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**Title**

**Competition is crucial for social comparison processes in long-tailed macaques**

*Stefanie Keupp<sup>\*1,6</sup>, Rowan Titchener<sup>1</sup>, Thomas Bugnyar<sup>2</sup>, Thomas Mussweiler<sup>3,4</sup>, Julia Fischer<sup>1,5,6</sup>*

\* corresponding author

<sup>1</sup> German Primate Center, Cognitive Ethology Laboratory, Kellnerweg 4, 37077 Göttingen, Germany

<sup>2</sup> Department of Cognitive Biology, University of Vienna, Althanstrasse 14, 1090 Wien, Austria

<sup>3</sup> Social Cognition Center Cologne, University of Cologne, Richard-Strauss-Str. 2, 50931 Cologne, Germany

<sup>4</sup> London Business School, London, United Kingdom

<sup>5</sup> Georg-August-University Göttingen, Göttingen, Germany

<sup>6</sup> Leibniz ScienceCampus 'Primate Cognition', Göttingen, Germany

Corresponding author details:

Email: [skeupp@dpz.eu](mailto:skeupp@dpz.eu)

ORCID: 0000-0002-5451-4256

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### Abstract

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Humans modulate their self-evaluations and behaviour as a function of conspecific presence and performance. In this study we tested for the presence of human-like social comparison effects in long-tailed macaques (*Macaca fascicularis*). The monkeys' task was to extract food from an apparatus by pulling drawers within reach and we measured latency between drawer-pulls. Subjects either worked on the task with a partner who could access the apparatus from an adjacent cage, worked in the absence of a conspecific but with food moving towards the partner's side or worked next to a partner who was denied apparatus access. We further manipulated partner performance and competitiveness of the setup. We found no indication that long-tailed macaques compare their performance to the performance of conspecifics. They were not affected by the mere presence of the partner but they paid close attention to the partner's actions when they were consequential for food availability. If social comparison processes are present in long-tailed macaques, the present study suggests they may only manifest in situations involving direct competition and would thus be different from social comparisons in humans, which manifest also in the absence of direct competition, for example in evaluative contexts.

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Keywords: nonhuman primates, social comparison, co-action

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## Introduction

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Human sensitivity to conspecifics results in sophisticated social comparison processes, where humans modulate their behaviour in response to people in their surroundings (1-4). Social comparison is the utilization of conspecifics as comparison standards in order to ascertain how one fares along a particular dimension. A number of studies have shown that humans modulate their behaviour as a function of others' presence and performance (3). In humans, social comparison is thought to be employed primarily for the purpose of self-evaluation and social comparison processes play a role in group formation and contribute to the gregarious nature of humans (2, 5). If this is the case, might a precursor to the social comparison process exist in gregarious animals which form socially complex groups?

Observational and experimental studies document various degrees of sensitivity to conspecific presence and performance in the wider animal kingdom. Several animal species are thought to assess conspecifics along fighting ability related dimensions. For example, roaring displays in stags present a chance for males to assess opponent strength – to assess whether escalation is advisable (6). Chimpanzees are able to assess the relative difference in group size between their own and neighboring rival parties and use this information to decide whether to retreat or attack (7). In addition, experimental studies on inequity aversion (8, 9) indicate that some species are sensitive to working effort and reward granted a conspecific relative to the self. Social comparisons with group members might also be useful to decide how to choose good or fair interaction partners in future encounters (see (10)). This said, the systematic study of human-like social comparison effects is a relatively new topic in animal cognition research (11, 12).

The current study was inspired by an experiment by Seta (13) in which human participants performed a simple manual task – pressing a sequence of buttons with four fingers. The task was carried out in the presence of a co-actor independently engaged in the same task. Acoustic feedback provided participants with information about the other person's performance. As the tasks were identical subjects could attribute any apparent difference in co-actor performance to differing ability level. The experimenter manipulated the feedback such that co-actors appeared to be performing better, worse or equally well compared to the participant. Seta found that when paired with a slightly better performing partner, i.e. a performance that was within the capability of the participant, participants' performance increased compared to when working alone. Previous findings from a study which applied the co-action paradigm to long-tailed macaques (*Macaca fascicularis*) indicated that a certain level of competition might be necessary to draw subjects' attention to relevant aspects of the partner's behaviour and that simply working in parallel on two touchscreens is not sufficiently relevant for catching the monkeys' attention (12; Keupp et al., in preparation).

