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1 Chimpanzees' flexible targeted helping based on an understanding of conspecifics'

2 goals

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13

14 **Abstract**

15 Humans extensively help others altruistically, which plays an important role in
16 maintaining cooperative societies. Although some non-human animals are also capable
17 of helping others altruistically, humans are considered unique in our voluntary helping
18 and our variety of helping behaviors. Many still believe that this is because only humans
19 can understand others' goals due to our unique theory of mind abilities, especially
20 shared intentionality. However, we know little of the cognitive mechanisms underlying
21 helping in non-human animals, especially if and how they understand others' goals. The
22 present study provides the empirical evidence for flexible targeted helping depending on
23 conspecifics' needs in chimpanzees. The subjects of this study selected an appropriate
24 tool from a random set of seven objects to transfer to a conspecific partner confronted
25 with differing tool-use situations, indicating that they understood what their partner
26 needed. This targeted helping, i.e. selecting the appropriate tool to transfer, was
27 observed only when the helpers could visually assess their partner's situation. If visual
28 access was obstructed, the chimpanzees still tried to help their partner upon request, but
29 failed to select and donate the appropriate tool needed by their partner. These results
30 suggest that the limitation in chimpanzees' voluntary helping is not necessarily due to
31 failure in understanding others' goals. Chimpanzees can understand conspecifics' goals

32 and demonstrate cognitively advanced targeted helping as long as they are able to
33 visually evaluate their conspecifics' predicament. Yet, they will seldom help others
34 without direct request for help.

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36

37 Keywords: targeted helping, theory of mind, understanding other's goal, chimpanzee,
38 altruism prosociality

39

40 **\body**

41 **Introduction**

42 Humans extensively help others altruistically, which plays an important role in
43 maintaining cooperative societies. How have humans evolutionarily achieved this
44 cooperative trait? Previously, many theoretical studies have explained why altruism and
45 cooperation evolved from an ultimate perspective. These studies have addressed the
46 “why”, but not the “how”. Many non-human animals demonstrate cooperative abilities
47 (1-3), and recent empirical studies have also revealed that some non-human primates
48 can help or share food with conspecifics without any direct benefit to themselves
49 (cotton-top tamarin (*Saguinus oedipus*): 4, capuchin (*Cebus appella*): 5-7, marmoset
50 (*Callitrix jacchus*): 8, bonobo (*Pan paniscus*): 9, chimpanzee (*Pan troglodytes*): 10-14).
51 However, our understanding of the cognitive mechanisms involved remains limited and
52 urgently requires further investigation, especially from a comparative perspective.

53

54 Regarding the cognitive mechanisms involved in helping, much focus has been
55 given to “targeted helping” (also known as “instrumental helping” (10-11)) defined as
56 help and care based on the cognitive appreciation of the need or situation of others (15).

57 Targeted helping is considered to be linked to the cognitive capacity for empathy. For
58 now, among non-human animals, only some great ape, cetacean, and elephant species
59 demonstrate this form of helping behavior (15). By definition, the animals are expected
60 to understand the others' needs. However, to date, empirical studies clearly
61 demonstrating this cognitive ability in non-human animals are lacking. If and how the
62 animals understand the others' goals and help others effectively are core questions
63 which have to be examined if we are ever to deepen our understanding of the evolution
64 of cooperation.

65

66 Among those animal species known to demonstrate targeted helping,
67 chimpanzees, one of our closest living relatives, help others upon request, but seldom
68 voluntarily in contexts requiring assistance provisioning (12-13). This concurs with
69 observations of food sharing among chimpanzees in the wild (16-17). Interestingly, in
70 our previous experiments (12), observation of a conspecific in trouble did not elicit
71 chimpanzees' helping behavior. A recent study has documented chimpanzees'
72 spontaneous generosity in a prosocial choice test (14). Other studies, however, indicate
73 that chimpanzees fail to give food spontaneously to a conspecific even at no cost to
74 themselves (18-20), between a mother and her infant (21-23), and in reciprocal contexts

75 (21-22,24-25). Direct request, e.g. an out-stretched arm directed at a potential helper,
76 may be required to prompt targeted helping in chimpanzees (26).

