1 # Transition to siblinghood in a wild chacma baboon population

2 ## AUTHORS

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HIGHLIGHTS

- We examine the transition to siblinghood in wild chacma baboons

- Maternal behaviour does not change following the birth of a younger sibling

- But juveniles solicit their mother more often, and show more signs of anxiety

- These results suggest that weaned siblings may compete for maternal attention

ABSTRACT

In monotocous mammals (i.e. where females produce one offspring at a time), most juveniles will experience the birth of a younger sibling in their life. Transition to siblinghood (TTS) has rarely been studied in primates, although it reflects the last step in the shift of maternal investment from one offspring to the next and could thus represent a critical moment for mother-offspring conflict and sibling competition. Here, we use behavioural data on juvenile primates who recently experienced, or not, the birth of a younger sibling to investigate changes in mother-juvenile relationships during TTS in a wild population of chacma baboons (*Papio ursinus*). We show that (1) mother-juvenile spatial association remained stable; (2) mothers did not decrease their probability to initiate proximity or affiliation with their juvenile; and (3) juveniles initiated proximity and affiliation more frequently toward their mothers, and showed more signs of anxiety after the birth of their younger sibling. Taken together, these findings suggest that juveniles with a younger sibling solicit their mother more often and seek more maternal attention than juveniles without. Overall, mother-offspring conflict could extend in the post-weaning period, during which more subtle maternal resources, such as maternal attention, could be at stake in sibling competitive relationships.

KEYWORDS

42   Maternal behaviour; mother-offspring bonds; mother-offspring conflicts; sibling birth; sibling

43   rivalry; sibship

INTRODUCTION

45   Parental investment is defined as any type of investment a parent can provide to its offspring

46   that will enhance the offspring's fitness at the cost of the parent's future reproduction (Trivers,

47   1972). In a seminal paper, Trivers argued that natural selection should favour, in offspring, the

48   expression of traits favouring the monopolisation of parental resources, above the level that

49   parents may be willing to provide (Trivers, 1974). This difference in the optimal amount of

50   parental investment is triggered by an asymmetry in genetic relatedness between the

51   different family members: an offspring is twice as related to himself as it is to its siblings, while

52   a parent is equally related to all offspring. This genetic conflict of interest is predicted to trigger

53   conflicts over the amount and duration of parental investment, not only between parents and

54   offspring, but also between siblings, who should all try to maximize their share of parental

55   investment until the costs for their siblings decrease their own inclusive fitness.

56   Sibling competition has found empirical support in a wide range of taxa from insects

57   to mammals (see for reviews: Mock et Parker 1998; Drummond 2006) where it can largely

58   impact offspring's development, with long-term consequences in three areas: morphology

59   (e.g. insects: Schrader et al., 2018; birds: de Kogel and Prijs, 1996; mammals: Fisher et al.,

60   2018; Hofer and East, 2008), physiology (e.g. birds: Drummond and Rodríguez, 2013; Nettle et

61   al., 2015; Verhulst et al., 2006; mammals: Fey and Trillmich, 2008; Guenther and Trillmich,

62   2015; Stauffer et al., 2018) and behaviour (e.g. birds: Bebbington et al., 2017; Ekman et al.,

63   2002; mammals: Guenther and Trillmich, 2015; Hudson et al., 2011) and even lead to siblicide

64   (e.g. birds: Braun and Hunt, 1983; Fujioka, 1985; Lougheed and Anderson, 1999; mammals:

65 Andersen et al., 2011; Hofer and East, 2008). However, our understanding of family

66 competition suffers from a taxonomic bias: most studies have focused on brood or litter-

67 rearing species (especially in mammals, see for reviews: Drummond 2006, Hudson et Trillmich

68 2008, Roulin et Dreiss 2012). Most of the theoretical models and evolutionary hypotheses

69 have thus been developed for same-age siblings and within-brood competition (Hudson &

70 Trillmich, 2008), leaving the competition between siblings of different ages virtually

71 unstudied.

