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► **To cite this version:**

Cédric Sueur, Sarah Zanaz, Marie Pelé. What if animal agency could improve behavioral and neuroscience research?. 2022. hal-03299505v4

HAL Id: hal-03299505

<https://hal.science/hal-03299505v4>

Preprint submitted on 1 Jun 2022 (v4), last revised 14 Sep 2022 (v5)

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1 **What if animal agency could improve behavioral and neuroscience research?**

2 Cédric Sueur^{1,2,3}, Sarah Zanaz^{1,4}, and Marie Pelé⁵.

3 1 Université de Strasbourg, CNRS, IPHC UMR 7178, Strasbourg, France.

4 2 Institut Universitaire de France, Paris, France.

5 3 CEERE Centre Européen d'Enseignement et de Recherche en Ethique, Strasbourg, France.

6 4 Benemérita Universidad Autónoma de Puebla, Facultad de Filosofía y Letras, Puebla

7 5 Anthro-po-Lab, ETHICS EA7446, Lille Catholic University.

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9 The authors declare no competing interests.

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11 Correspondence to Cédric Sueur: cedric.sueur@iphc.cnrs.fr

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13

14 **Abstract**

15 Despite increasing numbers of publications showing that many animals possess the neural
16 substrates involved in emotions and consciousness, many animals are still restrained and
17 forced to take part in applied or fundamental research. However, these restraints stress
18 animals and may result in false negatives or false positives. A change is needed in
19 researchers' work paradigm with animals to progress in behavioral and neuroscience
20 research and thus gain access to hitherto inaccessible yet important scientific results.
21 Animals interact with the world in their own ways, and researchers need to adopt these
22 ways, i.e. their agency, to perform better research and develop a better understanding of
23 how the brain and behavior evolve. This paper discusses how animal agency can not only be
24 the key to more wide-ranging and improved research in existing domains, but can also lead
25 to new research questions resulting from a non-anthropocentric view.

26

27 **Keywords:** 3Rs, animal research, ethology, ethics, sentience.

28 **Introduction**

29 By definition, animal research requires the involvement of animals. Although researchers
30 have made great progress and improved experimental conditions for animals through the
31 application of the 3R (Replace, Reduce, Refine) rules, some behavioral experiments showed
32 that animals are still restrained through different methods, such as the use of throw nets,
33 restraint chairs, cages, or by food deprivation (Ben-Ami Bartal, Decety, & Mason, 2011;
34 Chang et al., 2021; He et al., 2020; McMillan, Bloomsmith, & Prescott, 2017; Prescott &
35 Buchanan-Smith, 2003; Slater et al., 2016). According to McMillan et al. (2017), too many
36 researchers continue to use methods that entail negative reinforcement (when the
37 individual has to perform an action to remove a stressor), whilst procedures using restraint
38 chairs could comprise positive reinforcement methods (when the individual receives a
39 reward after entering in the chair and then getting its head out from the chair) (McMillan et
40 al., 2017). These protocols are realized to obtain results in behavioral or neuroscience
41 research but may also lead to different issues. Beyond the ethical issues of such restraints
42 for animals, these examples of experimental setups lead us to consider which possibilities
43 and results have yet to be investigated and more importantly, whether such compulsory
44 protocols could lead to false negatives or false positives (Chang, Zhang, Poo, & Gong, 2017;
45 Huttunen, Adams, & Platt, 2017; Liu, Liu, & Huang, 2017). False negatives or false positives
46 mean that studies show respectively negative (not expected, H₀) or positive results
47 (expected, H₁) but these results are not due to the tested condition (e.g. a drug, a gene, an
48 environmental condition) but to uncontrolled factors (e.g. stress, personality). Indeed, stress
49 and contention (i.e., the animal is immobilized and restrained in an apparatus, such as a
50 chair or a box) can not only modify some animal behaviors but also entirely prevent others
51 from being displayed (Lecorps, Weary, & von Keyserlingk, 2021; Mason et al., 2019; Prescott,
52 2016). Some authors, such as Patter, Blattner, Matsuzawa, King B. J., and McMillan, consider
53 that the current 3R framework is not sufficient to ensure that animals are meaningful
54 participants in experiments, which is crucial to guarantee that scientific results are not
55 altered by stress or personality of animals (King, 2021; Matsuzawa, 2016a; McMillan,
56 Perlman, Galvan, Wichmann, & Bloomsmith, 2014; Van Patter & Blattner, 2020). Studies
57 carried out on animals under restraints offer few meaningful opportunities for them to show
58 their full behavioral and cognitive capacities, and in this way to exercise agency with their

59 environment and in their relationships, both between each other and with humans (Blattner,
60 Donaldson, & Wilcox, 2020). Gillespie (2019) wrote that ‘there is a long tradition of studying
61 nonhuman animals in spaces of animal use and exploitation, where researchers and teachers
62 in effect become complicit through passive participation in violence against nonhuman
63 animals...’ (p. 19). According to Blattner et al. (2020), who worked on animal agency in
64 rehomed farm animals and from which this paper is inspired, ‘longstanding ideological
65 blinders and anthropocentric bias frame animals as limited beings whose lives unfold
66 according to fixed genetic or species-specific scripts, rather than as complex subjects who
67 act with intention and purpose, both individually and collectively’ (p. 1). Restraint-based
68 experiments are severely limited in terms of what researchers can learn from animals, in
69 individual and group contexts. On the contrary, letting animals express their behavior, will,
70 intentions, or even imagination could bring new advances in research and human-animal
71 cooperation. The use of animal agency must now be considered a central and strong point of
72 the protocols put in place, particularly when applying for funding. In any case, we do not
73 pretend to sermonize researchers, we only seek to provide them with arguments in favor of
74 such new leads of investigation when working with animals.