77

78 Why do chimpanzees seldom help others without being requested? One
79 plausible explanation from the perspective of cognitive mechanisms is that chimpanzees
80 cannot understand others' goals upon witnessing another's predicament. Many still
81 believe that humans are unique in this respect, because we are the only animal species
82 endowed with unique theory of mind abilities enabling us to understand the goals and to
83 share the intentions of others (27). Warneken and Tamasello (10) empirically
84 demonstrated that chimpanzees, compared to humans, have a limited range of helping
85 behaviors, and suggested that this is because of the inability of chimpanzees to interpret
86 what others need in different situations. Nevertheless, we still know little about the
87 cognitive mechanisms underlying helping behavior in non-human animals, and no study
88 has empirically examined if and how chimpanzees understand others' goals in these
89 types of helping contexts.

90

91 We developed a new experimental paradigm aimed at examining chimpanzees'
92 ability and flexibility in helping effectively a conspecific pending on his/her specific
93 needs. This experiment required participants to select and transfer an appropriate tool to
94 a conspecific partner so that he/she could solve a task to obtain a juice reward. We set
95 up one of two tool-use situations, i.e. a stick-use situation or a straw-use situation, in the
96 potential recipient's booth. Seven objects including a stick and a straw (Figure 1) were
97 supplied on a tray in an adjacent booth occupied by a potential helper. The potential
98 recipient could not directly reach any of the tools available in the adjoining booth, but
99 could demonstrate request by poking his or her arm through a hole in the panel wall
100 separating the two booths. In previous experimental studies (10-13), a potential helper
101 was never confronted with a behavioral choice when given the opportunity to help.
102 These experiments therefore failed to examine whether chimpanzees actually
103 understood what others needed. In our study, the helper had to select a tool from an
104 array of seven objects to effectively help his/her partner accomplish the task he/she was
105 confronted with. We also developed and compared two conditions in which a potential
106 helper could or could not see the partner's tool-use situation. Our study highlights
107 notable cognitive mechanisms underlying helping behavior in chimpanzees.

108

109 The setup of the present study is fairly similar to previous experiments
110 conducted by Savage-Rumbaugh and colleagues (28). However, there are clear
111 differences between this latter study and our own. In these previous experiments, the
112 two chimpanzee participants correctly chose and donated tools which their partner
113 requested using symbols. This study significantly promoted our understanding of
114 symbolic communication abilities in chimpanzees; however, it provided limited insight
115 into their helping behavior and its mechanisms. In addition, pre-test training artificially
116 shaped the subjects' symbolic communication and also their giving and sharing
117 interactions. The potential recipient chimpanzees were trained to indicate which tool
118 they needed by selecting a corresponding lexigram, and the potential donors were
119 trained to select and transfer the tool corresponding to the presented lexigram. The
120 performances were established through standard fading, shaping, chaining, and
121 discrimination procedures, as also used in studies with pigeons (29). In order to
122 eliminate these possibilities, we developed significantly different procedures. First,
123 although the chimpanzees were all trained in solving the two tool-use tasks presented to
124 them, the experimenter never performed any other type of training or shaping of
125 behavior of the participants. Second, we allowed our subjects to communicate with each
126 other without symbols or any other form of artificial communication medium. With

127 these modifications, we investigated how chimpanzees understand what others require
128 based on their natural communicative abilities, and whether or not they can flexibly and
129 spontaneously modify their helping behavior according to the others' needs.

130

131 **Results & Discussion**

132 *The first "Can see" condition*

133 We first tested the chimpanzees in a "can see" condition, where the panel wall
134 was transparent so that a potential helper could see his/her partner's tool-use situation in
135 the adjacent booth. Overall, object offer (at least one object regardless of whether it was
136 a tool or a non-tool object) from potential helpers was observed on average in 90.8% (N
137 = 5, SEM = 3.4) of trials. In the familiarization phase prior to testing (eight 5-min trials
138 for each participant), where the chimpanzees could freely manipulate the seven objects
139 without any tool-use situation, object offer was observed only in 5.0% (N = 5, SEM =
140 3.1) of trials, suggesting that the chimpanzees were not motivated in transferring objects
141 to their partner for its own sake. Object offer mainly occurred following recipient's
142 request. Upon-request offer accounted for 90.0% (N = 5, SEM = 5.7) of all offers. This

143 result concurs with previous findings that direct request is important for the onset of
144 targeted helping in chimpanzees (12-13,26).