72   In long-lived species, such as monotocous mammals, which generally produce and

73 nurse one offspring at a time (Altmann 1980, Clutton-Brock et al., 1983), siblings could

74 compete for different resources than milk (Hudson & Trillmich, 2008), meaning that sibling

75 competition can last beyond weaning age. In those species, offspring may form long and

76 enduring bonds with mother that can extend far beyond independency (e.g. yellow baboons,

77 *Papio cynocephalus*: Silk et al., 2006b, 2006a; Asian elephants, *Elephas maximus*: Lynch et al.,

78 2019; red deer, *Cervus elaphus*: Clutton-Brock et al., 1982), and exhibit a period of post-

79 weaning juvenility, during which they keep benefiting from maternal care such as social

80 support, facilitated access to food, or protection against predators (Clutton-Brock, 1991).

81 Maternal presence during the post-weaning developmental period improves offspring growth

82 (e.g. chimpanzees, *Pan troglodytes*: Samuni et al. 2020), and increases future reproductive

83 success and longevity (chimpanzees: Crockford et al., 2020, Stanton et al. 2020; bonobos, *Pan*

84 *paniscus*: Surbeck et al., 2011; red deer: Andres et al., 2013), potentially through a prolonged

85 access to such forms of maternal care. Monopolising such resources might be advantageous

86 for offspring, and could thus induce competition between siblings.

87   In line with this, several empirical studies show that sibling competition can have

88   substantial fitness consequences in monotocous species. In Galapagos fur seals

89   (*Arctocephalus galapagoensis*) and sea lions (*Zalophus wollebaeki*), calves whose mother is

90   still nursing the older sibling experience a reduced growth and increased mortality risk

91   (Trillmich & Wolf, 2008). In rhesus macaques (*Macaca mulatta*), short interbirth intervals

92   reduce the survival to adulthood for the older offspring and the survival to weaning for the

93   younger one (Lee et al., 2019). In female yellow baboons, having a close-in-age younger sibling

94   nearly doubles the mortality risk during adulthood (Tung et al., 2016). Moreover, this effect

95   has intergenerational consequences because adult females whose mother had a close-in-age

96   younger sibling further experienced higher offspring mortality (Zipple et al., 2019). In humans

97   (*Homo sapiens*) as well, short interbirth intervals increase offspring mortality risk (Conde-

98   Agudelo et al., 2006; Rutstein, 2005; Wendt et al., 2012). Overall, these studies show that the

99   dilution of maternal care between different-age offspring has fitness costs, setting the

100   conditions under which sibling competition over access to maternal resources should evolve.

101   Regarding the behavioural mechanisms at play, while many primate studies have

102   focused on mother-offspring conflicts during the weaning period or around a mother's cycle

103   resumption (Barrett and Henzi, 2000; Bateson, 1994; reviewed in Maestripieri, 2002), the birth

104   of a younger sibling has been somewhat overlooked. This is striking as the arrival of a younger

105   sibling is the last step in the mother's shift from her current offspring to the next one, and

106   could thus represent a critical moment for both mother-offspring conflict and sibling

107   competition. A few studies led on captive or free-ranging cercopithecines showed that the

108   birth of a younger sibling induces an abrupt decrease in time spent in contact or in proximity

109   to the mother and in the rate of mother-offspring interactions, primarily driven by the juvenile

110   itself (Devinney et al., 2001; DiGregorio et al., 1987; Holman & Goy, 1988; Schino & Troisi,

111 2001). Maternal rejection and aggression also increased, often associated with signs of stress

112 and "depression" in the offspring (Bolwig, 1980; Devinney et al., 2001; DiGregorio et al., 1987;

113 Holman & Goy, 1988). In bonobos, juveniles face an increase in cortisol and a decrease in

114 neopterin levels that can last more than six months after the birth of their younger sibling

115 (Behringer et al., 2022). The behavioural transition to siblinghood has been more thoroughly

116 studied in humans: it is often characterized by a decrease in maternal care and in the rate of

117 mother-offspring interactions, an increase in the rate of confrontational behaviour with the

118 mother and a reversal in who initiates most interactions, with children (instead of mothers)

119 becoming the primary initiators (Dunn et al., 1981; Dunn & Kendrick, 1980; Stewart et al.,

120 1987; Volling, 2012). Children can also show signs of distress, and exhibit more demanding

121 behaviours (Dunn et al., 1981; Volling, 2012). Finally, a striking aspect emerging from the

122 human literature is the high inter-individual variability in children's behavioural adjustment to

123 the birth of a sibling (Dunn et al., 1981; Volling, 2012, 2017). Poor behavioural adjustment

124 (e.g. higher frequency of tantrums and jealousy events toward the younger sibling) is

125 associated, possibly causally, with lower quality relationships between siblings later in life

126 (Brody, 1998; Pike et al., 2005), which could potentially be costly as siblings' relationships and

127 support during adulthood can promote fitness (Pollet & Hoben, 2011).