71 In the current study, we presented our monkeys with a hands-on task in which food items had to be  
72 extracted from an apparatus that could be accessed from two sides. We aimed to test whether long-  
73 tailed macaques are sensitive to a conspecific's task performance. Importantly, our definition of social  
74 comparison thus concerns whether someone performs similar/different than oneself rather than  
75 comparison of different pay-offs or experimenter treatment. To this end, we tested a group of  
76 monkeys in a co-action task where there was either direct food competition or no element of  
77 competition. We manipulated the designated partner's performance by changing the effort he had to  
78 apply to perform the task. In addition, we presented the monkeys with a social control condition in  
79 which the partner was present but not working at the task and a ghost control condition in which no  
80 partner was present but parts of the apparatus appeared to move on their own. Our specific questions  
81 were: (i) Do monkeys compare themselves to others and adapt their performance to the performance  
82 level of a co-actor? And (ii) Is performance change due to social presence of conspecifics or due to  
83 food disappearing from the monkey's reach? Reaction to the manipulation of partner performance in  
84 the co-action context would be an indication for presence of classical social comparison processes. In  
85 contrast, the competition context should result in fast reaction times irrespective of partner  
86 performance. Furthermore, if disappearing food from subject's reach is the driving factor we expect  
87 shorter latencies in competition ghost control compared to competition social control, co-action ghost  
88 control and co-action social control. If social presence is the driving factor we expect shorter latencies  
89 in social control compared to ghost control conditions.

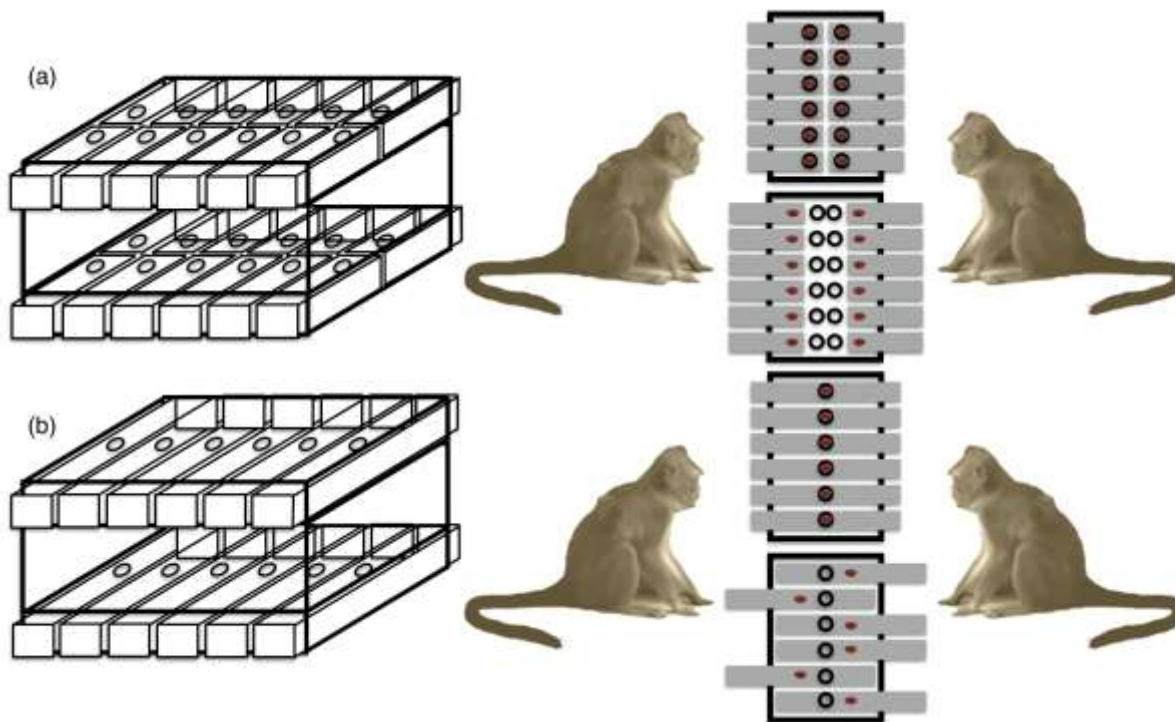
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## Methods

