

1 *Short report*

2 **Chimpanzees communicate to coordinate a cultural practice**

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19 **Abstract**

20 Human culture is considered to differ from animal culture due to its interactive nature built  
21 on shared intentionality and cognitive flexibility. Here, we investigated whether chimpanzees  
22 use communication to engage in cultural practices by analyzing grooming handclasp (GHC)  
23 interactions – a socio-cultural behavior requiring coordination. Previous accounts attributed  
24 GHC imitations to behavioral shaping whereby the initiator physically molds the partner’s  
25 arm into the GHC posture. Using frame-by-frame analysis and matched-control methodology,  
26 we find that chimpanzees use gestural communication to initiate GHC, which requires an  
27 active and synchronized response from the partner. This showcases a behavioral expression  
28 of joint commitment to engage in this shared cultural practice. Moreover, we show that GHC  
29 initiators used various initiation strategies, attesting to situation-contingent interactional  
30 flexibility. We conclude chimpanzees can be jointly committed to a cultural practice, which  
31 suggests that culture predicated on shared intentionality and flexible communication may not  
32 be unique to the human species.

### 33 **Introduction**

34 Culture – the inheritance of behavioral phenotypes through social learning (Laland and Janik,  
35 2006) – lies at the heart of the biological success of the human species (Henrich, 2016). It is  
36 thought to qualitatively differ from culture in non-human animals (henceforth ‘animals’) by  
37 its communicative nature reflecting both shared intentionality and cognitive flexibility  
38 (Enfield and Levinson, 2006; Tomasello, 2019). Shared intentionality is present in  
39 collaborative interactions in which participants share psychological states with one another  
40 (Tomasello and Carpenter, 2007). It facilitates mutual engagement and commitment from the  
41 collaborators by synchronizing their attention and attuning their actions into adequate and  
42 complementary action-response sequences. In human culture, two individuals may thus enter  
43 a state of shared commitment to engage in a cultural ritual together (e.g., shaking hands when  
44 meeting each other (Oxlund, 2020)), which allows for the coordination of the required actions  
45 to pursue and complete the shared ritual (Bratman 1992; Enfield and Levinson 2006).

46         According to an influential view in developmental psychology, animals lack the  
47 prerequisites for shared intentionality (Tomasello, 2019; Tomasello et al., 2012; Tomasello  
48 and Carpenter, 2007; Tomasello and Moll, 2010). Series of experiments showed that  
49 chimpanzees (*Pan troglodytes*) are equivalent to humans when it comes to cognitive skills for  
50 dealing with the physical world (e.g., space, causal reasoning), but lag behind substantially in  
51 the social realm (e.g., high-fidelity imitative learning, cooperative communication; Herrmann  
52 et al. 2007; Tomasello and Moll 2010). In turn, it has been suggested that these reduced  
53 socio-cultural capacities preclude chimpanzees from understanding the roles of joint activities  
54 and sharing joint goals, the prerequisites for shared intentionality (see (Tomasello and Moll,  
55 2010)).

56         Recent work, however, has challenged this view and proposed to seek for  
57 evolutionary precursors of human shared intentionality not with experimental designs but

58 within naturally occurring contexts of interacting animals (Genty et al., 2020; Heesen et al.,  
59 2020, 2017). From an interactional perspective, correlates of shared intentionality could  
60 manifest in the establishment of joint attention, joint commitment and joint actions, given  
61 their requisite functions for sharing psychological states (Enfield and Levinson, 2006; Genty  
62 et al., 2020). Bonobos, for example, have been observed to use communication to facilitate  
63 re-engagement of the partner during social games (Pika and Zuberbühler, 2008), and  
64 naturally occurring interactions (Heesen et al., 2020), which attests to their commitment to  
65 joint activities (Genty et al., 2020). Given the interactional nature of human culture (Enfield  
66 and Levinson, 2006; Tomasello, 2019) and the quest for what makes human culture unique  
67 (Boyd et al., 2011; Ramsey, 2013; Richerson and Boyd, 2005), an important outstanding  
68 question is whether great apes similarly display (correlates of) shared intentionality during  
69 the execution of their joint cultural practices.