145

146 The chimpanzees, except Pan, first offered potential tools (a stick or a straw)
147 significantly more frequently than the other non-tool objects (Ai: 87.5%, Cleo: 97.4%,
148 Pal: 93.5%, Ayumu: 78.0%; Fisher's exact test: $p < 0.05$ for each of these four
149 participants, with a chance level set at 50% due to the binary choice between tool and
150 non-tool objects; see Table S1 for the individual details). In Pan's case, she most
151 frequently offered a non-tool brush (79.5% of her first object offers). When we
152 eliminated brush offer from the analysis, her offer of the potential tools was also
153 significantly above chance level (88.6%; Fisher's exact test: $p < 0.01$ with a chance
154 level set at 50%). This bias towards offering a stick and a straw suggests that the
155 chimpanzees distinguished the potential tools from the other useless objects. The
156 chimpanzees' prior experience with these tools in previous experiments may explain
157 this bias (12).

158

159 We then examined the chimpanzees' first offer, limiting our analysis to the
160 potential tools only: which tool, a stick or a straw, they chose to transfer to the partner.
161 Among four of the five chimpanzee participants we tested, there was a significant
162 difference in the first offer between the partner's two tool-use situations (Fisher's exact
163 test: $p < 0.05$ for each of the four participants; see Table 1 for details). Helpers selected
164 to offer more frequently a stick (or a straw) when their partner was confronted with the
165 stick-use (or the straw-use) situation than when he or she was faced with the straw-use
166 (or the stick-use) situation (Figure 2a; Video S1; see Table S1 for individual details).
167 Therefore the chimpanzees demonstrated flexible targeted helping depending on their
168 partner's predicaments. This result suggests that the chimpanzees understood which tool
169 their partner required to solve successfully the tool-use task he/she was confronted with.

170

171 ***The "Cannot see" condition***

172 In order to investigate how the chimpanzees understood which tool their
173 partner required, we next developed the "cannot see" condition. In this condition, the
174 panel wall was opaque so that a potential helper could not readily see his/her partner's
175 tool-use situation unless he/she purposely stood up and peaked through a hole

176 approximately 1m above the floor. In this condition, the chimpanzees continued to help,
177 offering at least one object (regardless of whether a tool or non-tool) in 95.8% of trials
178 on average (N = 5, SEM = 1.9). There was no significant difference in the frequency of
179 object offer between the previous “can see” condition and this “cannot see” condition
180 (paired t-test (two-tailed): $t = -2.1$, $df = 4$, $p = 0.099$). Upon-request offer (71.7%, N = 5,
181 SEM = 18.3) again predominated over voluntary offer (28.3%, N = 5, SEM = 18.3),
182 although the ratio of voluntary offer significantly increased from the previous “can see”
183 condition in two individuals (Ayumu and Cleo; Fisher’s exact test: $p < 0.05$,
184 respectively). This increase in voluntary offer was likely due to a carry-over effect from
185 the previous condition. The helper had possibly learnt that he/she was expected to offer
186 an object to his/her partner in this new experimental condition.

187

188 As in the “can see” condition, the chimpanzees, except Pan, first offered
189 potential tools (a stick or a straw) significantly more frequently than the other non-tool
190 objects (Ai: 89.4%, Cleo: 88.9%, Pal: 100%, Ayumu: 93.0%; Fisher’s exact test: $p <$
191 0.01 for each of these four participants with a chance level was set at 50%). Pan again
192 showed a particular preference for offering a brush (55.3% of her first object offer);
193 however, when we eliminated brush offer from the analysis, her offer of the potential

194 tools was also significantly above chance level (100%; Pearson Chi-square test: $p <$
195 0.01 with a chance level set at 50%).

196

197 The most important and suggestive difference between the “can see” and
198 “cannot see” conditions appeared when we examined which tool, a stick or a straw, the
199 chimpanzees offered first, and compared this between the two tool-use situations
200 presented in the partner’s booth. Contrary to the “can see” condition, where we found a
201 significant difference in stick/straw choice depending on the partner’s predicament,
202 such a difference disappeared in the “cannot see” condition in all participants except
203 one subject (see Table 1 for statistics). Ayumu was the only individual who selected the
204 appropriate tool even in the “cannot see” condition; he stood up and assessed his
205 partner’s situation by peaking through the hole before selecting and transferring the
206 appropriate tool (Figure 3). Therefore, for Ayumu, the “cannot see” condition was
207 equivalent to the “can see” condition. However, the chimpanzees who did not visually
208 assess their partner’s situation in the “cannot see” condition, failed to select and offer
209 the appropriate tool needed by their partner (Figure 2b; Video S2; see Table S1 for
210 individual details).