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93 We tested 10 long-tailed macaques (*Macaca fascicularis*) who were housed in a social group of 36  
94 individuals at the German Primate Center (more details on subjects, procedure, and analysis are  
95 provided in the electronic supplementary material [ESM]). After familiarization with the setup,  
96 subjects were tested in all test conditions in a within-subject design (order of condition  
97 counterbalanced across subjects). Subjects were tested with two versions of "Drawer" apparatus (see  
98 Figure 1) resulting in two contexts: competition (CO) and co-action (CoA). The task was to pull open  
99 drawers and extract food from the apparatus. During the test conditions, subjects were either paired  
100 with a partner who was working on the apparatus from an adjacent cage, or they worked alone while  
101 the partner's access was blocked (social control condition), or worked alone with no partner present  
102 but parts of the apparatus moved toward the partner's side (ghost control condition). We additionally  
103 manipulated speed of partner pulling by attaching weights to drawers such that for half of the social  
104 trials the partner was slowed down.

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**Figure 1** Schematic depiction of drawer-sets. (a) Co-Action (b) Competition. Left column shows a side-angled 3-D view of both levels of drawers, right column shows a bird-eye view of starting position and position of drawers after having been pulled towards each side. The drawers were baited via a small opening (white circles) in the transparent ceilings covering each drawer level; raisins (brown oval symbols) were retrievable when drawers had been pulled to the respective side.

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108 We coded latencies between drawer pulls to assess if subjects' behaviour changed as a function of

109 condition. We used Linear Mixed Models (14) to analyze the data. As the effect of the weight

110 manipulation diminished during the study, we included the partners' actual pulling latencies in each

111 trial as predictor in the model, instead of weight condition (see ESM). We first tested if partner ID and

112 performance had an effect on subject performance (full model included partner performance and

113 partner ID as fixed predictors of interest and trial number as fixed control predictor). We then tested

114 for the effect of disappearing food and social presence (full model included condition [ghost, social

115 control, co-action/competition] as fixed predictor variable and trial number as fixed control predictor).

116 In a separate analysis we compared test conditions to a baseline condition where subjects worked in

117 the absence of a next-door partner. We analyzed the data separately for CoA and CO setup.

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## Results

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121 *Effect of partner performance and partner identity*

122 We tested if partner performance and partner identity affected subjects' behaviour. Model  
123 comparisons revealed no such effect for either of the two setup conditions (co-action:  $\chi^2 = 3.36$ ,  $df =$   
124  $2$ ,  $p = .19$ ; competition:  $\chi^2 = 4.43$ ,  $df = 2$ ,  $p = .11$ ).

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### 126 *Effect of disappearing food and social presence*