70         Here, we investigate whether chimpanzees communicate their desire to engage  
71 partners in a joint cultural practice requiring the coordination of actions – the grooming  
72 handclasp (McGrew and Tutin, 1978). The grooming handclasp (henceforth “GHC”) is a  
73 cultural social-grooming variant defined as a symmetrical postural configuration in which  
74 two partners simultaneously extend one of their arms overhead and clasp each other’s  
75 extended hand at the palm, wrist or forearm, while grooming each other with the other arm  
76 (McGrew and Tutin, 1978; Nakamura and Uehara, 2004; van Leeuwen et al., 2012). While  
77 the cultural nature of GHC has been firmly established (McGrew et al., 2001; Nakamura,  
78 2002; van Leeuwen et al., 2017, 2012; Wrangham et al., 2016), little is known about the ways  
79 in which chimpanzees (or bonobos: (Fruth et al., 2006)) coordinate the execution of the GHC,  
80 other than one individual (i.e., the initiator) physically shaping the body of the envisioned  
81 partner into the GHC posture (De Waal and Seres, 1997). To learn more about this  
82 coordination process, we studied the onset of GHCs with frame-by-frame analysis and

83 compared the observed behaviors with matched-control windows (i.e., social grooming  
84 events of the same partners without GHC) (*sensu* De Waal and Yoshihara 1983).  
85 Furthermore, we examined whether chimpanzees initiated GHCs flexibly or in ritualized  
86 sequences to shed light on their interactional versatility. Lastly, we inspected whether  
87 chimpanzees showed signs of determination/goal-directedness to perform this joint action  
88 together with their allocated partner, by identifying the use of persistence and/or elaboration  
89 of initial initiation strategies when the desired response (i.e., the partner's commitment to  
90 GHC) remained absent. In conjunction, these investigations may illuminate if great apes have  
91 the capacity and motivation to engage in socio-cultural practices by means of (correlates of)  
92 shared intentionality.

## 93 **Results**

### 94 ***GHC initiations***

95 We examined GHC initiations in a group of 52 semi-wild chimpanzees (Table S1). To  
96 determine the mechanisms underlying GHC initiation, we investigated the occurrences of ten  
97 selected chimpanzee behaviors (Table S2 and Table S3) in a comparison between *i*) GHC  
98 initiations and initiations of regular grooming bouts, and *ii*) pre-handclasp (PH) periods and  
99 their matched-control (MC) windows (see Methods and Figure 1). Four behaviors (“head  
100 touch”, “nosewipe”, “self-scratch” and “torso”) occurred both during GHC initiations and  
101 initiations of regular grooming bouts (>15% of the bouts; see Table S3), and were thus not  
102 considered unique to GHC initiations. Six behaviors were observed infrequently during  
103 initiations of regular grooming bouts (<15%) and more frequently in the PH compared to the  
104 MC context (Wilcoxon signed-rank: all  $p < 0.04$ , Holm-corrected;  $n_{ph-mc}=94$ ;  $n_{ind}=33$ ; see  
105 Table S4). These behaviors were thus considered specific to GHC initiations. Two of these  
106 behaviors (“elbow hold” and “hand grab”) corresponded to the practice of shaping (De Waal  
107 and Seres 1997; e.g., Video S11), while the remaining behaviors (“elbow touch”, “hand  
108 touch”, “head move”, and “hold”) did not involve any/prolonged physical contact with the  
109 partner. These latter behaviors were considered to be potentially communicative, i.e., in the  
110 form of gestures (Liebal and Call 2012; e.g., Video S12).



111

112 **Figure 1.** GHC bout including the identified pre-handclasp (PH) and matched-control period (MC).

113 The PHs and MCs were chosen to exactly match in terms of individuals, bodily positioning and

114 activities (grooming) in order to identify mechanisms specific to the initiation of GHC.

115

116 Gestures are defined as bodily actions that are mechanically ineffective and recipient-

117 directed, and result in a voluntary response from the recipient (Pika, 2008; Liebal and Call

118 2012). The four potentially communicative GHC-initiation behaviors followed this definition

119 – they were mechanically ineffective bodily actions resulting in voluntary GHC responses.