211

212 The chimpanzee helpers understood their partner's goals only when they could
213 visually appreciate their partner's situation. Potential recipients performed request
214 behavior similarly in form and frequency in the "cannot see" condition and in the "can
215 see" condition (mean percentage of trials in which request was observed: "can see":
216 85.0% N = 5, SEM = 7.3; "cannot see": 71.3% N = 5, SEM = 18.1; paired t-test
217 (two-tailed): $t = 1.1$, $df = 4$, $p = 0.35$). Therefore, chimpanzee request behavior on its
218 own failed to convey any reliable information on the requester's specific needs, i.e. the
219 appropriate tool needed. This means that, although request behavior might elicit the
220 onset of chimpanzee helping, it is insufficient on its own for effective targeted helping.
221 Ayumu's behavior, i.e. selecting and transferring the appropriate tool after assessing his
222 partner's situation by peaking through the hole, further demonstrates that the
223 chimpanzees depended on visual assessment of their partner's situation to acquire the
224 necessary information to appropriately help their partner.

225

226 *The second "Can see" condition*

227 In order to confirm that the difference in appropriate tool selection between the
228 two conditions (significant difference in the “can see” condition and non-significant in
229 the following “cannot see” condition for three of the participants) was not due to the
230 experimental order of the two conditions, we repeated the “can see” condition for these
231 three participants. We observed object offer in 97.9% (N = 3, SEM = 0.93) of the trials,
232 and upon-request offer accounted for 79.4% (N = 3, SEM = 3.2) of all offers. The three
233 chimpanzees first offered potential tools (a stick or a straw) significantly more
234 frequently than the other non-tool objects (Ai: 81.3%, Cleo: 95.7%, Pal: 100%; Fisher’s
235 exact test: $p < 0.01$ for each of these three participants with a chance level set at 50%).
236 As in the first “can see” condition but not in the “cannot see” condition, we again
237 confirmed a significant difference in the chimpanzees’ choice, a stick or a straw, in their
238 first offer between the partner’s tool-use situations (Fisher’s exact test: $p < 0.01$ for each
239 of the three participants; see Table 1 for details). The three participants significantly
240 more frequently selected and transferred a stick (or a straw) when their partner was
241 confronted with the stick-use (or the straw-use) situation than when the partner was
242 faced with the straw-use (or the stick-use) situation (Figure 2c; see Table S1 for
243 individual details). This confirms that the chimpanzees demonstrated flexible targeted

244 helping with an understanding of which tool their partner needed when they could
245 visually assess their partner's situation.

246

247 **General Discussion**

248 This study provides the empirical evidence for chimpanzees' flexible targeted
249 helping based on an understanding of others' goals. When helpers could visually assess
250 their partner's predicament, they appropriately selected out of seven objects an
251 appropriate tool to transfer to their partner so he/she could obtain a reward. This kind of
252 targeted helping is cognitively advanced; it is clearly neither a programmed behavior
253 nor an automatic stimulus response. Even without shared intentionality and
254 sophisticated communicative skills such as language or pointing, chimpanzees can
255 understand others' goals when situations are visibly obvious and understandable.

256

257 The present study also offers novel insights into the cognitive mechanisms
258 underlying helping behavior in chimpanzees. Firstly, chimpanzees are motivated to help
259 others upon request even when they cannot properly assess the others' predicament. Our
260 results show that even if visually prevented from understanding their partner's needs,

261 the chimpanzees persisted in helping their partner upon request, although their tool
262 choice often failed to correspond to their partners' requirements (Video S2). Although
263 Pan failed to choose an appropriate tool on first offer even in the "can see" condition,
264 she persisted in offering objects to her partner upon request. It is clear that all
265 chimpanzees, including Pan, were motivated to respond to their partner's request.
266 Secondly, even when chimpanzees understand the needs of others, they seldom help
267 others unless directly requested. Our results also suggest that chimpanzees are able to
268 understand what others need by simply witnessing the situation. Therefore, the
269 limitation in chimpanzees' voluntary helping (10-13,18-25) cannot solely be explained
270 by a failure in understanding others' goals. Chimpanzees may not provide assistance to
271 others unless requested in spite of being able to understand others' goals. Combining
272 these two points, we suggest that both understanding of others' goals and detection of
273 directed request are essential prerequisite in eliciting targeted helping in chimpanzees.

274

275 A crucial question for future research is to investigate similarities and
276 differences in targeted helping and its mechanisms among humans, chimpanzees and
277 other non-human animals. In humans, sometimes only observing others in trouble seems
278 to suffice in prompting the onset of helping even without directed request (e.g.