75 Indeed, increasing numbers of publications show that many animals (mammals, birds, and
76 other creatures including octopuses) possess the neural substrates involved in emotions and
77 consciousness (Ben-Haim et al., 2021; Low et al., 2012). Rats, primates, and pigeons are
78 capable of metacognition, i.e., knowing if they are wrong or right in a test (Le Neindre et al.,
79 2017, 2018). Cetaceans and apes are conscious of their own existence, and that of others
80 (Gallup, Anderson, & Shillito, 2002). Self-awareness was also found in cleaner fishes (de
81 Waal, 2019; Kohda et al., 2019). Apes know what their conspecifics know (Kaminski, Call, &
82 Tomasello, 2008) and believe (Krupenye, Kano, Hirata, Call, & Tomasello, 2016). Empathy
83 has been observed in apes (De Waal, 2012) and rats (Ben-Ami Bartal et al., 2011). Finally,
84 some apes have a sense of morality (De Waal, 2006; Jensen, Call, & Tomasello, 2007;
85 Tomasello & Vaish, 2013). Of course, there remains some debate on how to interpret
86 behavioral studies when it comes to the cognitive capacities we listed below (Bekoff & Allen,
87 1997; Buckner, 2011; Sober, 2009), and we need to be careful about how to interpret these
88 results since animals minds are still black boxes in multiple ways (Janson & Byrne, 2007;
89 Péron, 2012). There may be evidence of these capacities, but it is by no means a settled

90 matter that, for instance, all fish on Earth are self-conscious. Whilst some individuals show
91 capacities, such as the theory of mind, anticipation, or metacognition in some experiments,
92 other members of the same species fail in other setups or replications (Boyle, 2021; Voelkl et
93 al., 2020, 2021), thus proving, if still necessary, the importance of comparative methods
94 (Krasheninnikova, Berardi, Lind, O'Neill, & von Bayern, 2019; Schmitt, Pankau, & Fischer,
95 2012). Moreover, there is perhaps no need to have these specific cognitive capacities to be
96 an agent, certainly not according to some views of agency. More and more, researchers
97 showed that animals may have cognitive capacities similar to or close to the ones of human
98 beings by changing their way of thinking from an anthropocentric approach (Birch, Schnell, &
99 Clayton, 2020) to an acceptance of anthropomorphism as a way to explain animal behavior
100 (Griffin, 2013) but also by hypothesizing that animals can think in a way different from how
101 humans do (Andrews, 2020b; Birch et al., 2020; De Waal, 2016). For instance, self-awareness
102 was not found in some species when the mirror test (Gallup et al., 2002) was used, but it was
103 found when researchers used the senses of animals, such as the sense of smell for dogs
104 (Cazzolla Gatti, 2016) or vocalizations in gibbons (D'Agostino, Pasetta, & Reichard, 2017).
105 Merleau-Ponty had already noted this problem in his *Causeries* back in 1948: researchers
106 usually do not try to understand animals in their singularity, *as they are*, but rather in
107 comparison with human beings, projecting what are essentially human characteristics onto
108 animals (Merleau-Ponty, 2017). However, this is a means to measure the distance between
109 human beings and other animals rather than a tool allowing a real understanding of how
110 animals live and express a subjective existence (Sueur, Forin-Wiart, & Pelé, 2020; Sueur &
111 Pelé, 2017; Tokuyama et al., 2012). Studied in the light of human normative references,
112 animals always lack something (Merleau-Ponty, 2017). Moreover, most studies on
113 comparative cognition are carried out on captive animals, not only because we lack field
114 technology to make these studies on wild ones, but also because it is easier for researchers
115 to experiment in controlled conditions. Of course, captivity may limit the potentiality of
116 animals to display natural behaviors and then, to prove the ecological validity of the
117 protocols. For as long as animals are studied from a human perspective and are tested in
118 terms of human problems (capacity to count, to draw, to speak a human language) instead
119 of their own questions and problems, they will always respond 'as they can' (Canguilhem,
120 1992), without ever being able to fully express their agency. However, there have been
121 philosophical and anthropological attempts to blur the boundaries between humans and

122 other animals (Andrews, 2020b; Böhnert & Hilbert, 2018; Daly Bezerra de Melo, 2012; Daly,
123 2018; De Waal, 2016; Langlitz, 2020; Wendler, 2020). Animals interact with the world in their
124 own ways and these ways, i.e. their agency, are precisely the view that researchers need to
125 adopt to perform better research and develop a better understanding of how the brain and
126 behavior evolve.

127 **Animal agency**

128 Agency is the capacity of an actor to act in a given environment. In the broadest sense,
129 agency is the ability to have an influence or an effect on something. In this sense, agency is
130 possessed not only by all humans and animals, but also by inanimate objects, such as
131 viruses, stones, or tornadoes, as explained by Blattner et al. (2020). However, its focus might
132 be narrower when agency is considered as the expression or manifestation of a subjective
133 existence; agency implies affecting the world in ways that reflect a subject's desires or will
134 (Krause, 2013). It refers to an individual pursuing its own good in its own way (Taylor, 2011).
135 In the book *Fellow Creatures: Our Obligations to the Other Animals*, Korsgaard (2018) revised
136 Kant's argument of the value of humanity and raised three claims: humans need to join
137 other autonomous beings with reciprocal moral rules, humans need to care about every
138 sentient animal and human beings are not more important than other animals. Blattner et
139 al. (2020) investigate animal agency in a sanctuary for rehomed farm animals, considering
140 how a careful exploration of dimensions of agency in this setting might inform ideas of
141 interspecies interactions (work, research, politics, etc.) and ethics. Their study focused on
142 multispecific animals living in a sanctuary. For the owners of the sanctuary and the
143 researchers, the sanctuary is an 'integrated multispecies community or society whose
144 members shape spaces and practices together, take on recognized social roles, and create
145 and transmit social norms across species lines'. Blattner et al. (2020), De Waal (2016), Le
146 Neindre et al. (2017, 2018), Meijer (2019) affirm that researchers need to spend time in
147 community with animals, learn from them, and be prepared to respond and adjust scientific
148 learning process through relationships with them. This means that animals should no longer
149 be considered as the subjects of scientific experiments, but rather as participants. As
150 Andrews (2020) notes, it is important to treat animals as sentient research participants who
151 exist within their own context and with whom researchers will be in a relationship. She
152 defends a range of scientific benefits than come from forming relationships with animal