120 Only for “head move” we could envision partly non-intentional co-variation with other

121 behaviors like changing grooming posture or redirecting attention. “Elbow touch” and “hand

122 touch” involved targeted physical contact from actor to recipient and were thus recipient-

123 directed, and during “hold” and “head move” signalers faced their recipient in 100% of

124 observed instances ( $n=31$  and  $n=18$ , respectively). These gestures were produced flexibly,

125 with 14 of 15 individuals with more than one GHC initiation showing variation in the start

126 behavior (only counting the 6 GHC-specific behaviors determined above) of their initiation

127 sequences (Binomial test:  $p<0.001$ ; also see Figure 2 and associated R-code). The gestures

128 were also produced in a goal-directed way, as indicated by the occurrence of *elaboration* (i.e.,

129 the use of additional behavior: Leavens et al., 2005) in 31% of the cases where an initial

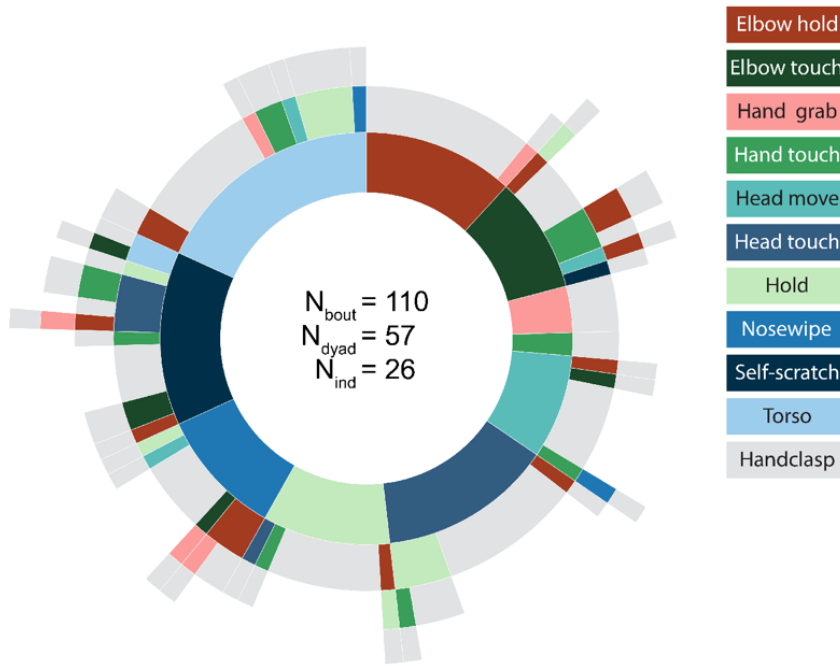
130 gesture failed to initiate a GHC ( $n=10$  out of the 32 instances where gestures were used as an

131 initiation strategy, see Figure 2 and details below). Elaboration occurred after an average

132 response waiting time of 0.5s and took the form of another gesture ( $n=4$ ), a shaping behavior  
133 ( $n=2$ ), or a combination of both another gesture and a shaping behavior ( $n=4$ ) before the  
134 GHC finally commenced. Taken together, these observations show that chimpanzees are  
135 flexibly capable and determined to (re-)transmit their motivation to engage in GHC when  
136 needed.

137         In general, of the 94 PH/MC comparison bouts, 21 (22%) contained either or both  
138 shaping behaviors (“elbow hold”, “hand grab”), 32 (34%) contained one or more of the four  
139 communicative gestures (“elbow touch”, “hand touch”, “hold”, “head move”) and no  
140 shaping, and 41 (44%) contained neither shaping nor potentially communicative behaviors.  
141 We labeled the third type of GHC initiation as “synchronous”, as the individuals appeared to  
142 commit to the GHC near-simultaneously. Moreover, if any behavior was scored during the  
143 PH window in the synchronous GHCs aside from the raising of the arms (which by definition  
144 occurs before every GHC), these were behaviors common to the initiation of regular  
145 grooming bouts (“head touch”, “nosewipe”, “self-scratch”, “torso”, see Table S3).





146

147 **Figure 2\***. Behavioral sequences by the initiator leading to GHC ( $n=110$ ). Starting behaviors are  
148 depicted in the inner colored circle, with the grey outer circle being the endpoint of the sequence (i.e.,  
149 GHC). In order to consider the full flexibility of all types of GHC initiations, we included the four  
150 “synchrony” behaviors that are also common to the initiation of regular grooming bouts (“head  
151 touch”, “nosewipe”, “self-scratch”, and “torso”). \* Interactive version available as Figure S13.