128   In this study, we investigated changes in mother-juvenile relationships following the

129 birth of a younger sibling in a wild chacma baboon population (*Papio ursinus*). Baboons

130 typically live in matrilineal, multimale-multifemale societies, where females are philopatric

131 and males disperse from their natal group around the age of 7-8 years (Cheney et al., 2004).

132 Females maintain hierarchical and differentiated social bonds and give birth to one offspring

133 every two years on average (Cheney et al., 2004; Dezeure, Baniel, et al., 2021), an interbirth

134 interval somewhat closer to human traditional societies than to great apes (Kramer, 2005).

135 Offspring have a long developmental period and weaning occurs gradually during the second

136 year of life (Carboni et al., 2022; Dezeure, Baniel, et al., 2021), which is characterized by

137 elevated infant mortality (Altmann & Alberts, 2003a). Unweaned infants are sometimes

138 targets of infanticide in this species, with minimal risks to weaned, older offspring (Palombit

139 et al., 2000). In baboons, like in most primates, mothers form long-lasting bonds with their

140 offspring, which facilitate the transition to feeding autonomy (e.g. Lynch et al., 2020) and

141 subsequently translate into preferential grooming relationships and occasional support during

142 conflicts as long as offspring remain in their natal group. All these resources likely increase

143 offspring survival, as observed in chimpanzees (Nakamura et al., 2014; Stanton et al., 2020),

144 and may generate competition among siblings. Specifically, maternal support often allows

145 younger sisters to outrank their older sisters, which suggests that, for a female, having a

146 younger sister could induce lifetime costs through the loss of maternally-transmitted social

147 capital (Pereira, 1989).

148 In three social groups of chacma baboons from Namibia, we investigated immediate

149 changes in the mother-juvenile relationship during the transition to siblinghood (hereafter,

150 TTS), by comparing mother-juvenile interactions among juveniles with no younger sibling and

151 those of comparable ages who recently experienced the birth of a younger sibling. First, we

152 predicted (P1.1) that the amount and quality of affiliative relationships, specifically grooming

153 interactions, between the mother and the juvenile would decrease after the birth of a new

154 infant, with (P1.2) a shift in patterns of initiations of such interactions, from mostly mother-

155 initiated before the birth of the sibling, to mostly juvenile-initiated interactions afterwards, as

156 found in humans. Second, we predicted that juveniles (P2.1) would associate less often with

157 their mother, and (P2.2) would become primarily responsible for initiating and maintaining

158 spatial proximity to their mother after the birth of a younger sibling. Third, we predicted (P3)

159   that juveniles that had recently experienced the birth of a younger sibling would exhibit more

160   self-directed behaviours, generally indicating anxiety (Castles et al., 1999; Maestripieri et al.,

161   1992; Palagi & Norscia, 2011).

METHODS

Study site and population

164   We studied wild chacma baboons living in Tsaobis Nature Park, on the edge of the Namib

165   Desert (22°23' S, 15°44' E), Namibia. We collected data on three well-habituated troops (J, L

166   and M, the latter a fission group from J since 2016) over three observational periods: July-

167   August 2017, September-December 2018, and April-July 2019. The groups were followed

168   every day from dawn to dusk by observers on foot, collecting demographic, life history and

169   behavioural data. All individuals, including infants, are individually recognizable (Huchard et

170   al., 2013).

Individual data

172   Individual birth dates were assessed with certainty when field observers were present during

173   the birth (N = 10 offspring), or were estimated using two different methods, depending on the

174   available information: (i) infant's coloration using a standardized, validated protocol, when

175   the infant was not fully grey when first observed (N = 16, median date uncertainty = 41 days,

176   see (Dezeure, Dagorrette, et al., 2021)), (ii) mother's reproductive states in the previous

177   months otherwise (N = 32, median date uncertainty = 18 days). Overall, age uncertainty in our

178   sample ranged from 0 to 130 days (median = 10 days).