153 research subjects and that we develop below. For example, when it comes to assessing
154 animal intelligence, the researchers' focus should encompass goals that are meaningful,
155 useful, and of interest to animals instead of focusing on goals that are only relevant to the
156 human scientist (Pepperberg, 2006). Animals should no longer be seen as objects of
157 knowledge, or mere matter for the act of the human knower, but should rather be granted
158 status as an *agent* in the production of knowledge (Haraway, 1989). Interaction and
159 communication have to go in both directions. Researchers need to make themselves
160 understandable to animals as many species are able to understand our facial expressions
161 and emotions (Bhattacharjee et al., 2019; Good, Sterzinger, & Lavigne, 2018; Hoffman,
162 Creevy, Franks, O'Neill, & Promislow, 2018; Patterson & Cohn, 1990; Pedersen, 2020;
163 Savage-Rumbaugh & Lewin, 1994). Researchers need to extend their circle from species with
164 whom they are used to or with whom it is easier to communicate, such as apes, monkeys,
165 parrots, or cetaceans, as some other species are surely able to understand their intentions as
166 behavioral or even neuroscientific experiments, particularly in rats and mice being the most
167 used animals in laboratories but having a sense of empathy (Ben-Ami Bartal et al., 2011;
168 Klein & Gogolla, 2021; Venniro & Golden, 2020) and feeling human intention (i.e. the
169 Pygmalion effect – Good et al., 2018). Even species phylogenetically distant from humans,
170 such as cephalopods, show evidence of complex cognition but more research is needed to
171 understand their sense of self (Birch et al., 2020; Schnell, Amodio, Boeckle, & Clayton, 2021;
172 Schnell & Clayton, 2019). Now, the cognitive abilities of many species are not recognized for
173 their true value, whereas accepting their abilities to interact with researchers and
174 understand their will could advance our understanding of mind evolution. For instance,
175 applying the same agency and research protocols in horses as it was done in primates led to
176 advances in equine cognition and comparative cognition (Matsuzawa, 2017). The first study
177 on horses using computer touch panels was realized recently in 2015 (Tomonaga et al.,
178 2015). When researchers allow too little room for the animals' own forms of agency, the
179 true abilities of these individuals are obscured (McFarland & Hediger, 2009).

180 Blattner et al. (2020) analyzed in their paper what freedoms of actions may result in the
181 expression of agency in animals as well as how humans take up these freedoms. Their
182 observational analysis coming from multispecies ethnography and based on a number of

183 methodological and ethical questions on animal-human and animal-animal relationships led
184 them to divide animal agency into four schemes (Figure 1):

185 *1. Agency through space and time:*

186 Animals are mobile and explore/exploit their environments. This exploration and
187 exploitation can be used to better understand the behaviors of animals but also their
188 preferences in terms of habitats, sleeping areas, and social relationships and conduct to new
189 disciplines as animal geographies (Buller, 2014) or animal mobilities (Hodgetts & Lorimer,
190 2020). Whilst this form of agency seems obvious to many researchers and the criteria are
191 often applied to livestock and farmed animals (Bouissou, Boissy, Le Neindre, & Veissier,
192 2001; Scanes, 2018; Sosa et al., 2019), it is rarely applied in comparative psychology or
193 neuroscience. Specifically, modifications of the environment can be used to shape animal
194 decisions and can remove some of the negative reinforcement that is still applied to animals.
195 Animals could experience less stress in some parts of their environment than others, and
196 carrying out experiments in these places could increase their motivation to participate and
197 decrease the risk of false negatives (Coe & Hoy, 2020; Matsuzawa, 2020a). Of course, this
198 statement implies that the housing of animals should be redesigned in some manner. Size
199 and enrichment of cages of lab-rodents for instance are often insufficient, leading to high
200 mortality and high morbidity (Cait, Cait, Scott, Winder, & Mason, 2022). A consortium of
201 researchers called for including social housing information in biomedical research as the
202 social setting of subjects influenced results in biomedical research (Pomerantz et al., 2022).
203 Boundaries and fences cannot be only considered as barriers and limitations of freedoms but
204 also as security and communication touchstones as suggested by Blattner et al. (2020).
205 Humans should create barriers and fence placements according to the behavior of animals.
206 Similarly, for behavioral experiment apparatus, animals should not be forcibly brought to
207 where researchers want to test them but researchers should observe animals in the best
208 position to settle the devices. For approximately ten years, urban design is thought to be
209 adapted to human behavior in order to increase health, decrease stress, and the costs of
210 urban refurbishment (Park & Evans, 2016; Pereira, Nogueira, & Padez, 2019). A similar way
211 of thinking could be applied to animals. More and more in “modern” zoos animals of
212 different species begin to be mixed in larger enclosures, with still the possibility for each
213 species to be isolated from other animals. This is a way to apply the concept of nudge

214 (Thaler, 2008) to captive animals studies, as has already been done for species conservation
215 (Czap, Czap, Lynne, & Burbach, 2015; Eberle, 2021; Reddy et al., 2017). The Primate
216 Research Institute (Kyoto University) applied this concept with the WISH cages, a set of
217 enclosures connecting habitats and also equipped with a computer-controlled touch panel
218 system for cognitive tests. This framework increases the fission-fusion dynamics of
219 chimpanzees, i.e. their social agency, and their cognitive agency (Matsuzawa, 2020a).

220 *2. Agency through practice and routine:*

221 Animals have habits, even in the wild. Social animals collectively organize their day in order
222 to meet their requirements and maintain the advantages of living in groups (Sueur, 2011).
223 Rather than forcing animals to participate in experiments, accepting that animals can accept
224 or refuse to participate according to their routine would increase the robustness and
225 viability of the results. Any animal that wants to be tested seeks to use tablets or other
226 interactive apparatus, such as artificial fruits (Whiten, Custance, Gomez, Teixidor, & Bard,
227 1996) or opening boxes with food inside (Aplin et al., 2015), that are based on technologies
228 like RFID (Radio Frequency IDentification) (Claidière, Gullstrand, Latouche, & Fagot, 2017;
229 Matsuzawa, 2013); these tools respect their habits and routines as animals are allowed to
230 come and to stay to do the tests at the time they want and for the duration they want.
231 Medical aspects, such as health checks or medical procedures that require restraints, should
232 also be based on these routines in order to decrease animal stress and injuries, as already
233 shown in their use by zoos (e.g., the Great Ape Heart Project, Murphy et al., 2018). Whilst
234 experimentalists working with primates already invoke a form of consent to work with
235 animals (Fenton, 2014), this protocol could be applied to many other species, such as
236 rodents. To our knowledge, there are no testing devices that can be used in the cages of rats
237 with which they can play when they want and for the duration they want. This kind of
238 system should be extended to all species involved in behavioral neuroscience. Routines for
239 social animals are a well-known process where social and dominance relationships can be
240 observed in instances, such as when a group is exiting its night enclosure or going back to it
241 at the end of the day (Grasso, De Rosa, Napolitano, Di Francia, & Bordi, 2007; Reinhardt,
242 1964, 1992). Knowing this routine or observing why the routine of an animal is different
243 from others or for a day allows us to better understand their behavior without the need to
244 disturb them by subjecting them to experiments or health checks. Moreover, modifying the

245 routines of animals is a way to measure their behavioral flexibility, personality, and group
246 cohesiveness.