152

## 153 **Discussion**

154 Our findings show that chimpanzees communicate to engage in one of their most enigmatic  
155 socio-cultural practices, the grooming handclasp (McGrew and Tutin, 1978). To date, the  
156 mechanism underlying the emergence and stability of the GHC culture in chimpanzees has  
157 been described in terms of physical shaping (De Waal and Seres, 1997). By applying  
158 matched-control methodologies (De Waal and Yoshihara, 1983) and following established  
159 criteria in the field of communication (Leavens et al., 2005; Liebal and Call, 2012; Pika,  
160 2008), we identify flexible and goal-directed gestural communication as an additional  
161 mechanism by which chimpanzees initiate and coordinate their grooming handclasps.

162         The grooming handclasp is a cooperative activity that requires coordination for  
163 successful execution. Chimpanzees cooperate (Mitani, 2009), but not much is known about  
164 the ways in which they coordinate their joint efforts. In experimental settings, some  
165 chimpanzees used location enhancing behaviors (e.g., bodily positioning, touching, peering)  
166 (Melis and Tomasello, 2019), or generic gestures (e.g., arm fling, clapping, banging on  
167 panels; Voinov et al. 2020) to entice their conspecific partners into a joint action. In natural  
168 contexts, chimpanzees and bonobos communicate to coordinate joint actions like joint travel  
169 (Fröhlich et al., 2016) and social play (Heesen et al., 2017; Hobaiter and Byrne, 2014), yet  
170 “... the degree to which these actions are joint in terms of whether or not partners aim to  
171 achieve shared goals together, or whether partners have shared intentions, remains unknown.”  
172 (Genty et al., 2020). Moreover, none of these examples pertain to cultural practices, while  
173 joint and shared intentionality (Koreň, 2016; Tomasello and Carpenter, 2007) conducive to  
174 joint action are so central to human accounts of culture (Enfield and Levinson, 2006;  
175 Tomasello, 2019).

176         Our findings identify chimpanzees to use gestural communication in a natural context  
177 to overcome a coordination challenge in the socio-cultural domain (McGrew and Tutin, 1978;

178 Nakamura and Uehara, 2004; van Leeuwen et al., 2012). The socio-cultural interaction was  
179 not just shaped by one invested individual (De Waal and Seres, 1997), but when the initiator  
180 communicated its desire to engage in the GHC (e.g., by holding out its flexed arm at face  
181 level in front of the desired partner), an active commitment in the form of a complementary  
182 action by the partner was required to accomplish the interaction. As such, when  
183 communicated, the cultural GHC practice appeared to ensue with a degree of joint  
184 commitment regulating the coordination of the required actions, similar to the handshake  
185 example in humans. We conclude that chimpanzees synchronize their attention to a joint  
186 cultural action to which they are both committed, which suggests that chimpanzee social  
187 culture, like human culture, may be founded on (correlates of) shared intentionality (cf.  
188 (Tomasello et al., 2012; Tomasello and Carpenter, 2007; Tomasello and Moll, 2010)).

189         Reflecting on these findings, we posit that also for animals the socio-cultural context  
190 *i*) facilitates and shapes mechanisms conducive to coordinating joint actions (also see (Genty  
191 et al., 2020)), and *ii*) provides the adequate breeding ground for the transformation of  
192 individualistic to collaborative predispositions and capacities – a transformation thought to be  
193 unique to the evolution of the human species (Tomasello and Carpenter, 2007). Regarding *i*),  
194 the socio-cultural property of the GHC (McGrew et al., 2001; Nakamura, 2002; van Leeuwen  
195 et al., 2012) entails a group-level engagement which spurs in individuals both the motivation  
196 to instigate and be susceptible to requests for interaction and, in the case of initiating GHC,  
197 solve a coordination challenge. Whereas at first this context may produce overzealous  
198 individuals who physically shape their naïve partners into GHC (De Waal and Seres, 1997),  
199 in a later stage, the shared readiness to coordinate this joint cultural practice may catalyze the  
200 transformation of one-sided shaping (only one actor) into two-sided communication (two  
201 committed actors). This hypothesis would *a*) explain why communication for coordination  
202 purposes has not been readily observed in chimpanzees (i.e., cultural contexts have been