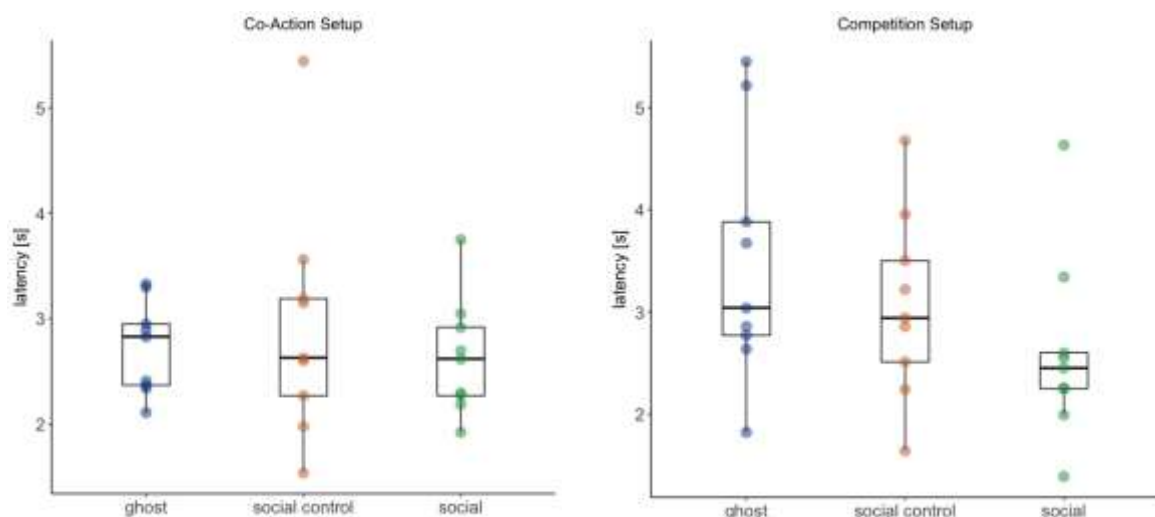
#### 127 **Co-action**

128 Figure 2 provides an overview of mean drawer pull latencies per condition. We compared co-action,  
129 ghost, and social control condition to test for the influence of social presence of a partner and of food  
130 disappearing from subject's reach. The full and null model were not different, indicating that for co-  
131 action setup neither factor had a systematic influence on subjects' pull latencies ( $\chi^2 = 4.1$ ,  $df = 2$ ,  $p =$   
132  $.13$ ).

#### 133 **Competition**

134 Figure 2 gives an overview of mean drawer pull latencies per condition. Model comparison revealed  
135 the full model was significantly different from the null model ( $\chi^2 = 12.05$ ,  $df = 2$ ,  $p < .01$ , *conditional*  $R^2$   
136  $= 0.47$ ). The negative coefficient of the trial estimate indicates that response latencies decreased with  
137 increasing trial number (see Table 1 for detailed summary of the full model). Pairwise comparisons  
138 (Table 2) revealed a significant difference between competition and social control condition (latencies  
139 in competition condition  $<$  social control) and between competition and ghost condition (latencies in  
140 competition condition  $<$  ghost control).

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**Figure 2** Average latencies between pulls for each individual in the different test conditions in co-action and competition setups. Black horizontal lines indicate means per condition; vertical lines indicate 95% confidence intervals.

142

Table 1

*Results for individual predictors for pull latency in CO setup*

*(full model: latency ~ condition + trial + (1 + condition + trial || subject ID))*

Term	Estimate	SE	CI <sub>2.5</sub>	CI <sub>97.5</sub>	$\chi^2$	Df	p-value
Intercept	1.050	0.095	0.866	1.226			
Competition <sup>(1)</sup>	-0.225	0.066	-0.352	-0.088	12.05	2	.002
Ghost <sup>(1)</sup>	0.119	0.091	-0.054	0.292			
Trial	-0.081						

<sup>(1)</sup> Condition was dummy coded with social control condition as the reference category. The indicated test refers to the overall effect of condition

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Table 2

*95 % family wise confidence intervals for pairwise multiple comparisons in CO setup*

	Estimate	Lower boundary	Upper boundary
Ghost – Social Control	0.120	-0.094	0.333
Competition – Social Control*	-0.225	-0.378	-0.071
Ghost – Competition*	0.344	0.148	0.540

\* indicates a significant difference between the compared conditions (both  $p < .001$ )

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147 *Comparison to baseline*

148 For co-action, we compared subjects' performance in baseline-social control, baseline-ghost, and  
 149 baseline-co-action conditions. None of the comparisons were significant. For competition, we  
 150 compared subjects' performance in baseline-social control, baseline-ghost, and baseline-competition  
 151 conditions. We found a significant difference only between baseline and competition ( $z = -2.81, p =$   
 152  $0.01$ ).

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**Discussion**

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156 In this study we tested whether monkeys compare themselves to others based on human-like social  
 157 comparison processes. Assimilation of own performance to the performance of a similar comparison  
 158 standard would be an indication of such social comparisons (3, 13, 15, 16). We tested for the role of  
 159 partner performance and competition on monkeys' behaviour in a co-active food extraction task.