247 *3. Agency through social roles:*

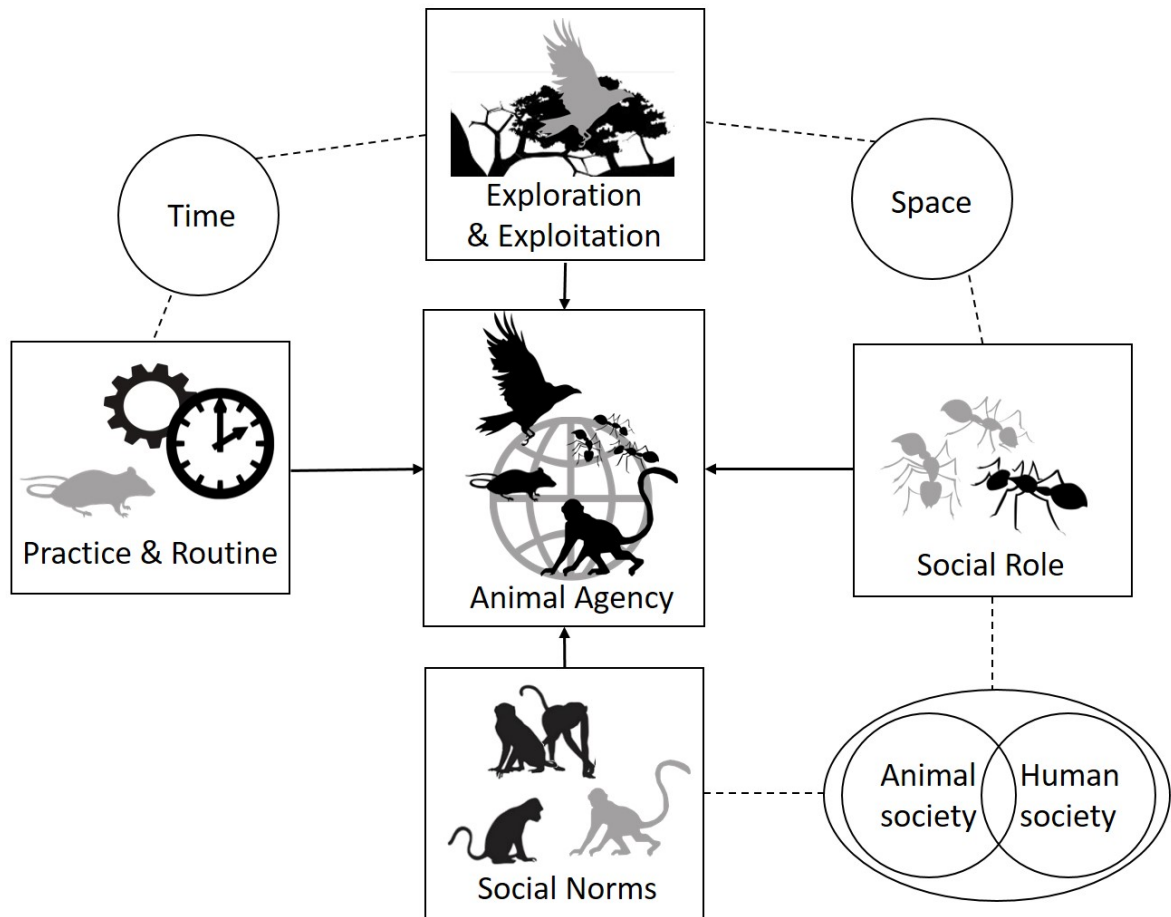
248 A social role is the behavior expected of an individual who occupies a given social position or
249 status. Individuals understand the place that conspecifics hold in their society (Borgeaud,
250 Sosa, Bshary, Sueur, & van de Waal, 2016; Levé, Sueur, Petit, Matsuzawa, & Hirata, 2016).
251 The adoption of roles that are recognized and acknowledged by others, and indeed mutually
252 constructed with conspecifics, is an important dimension of relational agency and a means
253 by which researchers can effectively affirm their subjective existence within a community.
254 This role can be intraspecific or interspecific. Roles of individuals inside their group have
255 been amply described in terms of dominance (policing behaviors, protecting groups),
256 kinship, and maternal relationships (Krause & Ruxton, 2002). Individuals also develop strong
257 relationships when they share similar attributes, such as sex or age (Abeyesinghe, Drewe,
258 Asher, Wathes, & Collins, 2013; Massen & Koski, 2014; Rault, 2012; Silk, 2002; Tsuji,
259 Shimoda-Ishiguro, Ohnishi, & Takatsuki, 2007). Knowing the relationships of individuals is
260 important to researchers when transferring animals, rehabilitating lab subjects, or forming a
261 new group. Pairs of affiliated animals have to be managed until observing stability in terms
262 of a few agonistic events and low stress. Moreover, when doing tests, researchers also know
263 which pairs of individuals can easily be tested together or not. Group members influence
264 each other, and share knowledge (Duboscq, Romano, MacIntosh, & Sueur, 2016). Dominant
265 or old individuals can transmit important information to others (Grampp, Sueur, van de
266 Waal, & Botting, 2019), and this social transmission can be used to make animals learn how
267 to use experimental apparatus or spaces (Biro, Sousa, & Matsuzawa, 2006; Whiten, 2011).
268 This biased attention of group members towards dominant or older individuals (Grampp et
269 al., 2019) might be used by researchers to make animals more rapidly and more efficiently
270 learn a new behavior. These individuals can consequently become leaders and by influencing
271 these leaders, through which researchers can manage the movements of an entire group
272 (Ramos et al., 2018, 2021). Multispecific and positive interactions or associations are also
273 found naturally in the wild in situations, such as multispecies group protection, interspecies
274 grooming, and predator alerts (Buchanan-Smith, Griciute, Daoudi, Leonardi, & Whiten, 2013;
275 Fitzgibbon, 1990; Goodale & Kotagama, 2005; Koda, 2012; Krebs, 1973; Pearson, Davis, &

276 Litchfield, 2010; Peres, 1993; Stensland, Angerbjörn, & Berggren, 2003), even if negative
277 interactions (cheating, predating, competition) are also observed. Blattner et al. (2020)
278 described multispecies interactions in the sanctuary for formerly farmed animals. Individuals
279 of specific species adopt different roles with geese, cows, or dogs acting as guardians and
280 policers, cows teaching sheep, and multispecies friendship and parenting. Multispecific
281 leadership is also described in different reports with geese leading ducks and chickens, and
282 goats leading sheep (Baratay, 2011, 2017; Baratay, 2012). Parenting or adopting an orphan is
283 also a role that some animals can manage, either in an intra- or inter-species context (Pelé &
284 Petit, 2015).