203 overlooked) (Duguid et al., 2020a, 2020b), and *b*) predict more communication and seamless  
204 coordination in more experienced dyads as focus for future research. Regarding *ii*), it has  
205 been posited that humans are unique in their cooperative engagement owing to their  
206 capacities for shared intentionality (Tomasello, 2019). Humans are thought to transform  
207 individualistic activities into joint, collaborative activities during ontogeny and especially  
208 throughout socio-cultural immersion – a process presumably absent in chimpanzees  
209 (Tomasello and Carpenter, 2007). It may thus be no coincidence that exactly in this socio-  
210 cultural GHC-context we observed capacities for joint attention and commitment in  
211 chimpanzees, similar to the ones ascribed to young children engaging in joint activities  
212 (Tomasello, 2019). The ontogeny of chimpanzees’ cultural engagement with a specific focus  
213 on elements of shared intentionality may provide exciting insights for theories on the  
214 evolution of human thinking (Heyes, 2018; Tomasello, 2019).

215

## 216 **Methods**

### 217 ***Subjects***

218 Subject were 52 chimpanzees (Table S1) at the Chimfunshi Wildlife Orphanage, Zambia.  
219 GHC has been a customary behavior in the group for over 15 years, and 39 individuals  
220 (including all 32 adults) were observed to GHC at least once. The study was approved by the  
221 Chimfunshi Research Advisory Board (permit: CWOT\_ 2019C039), and conformed to the  
222 nationwide legal requirements. Chimfunshi is accredited by PASA and adheres to the rules  
223 and regulations with respect to animal care and management as stipulated by the Zambia  
224 Wildlife Authority.

225

### 226 ***Collection & Coding***

227 Data were collected by ZG from 23-03-2019 to 04-06-2019 between 8am-4pm with handheld  
228 digital video cameras (Panasonic HDC-HS100). To capture GHC initiations, filming  
229 commenced as soon as two individuals approached one another. Filming continued if the  
230 individuals started social grooming and lasted until they (a) had stopped grooming for over  
231 30 seconds, (b) started grooming another individual, or (c) physically separated. A grooming  
232 bout was defined as running from the start of grooming until the moment one of the  
233 aforementioned ending conditions was met. A bout was considered a GHC-bout if it  
234 contained one or multiple GHCs, and a regular grooming bout if no GHCs occurred.

235 GHC-bouts had either a *side* or *back* view and were analyzed for initiation behaviors  
236 if a 10 sec pre-handclasp (PH) social grooming window was available before the first GHC in  
237 the bout. We only analyzed the initiation of the first GHC in GHC-bouts, because previous  
238 GHCs could possibly function as signals for subsequent GHCs. The start of a GHC was  
239 defined as the instance of handclasp above face level; the end as the instance that physical

240 contact of the palms/wrists was broken. Moreover, a Matched-Control (MC) period was  
241 recorded to enable comparison of individual initiation behaviors across conditions (De Waal  
242 and Yoshihara, 1983). The MC-period was defined as a 10sec-window minimally 10sec after  
243 the last GHC occurrence in the GHC bout, in which the individuals had to be positioned in  
244 the same relative positions as during the GHC, while still engaging in social grooming  
245 (Figure 1). Additionally, initiations of regular, non-GHC-bouts were opportunistically  
246 recorded ( $n_{side\ and\ back}=23$ , Table S3) to identify behaviors used in the initiation of regular  
247 grooming bouts.

248 Videos were scored in ELAN (Wittenburg et al., 2006), behaviors were coded based  
249 on preliminary screening of the videos and established chimpanzee ethograms (Nishida et al.,  
250 1999) (see Table S2 and SI videos). An individual was considered the initiator of a GHC bout  
251 when they were either a) the first one to produce a GHC-specific initiation behavior or b) in  
252 the absence of these behaviors, the first to raise their arm for the GHC. A subset of 20% of  
253 the data was coded by two further observers to establish IRR. Mean dyadic agreement was  
254 0.833 for coding behaviors (range 0.81-0.89), and 0.973 for identifying the initiating  
255 individual (range 0.89-1; see SI for details).