179   Female parity was known from life-history records and was defined as primiparous

180   (between the birth of the first-born offspring and the second one), or multiparous (after the

181   birth of the second offspring). Female dominance ranks were calculated separately for each

182   group and each year, using *ad libitum* data and focal observations of agonistic and approach-

183   avoidance interactions: supplants, displacements, attacks, chases and threats (Huchard et al.,

184   2010). We computed a linear hierarchy using Matman 1.1.4 (Noldus Information Technology,

185   2013), and transformed it into a proportional hierarchy with relative ranks (i.e. absolute rank

186   divided by number of adult females in a group), assigning each female one relative rank per

187   year, ranging from 0 (low-ranking) to 1 (high-ranking). We used proportional ranks rather than

188   simple ordinal ranks because they allow to control for group size across different social groups

189   and/or observational periods. Proportional ranks have recently been shown to better predict

190   some female traits associated with reproductive pace (Levy et al., 2020), and could thus better

191   predict patterns of maternal care during the post-weaning period.

192   ## Behavioural observations and sample selection

193   We collected 1401 hours of focal observations from 71 offspring born to 37 females (mean ±

194   SD = 19.7 ± 9.9 h of observation per individual, range 1.3-38.6 h) using 20-min long focal

195   observations (N = 57.6 ± 27.9 focal observations per individual, N = 4086 in total). Focal

196   individuals were aged from 1 to 34 months old (mean ± SD = 16.1 ± 8.7 months old). Focal

197   observations were spread equally across the day (split evenly into four 3h time blocks), and

198   focal individuals were chosen randomly and sampled no more than once per half-day. We

199   recorded the duration and direction of grooming interactions with the mother and the

200   occurrence of self-scratches, a self-directed behaviour generally indicating anxiety.

201   Maintenance of spatial proximity was assessed by recording every close approach or leave (to

202   and from 1m) between the focal individual and its mother. In addition, we collected scans

203   during focal observations every five minutes (i.e., up to 5 scans for each 20-min focal

204   observation, resulting in 20182 scans in total across 4086 focal observations), and recorded

205   whether the mother was in sight, and if yes, her distance to the focal. If the mother was out

206   of sight, observers indicated the number of meters around the focal individual for which they

207   could guarantee that the mother was not in sight (range: 1-100 m). Other cases where visibility

208   was too obstructed (e.g. when focal was in sight but in a dense bush) were recorded as missing

209   data.

210   In this study, we aimed to characterize the immediate behavioural response to the

211   birth of a younger sibling. To do so, we used a cross-sectional approach, comparing juveniles

212   who recently experienced, within the last three months, the birth of a younger sibling to

213   juveniles of similar ages who did not yet. Juveniles who had experienced the birth of a sibling

214   in the more distant past were excluded from this study. This 3-months window was chosen to

215   maximize our chances to detect changes in behaviour that immediately follow the birth of an

216   infant, i.e. reasonably close to the birth event while still ensuring a decent sample size of

217   observations. In our sample of focal observations, juveniles who had recently experienced the

218   birth of a younger sibling were 17- to 29-month-old. Therefore, we restricted our dataset to

219   any juvenile in this age range (17-29 months), who either had no younger sibling ($N = 28$), or

220   a younger sibling born within the last three months ($N = 18$). Individuals who were followed

221   both before and after the birth of their younger sibling were included in each group

222   respectively. We collected a total of 1525 focal observations and 7581 scan observations on

223   38 individuals (8 individuals were observed both with and without a younger sibling).

224   Statistical models

225   Mother-juvenile grooming relationships

226　To test predictions P1.1 and P1.2, we used focal data during which we recorded the duration

227　and direction of each grooming event. First, for each observation, we recorded whether the

228　focal juvenile groomed its mother at least once (binary: yes/no – model 1), and whether it

229　received grooming from its mother (binary: yes/no – model 2). The probability to give or to

230　receive grooming from the mother during a focal observation (models 1 and 2, respectively)

231　was modelled with two generalised linear mixed models (GLMMs) with a binomial error

232　structure. Second, we extracted the total duration (in seconds) the juvenile spent grooming

233　its mother (model 3), or being groomed by its mother (model 4) during a focal observation.