285 *4. Agency through social norms:*

286 Social norms are the customary rules that govern behavior in groups and societies (Bicchieri
287 & Muldoon, 2011). The previous example of learners and teachers brings us to the subject of
288 social norms. Behavioral rules and social systems are partly genetic in animals but are also
289 transmitted by cultures (Brent et al., 2013; Krause & Ruxton, 2002; Sinha, 2005; Sueur, 2015;
290 Ward & Webster, 2016). Many traditions of tool use and social habits have been described in
291 chimpanzees or macaques (Laland & Hoppitt, 2003). There is a debate as to whether animals
292 have social norms, and in this debate, Bicchieri (2016) is taken to require theory of mind for
293 social norms, which some think is too demanding to permit animal social norms (Schlingloff
294 & Moore, 2018). Other theorists (Andrews, 2020a; Fitzpatrick, 2020) have argued that some
295 animals do have social norms. On no account of social norms are cultural traditions sufficient
296 for norms, because social norms are thought by all theorists to require a social maintenance
297 constraint, such that other group members care whether an individual follows the pattern or
298 not. This might be the case in animal collective decisions (Sueur, Bousquet, Espinosa, &
299 Deneubourg, 2021). Although collective decision processes are species-specific, variations
300 are observed between groups and individuals of the same species. The roles played by
301 individuals can lead to a strong leadership or the development of a more democratic
302 process, such as voting (King & Sueur, 2011). Voting systems (Pennisi & Giallongo, 2018), are
303 described in many species, with intentional behaviors and perceptions of the mental states
304 of conspecifics indicating some theory of mind and reinforcing the idea of agency. A sense of
305 community (Blattner et al., 2020) seems to exist in chimpanzees and cetaceans, and indeed
306 many other animals know exactly who belongs or does not belong to their group by

307 recognizing the faces or voices of group members. Interestingly, even in primate species,
 308 olfactory cues about various physiological factors, for instance, parasite load, exist and
 309 influence social relationships and grooming rate (Poirotte et al., 2017; Romano, MacIntosh,
 310 & Sueur, 2020).



311
 312 Figure 1: The four schemes of animal agency (squares) and the environmental factors
 313 affecting them (circles)

314
 315 These different instances show that animals have agency over their spatial, temporal, and
 316 social environment. Animals can therefore be viewed as *agents*; their choice to act has direct
 317 consequences on their environment, or they can also resist conditions that do not please
 318 them and act accordingly to change them (Carter & Charles, 2013). The behavior that
 319 animals show, the facial expressions they display, and the places they occupy are cues to
 320 indicate their willingness. Researchers could use this agency to increase animal welfare and
 321 obtain more viable and robust results whilst extending the scope of behavioral and

322 neuroscience research. Indeed, the great difficulty today is to measure the behaviors or the
323 neuronal activities of sentient animals whilst seeking to do so in natural conditions: the
324 results of many experiments have been criticized, as the associated captivity, animal
325 microbiota, and genetic or behavioral variance of animals has made it impossible to allow
326 reproducing or generalizing any results that were unaffected by false negatives or false
327 positives (Barbee & Turner, 2019; Rader, 2004; Voelkl et al., 2020). Often, in the research
328 process, many of the limitations shown by the animals to date are actually the limitations of
329 the scientific methods, rather than the animals themselves (Savage-Rumbaugh, Rumbaugh,
330 & Fields, 2006). Similarly, De Waal (2006) argues: 'All that most experiments have done thus
331 far is testing the ape's theory of the human mind. We would do better to focus on the ape's
332 theory of the ape mind', (p. 70). Following the concept of animal agency, this paper proposes
333 a future research framework to work with animals and progress in research.

334 **Future research framework**

335 Some years ago, applying the use of touchscreens in macaques, or studying mouse
336 personality was almost unimaginable in neuroscience. Yet today, these projects have
337 become reality. Touchscreens or joysticks are used to understand cognition and self-agency
338 (Kaneko & Tomonaga, 2011) in a wide range of species (pigs, macaques, baboons,
339 marmosets, goats, horses, rats, mice, etc.) (Belsey, Nicholas, and Yttri (2020); Calapai,
340 Cabrera-Moreno, Moser, and Jeschke (2022); Claidière et al. (2017); Croney and Boysen
341 (2021); Jacobson, Kwiatt, Ross, and Cronin (2019); Tomonaga et al. (2015); Washburn, Rulon,
342 and Gullledge (2004); Yang et al. (2022); Zeagler, Gilliland, Freil, Starner, and Jackson (2014)).
343 However, this use is still limited given its potential even though more and more
344 neuroscience studies have been using it in mice or rats (Bussey et al., 1997, 2008; Delotterie
345 et al., 2015; Slutzky, Jordan, Bauman, & Miller, 2010). So, touchscreens and joystick
346 apparatuses promote animal agency, even though it is in a limited artificial environment.
347 Testing these same species in more natural and more complex captive habitats or even in
348 the wild could enhance the possibility of them expressing their agency. Other factors
349 influence this agency: there is a substantial amount of literature describing how animal
350 personality and microbiota can influence results (Bergvall, Schäpers, Kjellander, & Weiss,
351 2011; Bousquet, Petit, Arrivé, Robin, & Sueur, 2015; Brosnan et al., 2015; Carere & Locurto,
352 2011; Davidson, Raulo, & Knowles, 2020; Dougherty & Guillette, 2018; Galland, 2014; Griffin,