256

## 257 *Analyses*

258 Analyses were done in R 3.6.1. Non-parametric statistics were applied, including Bonferroni-  
259 Holm corrections for multiple testing (Holm, 1979). For the PH-MC comparison, we  
260 analyzed those behaviors that *i*) occurred  $\geq 5$  times in GHC-bouts, and *ii*) did not also  
261 frequently ( $>15\%$  of bouts) occur during initiations of regular grooming bouts (see Table S3).  
262 Given that social grooming occurred in both PH and MC windows by definition (see Figure 1  
263 and “Collection & Coding”), we did not consider the grooming behaviours (see Table S3) as

264 possible signals for GHC initiation. We only used GHC-bouts with a *side*-view (optimal  
265 vantage point) and a Matched Control period ( $n=94$ ). Auxiliary analysis including also *back*-  
266 view observations ( $n_{\text{total}}=133$ ) supported our main analyses (all 6 behaviors  $p<0.02$ , Holm  
267 corrected; see Tables S3 & S4). When assessing flexibility and elaboration in GHC initiations  
268 (Figure 2), we used all *side*-view bouts regardless of the presence of MCs ( $n=110$ ).

269

## 270 **Data availability statement**

271 The code and data used for analyses are available via <http://doi.org/10.5281/zenodo.4616274>.

272

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277 and inter-rater-reliability.

278

## 279 **Competing interests**

280 The authors declare to have no competing interests.

281

## 282 **Compliance with Ethical Standards**

283 The authors declare no conflict of interests to exist. The research on chimpanzees was strictly  
284 non-invasive/observational and adhered to the ethical guidelines provided by the Chimfunshi

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286 guidelines for the care and use of animals were followed.

287

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292



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## 398 **Supplementary Information captions**

399 **SI\_1.** Supplementary information and tables, including subject demographics, the behavioral  
400 ethogram, frequency table of behavior, outcomes of the Wilcoxon-signed rank tests,  
401 and details on the inter-rater reliability calculation.

402 **Video S1.** Elbow hold.

403 **Video S2.** Elbow touch.

404 **Video S3.** Hand grab.

405 **Video S4.** Hand touch.

406 **Video S5.** Head move.

407 **Video S6.** Head touch.

408 **Video S7.** Hold.

409 **Video S8.** Nosewipe.

410 **Video S9.** Self-scratch.

411 **Video S10.** Torso.

412 **Video S11.** Video example of a grooming handclasp initiated with shaping behavior.

413 **Video S12.** Video example of a grooming handclasp initiated with gestural communication.

414 **Interactive Figure S13.** Interactive version of Figure 2.

## 415 **Supplementary Information**

### 416 **Chimpanzees communicate to coordinate a cultural practice**

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424 **Table S1.** Subject demography of Group 2 at Chimfunshi Wildlife Orphanage on 01-07-  
425 2019.

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	Male	Female	Total
<b>Adult (&gt; 12 years)</b>	8	24	32
<b>Juvenile (3-11 years)</b>	7	5	12
<b>Infant (&lt; 3 years)</b>	3	5	8

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429 **Table S2.** Ethogram of behavior, with reference to supplementary videos of behaviors.

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<b>Behavior</b>	<b>Video</b>	<b>Definition</b>
Elbow Hold	S1	Places own hand on elbow or arm of other, maintaining physical contact as arm of other moves
Elbow Touch	S2	Briefly touches elbow or arm of other with own hand
Hand Grab	S3	Grabs hand of other with own hand, maintaining contact as arm or hand of other moves
Hand Touch	S4	Briefly touches hand of other with own hand
Head Move	S5	Tilts head up or downwards
Head Touch	S6	Touches (side of) head of other with hand, brief or prolonged contact
Hold	S7	Holds arm up in the air at peak of arm-raise movement, i.e., the raising of the upper arm with some flexion in the elbow
Nosewipe	S8	Swipes hand across or underneath nose in quick motion
Self-scratch	S9	Drags hand across body in long rough strokes
Torso	S10	Turns torso towards or away from other