279 spontaneous donation to disaster victims); however, the prevalence of this form of
280 helping in humans remains debated. A recent study on human toddlers' prosocial
281 behavior (30) revealed that 18-month-old infants helped an unfamiliar adult in trouble,
282 but required considerable communication from the adult about his/her needs.
283 Meanwhile, 30-month-old infants helped an adult more spontaneously, possibly due to
284 their acquired empathic abilities. The authors suggested that toddlers' helping develops
285 with their abilities to understand others' subjective internal states. The chimpanzees'
286 helping behavior in the present study was fairly similar to that of the 18-month-old
287 toddlers. However, our results showed that chimpanzees helped others upon request
288 even without proper knowledge of the others' needs, and also seldom helped others
289 unless being requested even when they understood the others' goals. In this respect,
290 humans and chimpanzees might differ in the onset mechanisms involved in prompting
291 helping behavior.

292

293 It is still too early to make any firm conclusions on similarities and differences
294 in helping behavior and its mechanisms between humans and chimpanzees because of
295 the lack of proper and rigorous comparative studies. In previous studies with human
296 infants (10, 30), the experimenters (recipients of infants' helping) expressed their needs

297 not only by gesture but also using language. This might prevent direct comparison
298 between humans and non-human animals. The previous studies also did not clearly
299 distinguish expression of desire and demonstration of request directed toward the
300 potential helpers, which confounds any evaluation of how the toddlers understood the
301 others' goals. The present study proposes a rigorous potentially comparative
302 methodology and novel perspectives for studying mechanisms of targeted helping.
303 Further comparative studies with humans, chimpanzees, and other non-human animals,
304 especially bonobos, who also demonstrate considerable helping and cooperative
305 behavior (9, 31), will no doubt shed further light on the evolution of targeted helping.

306

307 **Materials and Methods**

308 Participants were socially housed chimpanzees at the Primate Research
309 Institute, Kyoto University (KUPRI). All participants had previously taken part in a
310 variety of perceptual and cognitive studies, including experiments which examined their
311 helping behavior in a similar setting as the present study (12). We tested five
312 chimpanzees paired with kin (two mothers Ai and Pan were paired with their offspring
313 Ayumu and Pal respectively, and three juveniles Ayumu, Pal and Cleo were paired with

314 their mother Ai, Pan and Chloe respectively), since these kin pairs demonstrated
315 frequent tool-giving interactions in previous experiments (12). All participants were
316 experts at the two tool-use tasks presented in the current study. The present study was
317 approved by the Animal Care Committee of the Primate Research Institute of Kyoto
318 University, and the chimpanzees were tested and cared for in accordance with “the
319 Guide for the Care and Use of Laboratory Primates, 2nd edition” produced by the ethics
320 committee of the Primate Research Institute of Kyoto University (2002).

321

322 The paired chimpanzee participants were tested in two adjacent experimental
323 booths (136 cm × 142 cm and 155 cm × 142 cm, 200 cm high). A hole (12.5 cm × 35
324 cm) in the panel-wall divider separating the two participants was located approximately
325 1m above the floor. Each participant acted as either a potential helper or a potential
326 recipient. We set up one of either two tool-use situations (the stick-use situation or the
327 straw-use situation) in the recipient’s booth (for details see 12), and supplied in the
328 helper’s booth seven objects (a stick, a straw, a hose, a chain, a rope, a brush, and a belt)
329 randomly presented on a tray (26cm × 36cm) (Figure 1). Only one of the seven objects
330 (a stick or a straw) could serve as an effective tool to successfully obtain the juice
331 reward under either tool-use situation. In order to ensure that the chimpanzees were

332 equally familiar with these seven objects, we carried out a familiarization phase of eight
333 5-min trials (one trial a day) prior to testing, where the participants could freely
334 manipulate these objects in the experimental booth without any tool-use situation.

335

336 We developed two conditions: the “can see” condition (as the test) in which the
337 panel wall between the two booths was transparent, and the “cannot see” condition (as
338 the control) in which the panel wall was opaque. In the latter condition, helpers could
339 not readily see which tool-use situation their partner was faced with, unless he/she
340 purposely stood up and peaked through the hole. In either condition, chimpanzees could
341 transfer objects or poke their arm through the hole. We first conducted 48 trials (random
342 order of 24 trials of the stick-use and 24 trials of the straw-use situations) of the “can
343 see” condition. Thereafter, we carried out 48 trials of the “cannot see” condition, and
344 again 48 trials of the “can see” condition if participants’ performance differed between
345 the first “can see” and “cannot see” conditions. A trial started when we supplied the
346 helper’s booth with the tray loaded with the seven objects, and ended either when the
347 recipient succeeded in obtaining the juice reward upon being offered the appropriate
348 tool, or when 5 minutes had passed without appropriate tool transfer. We conducted two
349 or four trials per day.