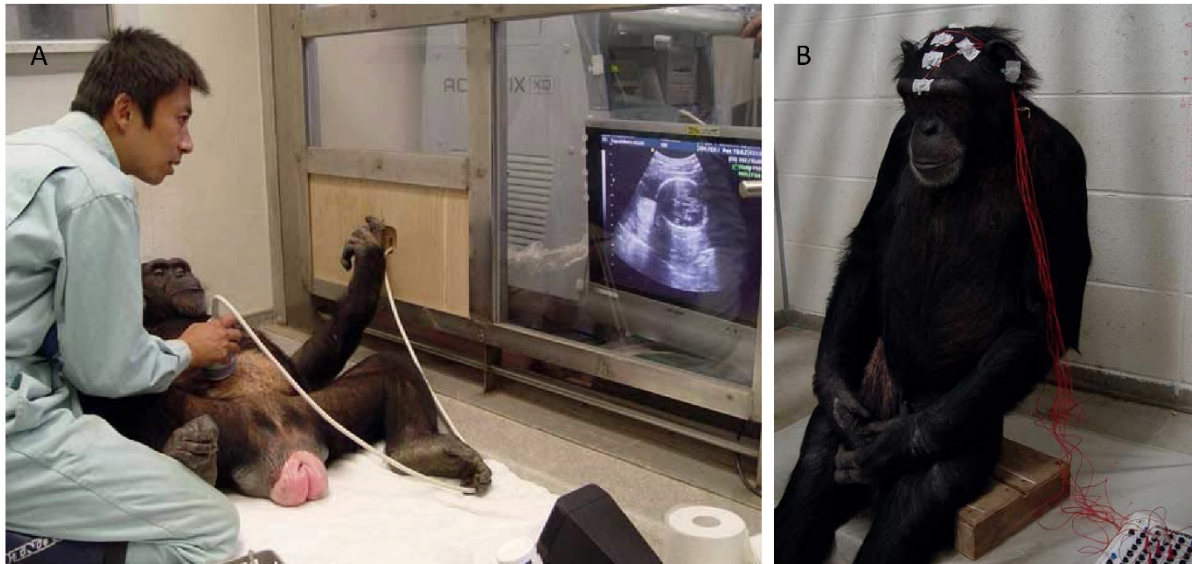
353 Guillette, & Healy, 2015; Kirchoff, Udell, & Sharpton, 2019; Montiel-Castro, González-
354 Cervantes, Bravo-Ruiseco, & Pacheco-López, 2013; Robinson & Cameron, 2020). This success
355 demonstrates the importance of not limiting scientific imagination about how researchers
356 could work with animals to obtain new results in biological sciences. Animals may show
357 imagination and pretense (Matsuzawa, 2020b; Mitchell, 2007; Picciuto & Carruthers, 2016),
358 which are important for agency, but researchers have to give animals the possibility to
359 express their agency with adequate testing conditions.

360 First, researchers need to change their way of thinking to a perspective of working *with*
361 animals rather than *on* animals. Animals are agents endowed with intentions that transcend
362 traditional subject-object relations. Researchers need to trust their capabilities (Nielsen,
363 2018; Nielsen, 2020) in order to increase research possibilities. Experimental setups, such as
364 restraint chairs or food privation, cause stress to animals and prevent them (both physically
365 and mentally) from fully expressing their agency. This challenge may certainly take time but
366 would be hugely beneficial. Patter and Blattner (Van Patter & Blattner, 2020) suggest core
367 principles to follow with animals: non-maleficence, beneficence, and voluntary participation
368 (Webb, Woodford, & Huchard, 2019). Positive methods exist and have proved to be efficient
369 (Laule, Bloomsmith, & Schapiro, 2003; Prescott et al., 2010; Prescott, 2016; Prescott &
370 Buchanan-Smith, 2003; Prescott & Buchanan-Smith, 2007; Schapiro, Bloomsmith, & Laule,
371 2003). The readiness of chimpanzees (which are no longer used for invasive experiments –
372 Matsuzawa, 2016b) to voluntarily participate in interactions or allow humans to observe
373 them can facilitate the measurement of embryo development and brain activities in
374 unanesthetized and unrestrained individuals (Figure 2 - Matsuzawa (2013); Sakai et al. (2011,
375 2012); Ueno et al. 2010). Unrestrained or minimally restrained and voluntary animals can be
376 trained to put their head in a mask (Slater et al., 2016) and be tested whilst receiving fruit
377 juice. This allows the measurement of different metrics with eye tracking (apes: Kano &
378 Tomonaga, 2009; Krupenye et al., 2016; monkeys: Machado and Nelson (2011); Ryan et al.
379 2019) and non-invasive neuroimaging (Basso et al., 2021) (Figure 3.A). Basso et al. (2021)
380 report the non-invasive neuroimaging from anesthetized monkeys and restrictions were
381 required for the neuroimaging of awake monkeys. Moreover, magnetic resonance imaging
382 (MRI) requires the restraining of the subject during the scan. However, neuroimaging studies

383 in dogs showed that they can be trained to remain still during fMRIs without any restriction.
384 Surely, this cooperation can be done in other species.

385

386

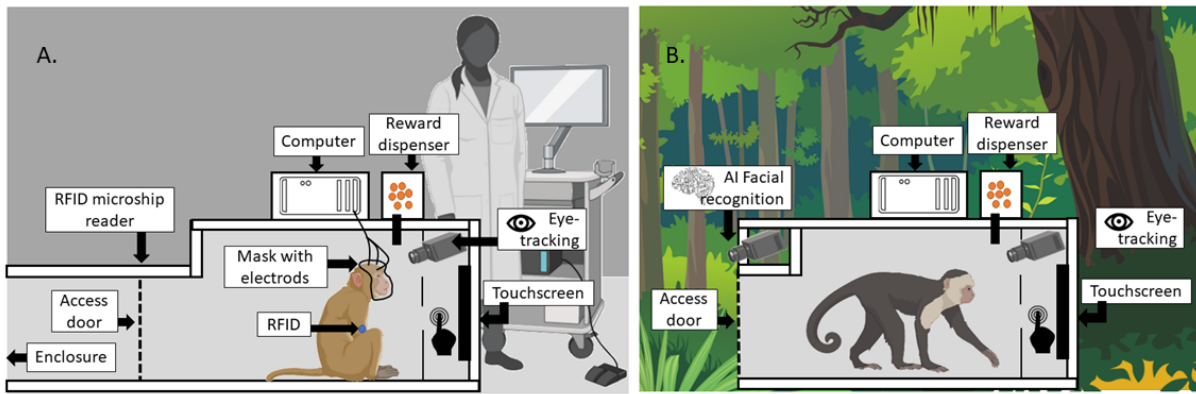


387
388 Figure 2: (A) Developmental neuroscience. Fetal brain development in chimpanzees was
389 measured by a non-invasive ultrasound technique. (B) EEG recordings in a chimpanzee. The
390 chimpanzee quietly sat on the chair and allowed the experimenter to put electrode patches
391 on the skin of her forehead and the top of her head. Photos provided courtesy of Satoshi
392 Hirata.