234　We ran two GLMMs with a negative binomial distribution and a log-link function.

Mother-juvenile spatial proximity

236　To test prediction P2.1, we used scan data to estimate how often a juvenile was found in close

237　proximity to the mother. For each scan observation (recorded every 5 minutes), we recorded

238　whether the juvenile focal was in proximity (1) or not (0) to its mother. We considered two

239　distinct ranges of proximity: within 1m (model 5) and 5m (model 6) of the mother. We ran two

240　GLMMs with a binomial error structure.

241　　Second, to test prediction P2.2 and characterize juveniles' responsibility in the

242　maintenance of spatial association with their mother, we used focal observation data. For

243　each focal observation, we established whether the juvenile initiated an approach to, or a

244　leave from its mother within a circle of 1m-radius (1) or not (0) (models 7 and 8, respectively).

245　We then determined whether the juvenile received an approach or a leave from its mother

246　(1) or not (0) (models 9 and 10, respectively). We ran four GLMMs with a binomial error

247　structure. In addition, we computed 'Hinde's Index' for each mother-juvenile dyad, calculated

248　as the percentage of approaches minus the percentage of leaves initiated by the juvenile

249 (Hinde & Atkinson, 1970). This index ranges from -100 (the mother is fully responsible for

250 maintaining proximity) to +100 (the juvenile is fully responsible for maintaining proximity). We

251 calculated one index per dyad for each observational period (i.e. field season) and for each

252 'sibling status' (i.e., experienced TTS or not). When the focal juvenile experienced TTS during

253 the period, we computed the Hinde's index before and after the birth event. We then tested

254 if the average Hinde's Index for a given sibling status differed from zero using a one-sample

255 Student's t-test (N = 13 indices on juveniles with a younger sibling, N = 22 on juveniles without

256 a younger sibling). We also tested whether the average Hinde's Index differed between

257 juveniles with or without sibling using a linear model (N = 34 indices across both groups). For

258 each test, if a dyad had several indices (because it was observed during two different

259 observational periods or because a sibling was born during a given period – N = 28 individuals

260 with 1 index, N = 9 with 2 indices and N = 1 with 3 indices), we randomly selected one of them

261 to avoid pseudoreplication.

262 <u>Juvenile self-directed behaviour</u>

263 To monitor the anxiety level of juveniles, we calculated the number of self-scratches per focal

264 observation and ran a GLMM with a negative binomial distribution and a log-link function

265 (model 11).

266 <u>Fixed and random effects</u>

267 For each GLMM, we tested the effect of having recently experienced the birth of a younger

268 sibling (yes/no), as well as the following control variables: focal juvenile sex, age (in months),

269 birth rank (first-born vs later-born), and maternal rank. We also tested the interaction terms

270 between the recent birth of a younger sibling and the focal juvenile age and sex (except for

271 model 3 because of a limited and unbalanced sample size). We further included three

272 additional fixed effects as controls: (1) group identity, to account for potential differences

273 between groups; (2) in binomial models, duration of the focal observation (in seconds) (except

274 models 5-6 using scan data) or, in negative binomial models, the log-transformed duration of

275 focal observation as an offset; and (3) in model 11, year of observation because preliminary

276 analyses showed that this variable had a strong effect only on self-scratch frequency.

277 We included the focal juvenile identity as a random effect in all models to control for

278 repeated focal observations within juveniles. In models 5 and 6, we initially fitted the focal

279 observation identity as a random effect to account for the non-independence of multiple scan

280 observations within a same focal observation. However, adding this random effect caused

281 convergence problems. We therefore restricted our dataset to two scans per focal

282 observation, which were separated by >15 minutes and for which the mother-focal juvenile

283 distance was documented ("out of sight" or "in sight" with the approximated distance; missing

284 data were removed). We therefore assumed that such scans were independent from each

285 other and omitted the "focal observation" random effect from our models to facilitate model

286 convergence.

287 In the linear model analysing Hinde's Index, because of limited sample size (N = 34), we

288 only included the three following explanatory variables to avoid over-parametrisation:

289 presence of a younger sibling, focal juvenile's sex and age (average age in months across the

290 observational period).