160 Our findings do not provide support for the notion that the monkeys' performance was influenced by  
 161 partner performance level. They increased their feeding speed when food disappeared out of reach  
 162 when they competed directly with a conspecific (CO condition). They decreased their feeding speed  
 163 when the food items moved out of reach in the ghost control condition. It seems that disappearing  
 164 food mattered to the subjects, however, the missing effect for social control vs ghost control condition



165 as well as the reversed direction of the effect for ghost (they pulled slower in ghost than competition  
166 condition) indicate that social presence probably also played a role.

167 The monkeys differentiated between the two drawer setups: unlike in the CO setup, in the CoA setup  
168 behaviour did not change according to social presence or moving food items. Comparisons with  
169 baseline revealed that subjects' performance differed significantly from baseline only in the partner  
170 competition but none of the other test conditions. Hence, the monkeys were not affected by the mere  
171 presence of the partner or by mere environmental changes of the test setup (moving drawers in the  
172 co-action condition). They paid close attention to the partner's actions however when they were  
173 consequential for the subject's own food availability. This pattern indicates that competition is crucial  
174 for the monkeys' attention to test partners.

175 At first sight, our results seem to contradict two previous studies reporting social comparisons in  
176 nonhuman primates (11, 12) and previous findings on social facilitation effects in macaques (for an  
177 overview, see (17)). However, such differences might rely on methodological details, including task  
178 type, trial duration, partner orientation and distance, choice of comparison standards, and response  
179 measure. Importantly, the field of comparative social comparison research is still in its infancy and it  
180 is important to explore scope and limits of different approaches. For example, longer exposition to the  
181 comparison standard might be necessary for social comparisons to manifest (13).

182 Another potentially important point is that long-tailed macaques are very despotic and hierarchical  
183 (18) with subordinate individuals normally not feeding from a high-quality food source in such close  
184 proximity to higher ranking individuals. Social tolerance might play an important role for the  
185 occurrence of social comparison effects in co-active tasks. To address this possibility, a systematic  
186 study of several macaque species ranging from highly despotic to very tolerant would be an interesting  
187 and informative project for future research. Unfortunately, our available sample size did not allow us  
188 to additionally test for effects of rank and bond strength between subject-partner dyads or sex-  
189 composition of the dyads. In humans, similarity of self and comparison standard is an important factor  
190 for social comparisons (19, 20). We would thus welcome replications of this study with other  
191 nonhuman primate groups to allow, at some point in the future, a meta-analysis where such additional  
192 factors can be considered.

193 In this study, we adapted the classic study by Seta (13) to a setup which is feasible for testing  
194 nonhuman primates. We found no indication that long-tailed macaques compared and adapted their  
195 performance to the performance-level of conspecifics. Competition was necessary to elicit sufficient  
196 attention to the co-actor, a necessary prerequisite for social comparisons. In contrast, humans also  
197 compare themselves to others in the absence of direct competition, for example in evaluative  
198 situations (which could be considered *indirectly* competitive) or out of social motivations such as

199 conforming to group norms. Whether this divergence between human and nonhuman primates  
200 reflects differences in the engagement of social comparison proper or is merely an effect of differences  
201 in the attention given to conspecifics remains to be tested in future research.

202

203 **Ethics statement**

204 This non-invasive behavioural study was approved by the ethics committee of the Animal Welfare  
205 Body of the German Primate Center (permit number E4-17). As confirmed by the Lower Saxony State  
206 Office for Consumer Protection and Food Safety, these experiments do not constitute a procedure  
207 according to the animal welfare legislation (§7, Abs. 2 TierSchG); therefore a permit was not required  
208 (LAVES Document 33.19-42502-04).

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210 **Data accessibility**

211 Data are available on Dryad (21): <https://datadryad.org/review?doi=doi:10.5061/dryad.47j2q8b>

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213 **Competing interests**

214 The authors have no competing interests.

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218 provided crucial help in training the monkeys to participate.

219

220 **Author contributions**

221 SK designed and coordinated the study, collected and analyzed the data and drafted the manuscript.  
222 RT collected data and contributed to the manuscript. TM and TB contributed to the development of  
223 the research question as well as to the manuscript. JF contributed to study design and substantially  
224 contributed to the manuscript. All authors gave final approval for publication. All authors agree to be  
225 held accountable for the content of this paper.

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