393

394 Some traditional approaches involve bringing animals into a lab and restraining them while
395 they perform tasks in order to ensure stable gaze-tracking and neural recordings. However,
396 this unnatural setting does not permit the study of brain activity during natural, social, and
397 complex behaviors. Different studies highlight the importance of studying animals in the wild
398 instead of in the laboratory (Cauchoix, Hermer, Chaine, & Morand-Ferron, 2017; Janmaat,
399 2019; Kumpan, Smeltzer, & Teichroeb, 2020; Verhaeghen, Martin, & Sędek, 2012) not
400 bringing different results but more interpretable ones. Specific ethical guidelines exist now
401 for research in the wild (Costello et al., 2016; Soulsbury et al., 2020). The likely benefits and
402 possible negative effects of researchers' presence and field methods on study subjects, their
403 environment, and the local human community should, of course, be considered (MacKinnon

404 & Riley, 2010). New technologies allow us to bring science into the wild and test
405 unrestrained animals in their natural environment, thus removing any experimental source
406 of stress (as they would come by themselves to be tested) and measuring their entire
407 behavioral repertoire. This allows the study of behavioral responses and brain activity during
408 natural, social, and complex behaviors. This field works are possible in many species
409 including rodents (Evans, Liechti, Boatman, & König, 2020; Lopes & König, 2020; Raulo et al.,
410 2021). The animals studied can be identified using RFID techniques (Fehlmann & King, 2016)
411 but also via artificial intelligence with the recognition of individuals by video tracking
412 (Ferreira et al., 2020; Poirotte & Charpentier, 2020; Schofield et al., 2019). The latter
413 removes the need to capture animals. A location can then be defined where different
414 touchscreens deliver food, with activation only for certain species and individuals.
415 Researchers can imagine going beyond the use of touchscreens with the implementation of
416 eye-tracking and neuroimaging apparatus in the wild (Figure 3B). This could open up new
417 research avenues in species that are in danger of extinction or cannot be easily maintained
418 in captivity. Some automatic devices already exist to make some playback experiments as
419 BoomBox: An Automated Behavioral Response (ABR) camera trap module for wildlife
420 experiments (Palmer et al., 2022). Artificial fruit or tool boxes exist in the field (van de Waal,
421 Borgeaud, & Whiten, 2013) and robots are increasingly used with wild animals (Grémillet,
422 Puech, Garçon, Boulinier, & Maho, 2012; Le Maho et al., 2014). Indeed, it is hard to imagine
423 a wild primate entering a closed box, but once habituated to the box, animals may be
424 vulnerable to poaching or capture. However, research possibilities in this domain are huge,
425 and we need to judge how best to build some of these systems while avoiding the potential
426 drawbacks, while ensuring the health and security of studied animals. Training procedures
427 should be devised to encourage animals into entering such boxes. Once one animal becomes
428 accustomed to it, social learning should make encourage other animals to enter these boxes
429 (Duboscq et al., 2016; Hoppitt & Laland, 2013). As Schaefer and Claridge-Chang (2012)
430 wrote, 'the new automation is not just faster: it is also allowing new kinds of experiments,
431 many of which erase the boundaries of the traditional neuroscience disciplines (psychology,
432 ethology, and physiology) while producing insight into problems that were otherwise
433 opaque' (p. 170).



434

435 Figure 3: (A) Non-invasive neuroimaging and eye-tracking system with voluntary experience
 436 in the lab. (B) Non-invasive touchscreen system with voluntary engagement and individual
 437 identification in the wild. In setup A, the subject would show better agency than if it was
 438 restrained in a chair. However, the same subject in setup B would show greater agency than
 439 in setup A, as it is free to express its entire behavioral repertoire in natural and wild
 440 conditions. This figure was realized using FAVPNG.com and Biorender.

441

442 Some studies, especially in the biomedical or physiological/cellular domains, cannot be
 443 performed outside the laboratory. It is important for these experiments to respect the 3Rs
 444 but also to think about the Bateson cube (Bout, Fentener van Vlissingen, & Karssing, 2014),
 445 meaning that scientists need to evaluate the ethical acceptability of their research for
 446 society as a whole, including animals. The 3Rs can be extended by testing animals in viable
 447 conditions. Overly standardized lab conditions, for instance, decrease the replicability of
 448 studies by decreasing the behavioral variability (this is commonly known as the
 449 standardization fallacy – Voelkl et al., 2021 (Würbel, 2000)). Indeed, lab conditions were
 450 standardized for many years in terms of animal genetics, husbandry, food for study
 451 comparison, and repeatability. However, this way of conducting research is criticized today
 452 as animals are now considered agents interacting with their world, and the lab conditions in
 453 which they live have a strong effect on them, and thus on the scientific results. Moreover, it
 454 is difficult to replicate similar conditions in the laboratory, specifically in comparative
 455 cognition (Boyle, 2021), as even animals that are genetically similar and live in similar
 456 environments develop different personalities (Bierbach, Laskowski, & Wolf, 2017).
 457 Moreover, even if animals are living in similar conditions, similar food and litter sources

458 affect their microbiota (Bradford, Tordoff, Eggers, Jones, & Newington, 2002; McCoy,
459 Geuking, & Ronchi, 2017; Xiang et al., 2019) and their behaviors differently (Montiel-Castro
460 et al., 2013). Animal sociality was long forgotten in neuroscience or biomedical research, but
461 it is an important part of animal agency (Blattner et al., 2020). Indeed, sociality has an
462 important impact on the health of animals, and a large number of publications highlight the
463 link between sociality and health aging (Boyer, Jaouen, Ibrahim, & Gascon, 2019; Lacreuse,
464 Raz, Schmidtke, Hopkins, & Herndon, 2020; Rosati et al., 2020). Making use of the sociality of
465 animals, i.e., their agency, can even reverse cognitive decline and extend longevity (Baker,
466 Wolschin, & Amdam, 2012; Richardson et al., 2020; Wild et al., 2021). Progress has to be
467 made to first avoid the restraining of animals in a captive environment and second, to
468 conduct tests on animals in more natural conditions. Such processes are applied today to not
469 only different primate species (Huebner Franziska et al., 2018; Schofield et al., 2019; van de
470 Waal et al., 2013) but also to horses (Maeda et al., 2021; Maeda et al., 2021; Matsuzawa,
471 2017), birds (Aplin et al., 2015; Shaw, 2017), or even bees (Muth, Cooper, Bonilla, & Leonard,
472 2018). These studies, conducted on different species all showed that testing in the wild is
473 more productive than testing in the labs in terms of ecological and even social cognition
474 (Janmaat, 2019; Pritchard, Hurly, Tello-Ramos, & Healy, 2016). An intermediate method
475 would be research in zoos, as research in zoos in collaboration with research institutes
476 seems to allow animals to express their agency through more adequate living conditions and
477 more technology devices than research in laboratories (McEwen et al., 2022), which may
478 result from the domain of the studies (behavioral versus neuroscience research) and except
479 for great apes research (Matsuzawa, 2016b).

