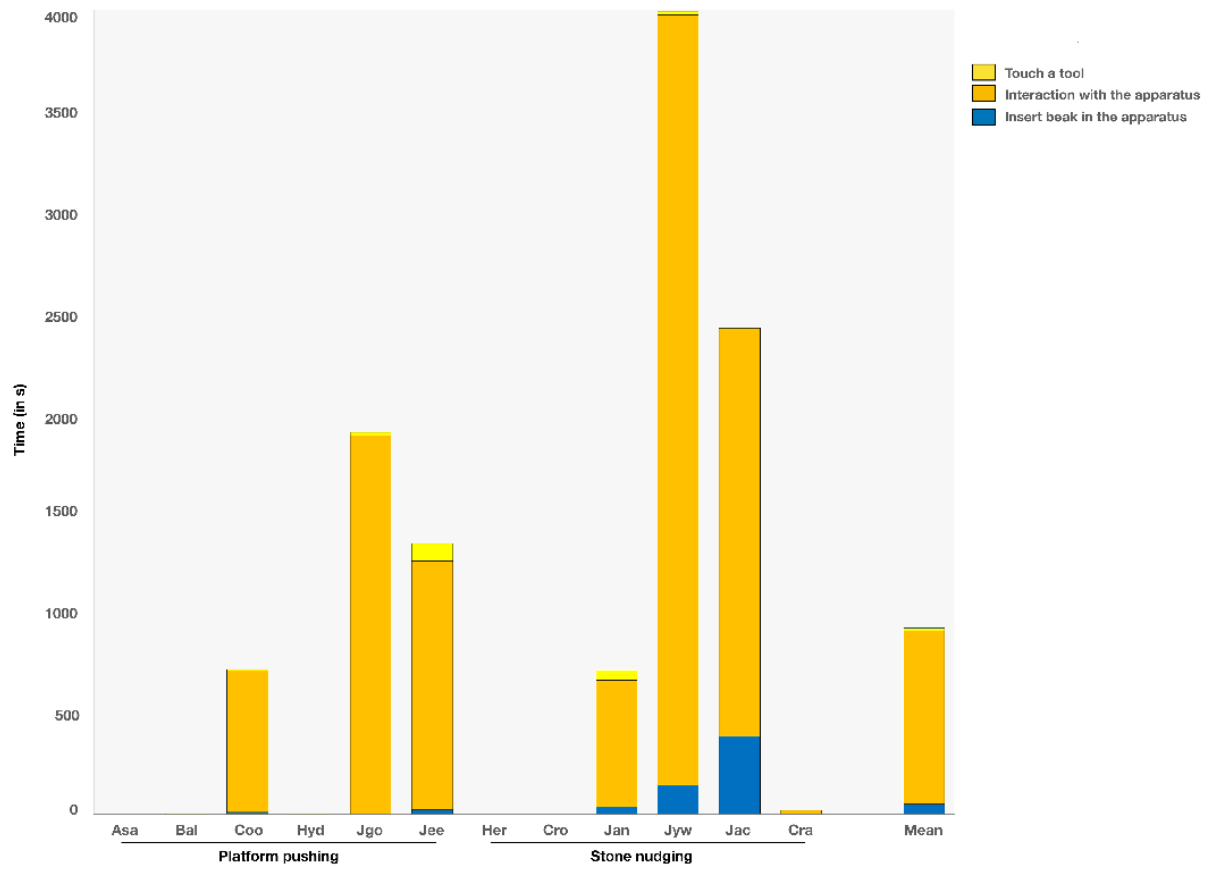
750 **Figure 3.**



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753 **Figure 4.**



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756 **Figure captions**

757 **Figure 1.** Schematic representation of the apparatus used during Tool-use task 1.

758 The reward, a fresh fish located inside a tissue box, was maintained horizontally inside the  
759 apparatus. To get the reward, the subject had to pick up a tool on the ground and to drop it  
760 into the upper end of the apparatus.

761 **Figure 2.** Schematic representation of the apparatus used during Tool-use task 2.

762 **a.** Subjects were first confronted in a pre-test phase to assess whether the subjects could  
763 spontaneously use tools (**Figure 2a**). The reward, a piece of fresh fish, was located on a  
764 magnetised collapsing platform. To get the reward, the subject had to pick up a tool on the  
765 ground and to drop it into the top hole of the apparatus. **b.** After having checked that subjects  
766 did not use tools during the pre-test phase, subjects were divided into two groups and moved  
767 to the experience phase. The stone-nudging group was trained to nudge a stone into the  
768 apparatus from a rimmed square plate with a central hole, which was mounted around the  
769 tube's top (**Figure 2b1**). Subjects in the platform-pushing group were trained to reach the  
770 reward into a shortened tube by pushing the platform with their beak (**Figure 2b2**). **c.** The  
771 test phase followed the experience phase. The same procedure as the pre-test phase was  
772 applied (**Figure 2c**).

773 **Figure 3.** Time spent (in s) in performing specified behaviours at the individual level and at  
774 the group level (Tool-use task 1).

775 **Figure 4.** Time spent (in s) in performing specified behaviours at the individual level and at  
776 the group level (Tool-use task 2: pre-test). The two experimental groups are indicated (i.e.  
777 platform pushing vs stone nudging).