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434 **Table S3.** Occurrence of all ethogram behaviors in pre-handclasp (PH) and matched-control  
 435 (MC) periods, as well as initiation of regular grooming bouts (IRG). Reported is the total  
 436 number of instances and between brackets the number of instances divided by the number of  
 437 bouts.  
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Behavior	Side view			Side and back view		
	PH (n = 94)	MC (n = 94)	IRG (n = 17)	PH (n = 133)	MC (n = 133)	IRG (n = 23)
Elbow hold	18 (0.19)	1 (0.01)	0 (0)	25 (0.19)	1 (0.01)	0 (0)
Elbow touch	14 (0.15)	0 (0)	0 (0)	16 (0.12)	0 (0)	0 (0)
Groom face	29 (0.31)	44 (0.47)	7 (0.41)	41 (0.31)	63 (0.47)	8 (0.35)
Groom hand/arm	24 (0.26)	25 (0.27)	5 (0.29)	28 (0.21)	32 (0.24)	6 (0.26)
Groom other	53 (0.56)	70 (0.74)	8 (0.47)	79 (0.59)	95 (0.71)	14 (0.61)
Hand grab	5 (0.05)	0 (0)	0 (0)	8 (0.06)	0 (0)	0 (0)
Hand touch	6 (0.06)	0 (0)	0 (0)	6 (0.05)	0 (0)	0 (0)
Head move	11 (0.12)	1 (0.01)	0 (0)	17 (0.12)	1 (0.01)	1 (0.04)
Head touch	14 (0.15)	3 (0.03)	3 (0.18)	18 (0.14)	3 (0.03)	4 (0.17)
Hold	14 (0.15)	1 (0.01)	1 (0.06)	16 (0.12)	1 (0.01)	1 (0.04)
Nosewipe	12 (0.13)	2 (0.02)	6 (0.35)	16 (0.12)	2 (0.02)	7 (0.30)
Self-scratch	25 (0.27)	9 (0.10)	3 (0.18)	31 (0.23)	13 (0.10)	5 (0.22)
Torso	30 (0.32)	0 (0)	10 (0.59)	44 (0.33)	0 (0)	11 (0.48)

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**Table S4.** Results of the paired Wilcoxon signed rank test of behavior frequency between the PH and MC periods.

Behavior	Side view (n = 94)			Side and back view (n = 133)		
	V	P-value (raw)	P-value (adjusted Holm)	V	P-value (raw)	P-value (adjusted Holm)
Elbow hold**	10	<0.001	0.001	13.5	<0.001	<0.001
Elbow touch*	0	<0.001	0.001	0	<0.001	<0.001
Hand grab*	0	0.037	0.039	0	0.006	0.012
Hand touch*	0	0.020	0.039	0	0.020	0.020
Head move**	6.5	0.004	0.013	8.5	<0.001	0.001
Hold**	0	<0.001	0.001	0	<0.001	<0.001

444 \* indicates  $p < 0.05$ , \*\* indicates  $p < 0.01$

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#### 447 **Inter-rater reliability assessment**

448 To establish inter-rater reliability, two additional coders (JB and AM) analyzed the PHs and  
449 MCs of 20% (N = 19) of the GHC bouts. Additionally, ZG coded this subset for a second  
450 time to compare to her first coding one year prior.

451 Due to the continuous nature of the behavioral scoring and the importance of  
452 observers not only agreeing on the presence of (often rare) behaviors but also the order in  
453 which they occurred, the usual Cohen's Kappa approach was not feasible. We calculated  
454 inter-rater reliability as follows (see also attached data for each rater's coding and an  
455 overview):

456 If raters both scored the same behavior in the same order at the same time (within 1  
457 second) it was noted as an "agree", if either of the raters scored a behavior the other one did  
458 not score it was a "disagree". As an informed estimation for the total amount of behaviors per  
459 video we used the sum of the instances of agree and disagree. To correct for the probability of  
460 two raters agreeing on a behavior by chance, we multiplied the probability of scoring a  
461 particular behavior (1/11, the amount of different behaviors) by the probability of scoring it  
462 for a certain individual (0.5).

463 The final calculation of the reliability score combined this probability of agreement  
464 based on chance (POA) with the relative observer agreement (ROA, defined as agreed  
465 behaviors/total amount of behaviors), in the form of  $\frac{ROA-POA}{1-POA}$ . For instance, 50 agrees out of  
466 70 total behaviors leads to a reliability score of  $\frac{(\frac{50}{70})-(0.5*\frac{1}{11})}{1-(0.5*\frac{1}{11})} = 0.70$ . For this study, all dyads  
467 showed inter-rater reliability scores above 0.80 (ZG\_2-ZG\_1 = 0.89; JB-ZG\_1 = 0.81; AM-  
468 ZG\_1 = 0.82; JB-AM = 0.81). Furthermore, each rater also coded who they thought initiated  
469 the bout, and inter-rater reliability on initiator was calculated in a similar manner (with POA  
470 being 0.5) and was above 0.90 for all raters (JB-ZG\_1 = 0.89; all other dyads = 1).