350

351 We recorded the participants' behaviors and interactions with three video
352 cameras (Panasonic NV-GS150), and analyzed what object the helper offered the
353 recipient (see also 12). We counted a helper's "offer" when a participant held out a tool
354 towards a recipient, whether the recipient actually received it or not. Only the helper's
355 first offer was retained for analysis. We categorized object offer into two types:
356 "upon-request offer" and "voluntary offer". In upon-request offer, the giver offered a
357 tool to the recipient upon the recipient's request. In voluntary offer, the giver actively
358 offered a tool to the recipient without the recipient's explicit request. When a tool was
359 taken away by the recipient without owner's offer (tolerated-theft transfer), this transfer
360 was categorized as "no offer". We counted a recipient's "request" when the recipient
361 poked an arm through the hole. We used paired t-test (two-tailed) to compare the
362 chimpanzees' averaged performance between the two experimental conditions, and
363 Fisher's exact test (two-tailed) to individually compare the rates of a helper's
364 performance between two categorical variables.

365

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374

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445

446 **Figure Legends**

447 **Figure 1.** Tool set consisting of seven objects which was supplied to a potential helper.

448 Only one of them (a stick or a straw) was needed for a conspecific to solve either a

449 stick-use or straw-use task in the adjoining booth.

450

451 **Figure 2.** Helpers' first tool selection and offer to their conspecific partner. Each

452 condition ("Can See" or "Cannot See") presented participants in the recipient booth with

453 one of either two tool-use situations ("stick" or "straw"). These graphs were based on

454 the data from three participants (Ai, Cleo and Pal) who completed all the conditions

455 based on an A-B-A design. For the statistical analysis, see Table 1.

456

457 **Figure 3.** Ayumu stood up and assessed his mother's situation by peaking through the

458 hole in the opaque panel wall separating the two booths. He was the only one to assess

459 so actively his partner's situation, and to select and transfer the appropriate tool to his

460 partner in the "cannot see" condition.

461

Table 1. P values of Fisher’s exact test (two-tailed) comparing each participant’s first offer ratio of stick and straw tools between the two tool-use situations presented in the recipient’s booth. Values highlighted in grey indicate a significant difference ($P < 0.05$).

	Can see (1 st)	Cannot see	Can see (2 nd)
Ai	0.015	0.54	0.008
Cleo	0.031	0.61	< 0.001
Pal	0.008	0.084	0.002
Ayumu	0.004	< 0.001	—
Pan	0.48	0.44	—



(a)



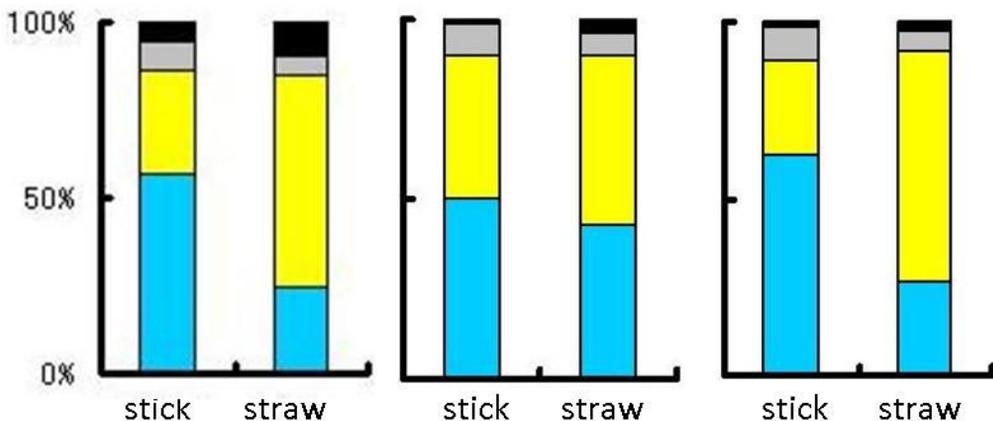
(b)



(c)



Helper's first offer: ■ stick ■ straw ■ others ■ no offer



Tool which a recipient needed

Ayumu