291 The structure of each model, the different fixed and random effects, and sample sizes are

292 summarised in Table A1.

293 Note that several other variables could account for some variability in mother-juvenile

294 relationships throughout the TTS, such as the mother's reproductive stage or the presence or

295   number of older siblings. In the first case, pregnant mothers may reduce their level of care but

296   it was impossible to test with this cross-sectional design because mother's reproductive stage

297   was correlated with the presence of a younger sibling (i.e. mothers of juveniles with a younger

298   sibling are all lactating, while mothers of those without are either cycling or pregnant). In the

299   latter case, older non-adult siblings may represent potential compensatory social partners, or

300   may alternatively contribute to dilute the level of maternal care received by each sibling.

301   Therefore, we re-ran all models with the number of older immature siblings as an additional

302   fixed factor, setting the maximum age threshold at 4 years old for older siblings, as some

303   females can reach menarche at this age in our population, and results are presented in the

304   Supplementary Materials (Tables A2 to A7). This additional control variable was never found

305   to exert a significant effect on our response variables, and did not improve our model fits, so

306   we present the results without it in the main text.

307   <u>Statistical analysis</u>

308   All statistical analyses were conducted using the R Studio software (version 4.0.2). We ran

309   mixed models using the function "glmer" from the lme4 package (Bates et al., 2015) for

310   binomial models and "glmmTMB" from the glmmTMB package (Brooks et al., 2017) for

311   Poisson and negative binomial models. To control for the focal juvenile's age in all analyses,

312   we started by investigating the developmental pattern of each response variable, i.e. the

313   shape of its relationship with age. To do so, we ran generalized additive mixed models

314   (GAMMs), using the "gam" function of the mgvc package (Wood, 2003), and fitted univariate

315   models using a smoothing function, a linear function, and a second- or third-degree

316   polynomial function to model the effect of age (offsets and random effects were also

317   included). We then compared model fits and selected the models with the lowest AIC (Zuur et

318   al., 2009). Linear, first-order functions of age produced the best fit to all types of data

319   analysed, so we subsequently used linear regression between the response variable and age.

320   When we obtained singular fits, we confirmed the results by running a Bayesian approach,

321   using the "bglmer" function from the blme package (Dorie et al., 2021). When a Poisson model

322   was overdispersed, we compared its fit with a type-I negative binomial model and a type-II

323   negative binomial model and selected the model with the lowest AIC (Zuur et al., 2009).

324   Following this test, models 3 and 4 were run with a type-I negative binomial distribution and

325   model 11 was run with a type-II negative binomial distribution. All quantitative variables were

326   z-transformed (mean = 0; SD = 1) using the "scale" function from the car package (Fox &

327   Weisberg, 2019) in order to facilitate model convergence, as well as to compare effect sizes

328   across estimates (Harrison et al., 2018). To diagnose the presence of multicollinearities, we

329   calculated the variance inflation factor (VIF) for each predictor in each model using the "vif"

330   function from the car package (Fox & Weisberg, 2019). VIFs were inferior to 2 in all cases,

331   suggesting that multicollinearities did not impact coefficients' estimation in our models. To

332   test the significance of fixed factors for each model, we used the likelihood ratio test (LRT) and

333   associated p-values computed by the "drop1" function, and calculated the 95% Wald

334   confidence intervals. Non-significant interactions were removed from the full model to limit

335   the risk of over-parametrisation and facilitate the interpretation of simple effects. Finally, we

336   assessed the significance of our full model by comparing its fit to the equivalent null model

337   (intercept only model, including the random effects) using a likelihood-ratio test. We further

338   checked the distribution of the residuals using "simulateResiduals" from the DHARMa package

339   (Hartig & Lohse, 2021).