480 **Conclusion**

481 Great efforts have been made toward enabling the agency of animals in behavioral research
482 but there is still much progress to be made to obtain a more compassionate, less stressful,
483 and more robust animal research model. This requires training and teaching researchers,
484 through MOOC (Massive Open Online Course; MacKay et al., 2016; Watson, Kim, & Watson,
485 2016), books (Dawkins, 2021; De Waal, 2016; King, 2021; Nielsen, 2020), or workshops, to
486 adopt new methods including animal agency and change their view of the role animals play
487 in research. As Jacques Derrida wrote in *The Animal That Therefore I Am*, the traditional
488 scientific and philosophical discourse on animals observes and speaks of non-human animals

489 but never really engages with, experiments *with*, or gains experience with the latter
490 (Derrida, 2008): this type of discourse can therefore only position animals as mere passive
491 objects of the theoretical knowledge these disciplines build. Such methods are completely
492 blind to the animals' own processes of interacting with their world (Derrida, 2008), and are
493 completely blind to their agency. Culture, ontology, political leaning, as well as university
494 courses influence how a person considers animals as objects (Bègue & Vezirian, 2021;
495 Furnham & Heyes, 1993; Miele, Tingley, Kimball, & Broida, 1993). It would be interesting to
496 look at the textbooks of comparative cognition to find evidence that students are being
497 taught to think of animals as objects; that is the method (Andrews, 2020b) used to defend
498 the claim that comparative cognition eschews the study of consciousness. This view of
499 animals as objects is not limited to research but is also found in different aspects of everyday
500 life (food, work, clothing, etc.). Researchers worldwide must have the conviction that ethical
501 animal research must consider individuals as subjects of their own lives and of their own
502 world, and as co-creators of knowledge. Co-creation means that animals participate and
503 contribute actively to our experience, their behavior appeals to cognition, and as this animal
504 species-specific cognition being different from the human one, unexpected behavior can
505 raise from experiments. For instance, the slime mold (*Physarum polycephalum*) simulated a
506 more efficient rail network of Tokyo than that which was constructed by humans (Tero et al.,
507 2010). Methods used by ants to find resources are used as an algorithm for the salesman
508 travel problem (Dorigo & Gambardella, 1997a, 1997b). In both illustrations, the organisms
509 are not only an inspiration for researchers to resolve a problem, they resolved it with their
510 own capacities in their own world. In that sense, both can be considered as co-creators of
511 the new knowledge, even if they are not aware of it. After all in humans, though important
512 discoveries have been the fruit of serendipity, it does not mean that they do not have
513 creators. Accepting this paradigm of co-creation of knowledge can create new research
514 questions that are different from those made under an anthropocentric view, as animal
515 consciousness dimensions are different from ours (Birch et al., 2020). Animals are agents in
516 scientific research. They are active in the research process and some researchers have even
517 gone so far as to add them in the acknowledgments or even list them as co-authors (Savage-
518 Rumbaugh, Wamba, Wamba, & Wamba, 2007; Van Patter & Blattner, 2020). This recognition
519 of animals as agents rather than objects is not approved by some researchers, who consider
520 that this is tantamount to removing animal agency, committing over-anthropomorphism,

521 and overstepping the will of animals to cooperate. Indeed, listing someone as a co-author
522 without their consent raises ethical questions (see Bradshaw, 2010; Sueur et al., 2022 for
523 discussion). However, acknowledging animal agency could facilitate social acceptance of
524 animal research (Webb et al., 2019) and be of benefit to the animals concerned (well-being
525 through learning, creating, and participating – Franks et al., 2020). The consideration of
526 animals as agents could be extended from research to other domains: a new ontology
527 considering non-human animals as agents can have political, ethical, and legal
528 consequences. Moreover, accepting and letting animals express their animal agency would
529 increase the validity of experiments but also their ecological validity as agency is also the
530 expression of more natural behavior. It will also make behavioral and neuroscience research
531 more efficient by accelerating data collection in the long term. Of course, at the beginning of
532 this new paradigm of research, understanding and training animals according to their agency
533 will be time-consuming, but when this is done, many more protocols could be carried out
534 and tests would be realized faster and more efficiently by animals. For instance, the use of a
535 touchscreen was initially difficult but after years of labor, conducted tests of new concepts
536 faster than tests without touchscreens in chimpanzees (Gao & Su, 2016; Inoue &
537 Matsuzawa, 2007; Martinet et al., 2021) and macaques (Ballesta et al., 2021; Ferrucci,
538 Nougaret, & Genovesio, 2019; Huskisson, Doelling, Ross, & Hopper, 2021). In the same vein,
539 it took time for naïve capuchin, macaques, and even apes to understand a food for food
540 exchange task (Dufour et al., 2007; Pelé et al., 2009; Pelé et al., 2010; Ramseyer et al., 2006),
541 but once the behavior was acquired, it is easily transmitted from adults to their young (Pelé,
542 personal observation). Considering the agency of the animals we work with is clearly a time
543 investment that ultimately pays off for more time-efficient data collection in the long term,
544 this time investment in animal agency should be highlighted and recognized as promoting
545 the animal welfare when readying a proposal for financial support (in the same way as for
546 rehoming lab animals for instance). Thereafter, the concept of capital applied to animals
547 needs to be extended to social capital, ecological capital, and cultural capital (Pelé, Georges,
548 Matsuzawa, & Sueur, 2020): citizens and not only researchers can learn from animals, and
549 animals can be part of human societies (Dakouré, Pelé, & Georges, 2022; Donaldson &
550 Kymlicka, 2011). This new way of viewing animal agency can therefore raise critical ethical
551 questions in regard to the treatment of animals in research and to the place humans grant
552 them politically in the human social world.

553

554 **Author Contributions Statement**

555 Conceptualization: CS and MP; Project administration: CS and MP; Writing original draft: CS;
556 Review and editions: all authors.

557

558 **Acknowledgments**

559 We thank the three reviewers who accepted to revise our manuscript for their helpful
560 comments.

561

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