340   Ethical Note

341 This study was strictly observational and relied on behavioural data collected noninvasively

342 on animals well habituated to human observers. Our research procedures were evaluated and

343 approved by the Ethics Committee of the Zoological Society of London and adhered to the

344 ASAB/ABS Guidelines for the Treatment of Animals in Behavioural Research and Teaching. This

345 research was carried out with the permission of the Namibian Ministry of Environment and

346 Tourism (MET), the Ministry of Land Reform, and the National Commission on Research,

347 Science and Technology. Our research was conducted under MET permit numbers 2303/2017,

348 RPIV00392018/2019.

349 RESULTS

350 Mother-juvenile grooming relationships

351 We first investigated whether a juvenile's grooming relationship with the mother was affected

352 by the birth of a younger sibling (P1.1 and P1.2). Both the probability and the duration of

353 grooming received from the mother were independent from the birth of a younger sibling

354 (probability: Odds Ratio − OR − = 0.89, duration: mean ± SD = 36.5 ± 13.8 seconds per

355 observation; Tables 1 and 2, Fig. 1b, 1d). In contrast, juveniles with a younger sibling had a

356 significantly higher probability (OR = 1.71; mean probability ± SD with a sibling: 0.10 ± 0.07 vs

357 without a sibling: 0.05 ± 0.04), and spent significantly more time grooming their mother (20.9

358 ± 17.3 seconds per focal observation for juveniles with a sibling vs. 9.1 ± 7.2 for those without;

359 Tables 1 and 2, Fig. 1a, 1c). Juvenile males had a significantly lower probability, and spent less

360 time grooming their mother than juvenile females (OR = 0.22, Tables 1 and 2). In contrast, the

361 probability and duration of grooming received from the mother was independent of juveniles'

362 sex (Tables 1 and 2). The probability to groom the mother and its duration both significantly

363 increased with age (an increase in one standard deviation in age increased grooming likelihood

364   by 49%, OR = 1.49, Tables 1 and 2), while the probability to receive a grooming from the

365   mother and its duration tended to decrease with juvenile age (OR = 0.84, Tables 1 and 2).

Mother-juvenile spatial proximity

367   Mother-juvenile proximity was not influenced by the birth of a younger sibling (P2.1): juveniles

368   with or without a younger sibling had the same probability to be within 1m or 5m of their

369   mother during a scan observation (OR = 0.92 and 1.12 respectively, Table 3). Males were

370   significantly less likely to be within 1m or 5m of their mother than females (OR = 0.53 and 0.72

371   respectively, Table 3). Juveniles born to higher-ranking females were significantly more likely

372   to be within 5m of their mother (OR = 1.21, Table 3). Overall, juveniles were significantly less

373   likely to be within 1m or 5m of their mother as they grew older (OR = 0.81 and 0.80

374   respectively, Table 3).

375   Juveniles who had recently experienced the birth of a younger sibling were, however,

376   significantly more likely to approach (OR = 1.74, mean probability ± SD = 0.24 ± 0.06 for

377   juveniles with a sibling vs. 0.18 ± 0.05 for juveniles without) and leave (OR = 1.71, 0.20 ± 0.05

378   for juveniles with a sibling vs. 0.14 ± 0.05 for juveniles without) their mother than juveniles

379   who did not yet have a younger sibling (P2.2, Table 4, Fig 2a, 2b). Males were significantly less

380   likely to leave their mother than females (OR = 0.66), while juveniles born to high-ranking

381   females were significantly more likely to approach and leave their mother (OR = 1.19 and 1.21

382   respectively, Table 4). Overall, the probability to approach and to leave the mother decreased

383   with age (OR = 0.81 and 0.83, Table 4).

384   The probability of receiving an approach from the mother (P2.2) was also influenced

385   by the interaction between the sex of the focal juvenile and the birth of a younger sibling:

386   juvenile females with a younger sibling were less likely to be approached by their mother

387 (mean probability ± SD = 0.05 ± 0.02) than those without a sibling (0.08 ± 0.04), while males

388 with a younger sibling were more likely to be approached by their mother (0.08 ± 0.02) than

389 those without a sibling (0.05 ± 0.04,Table 5, Fig. 2c). Juveniles born to high-ranking females

390 were also significantly more likely to be approached by their mother than those born to low-

391 ranking females (OR = 1.74, Table 5). The probability to be left by the mother was not

392 influenced by the birth of a younger sibling, and our model did not differ from the null model

393 (Chi^2 = 13.90, P= 0.084, Table 5, Fig. 2d).

394   Finally, average Hinde's indices were positively and significantly different from zero

395 both for juveniles with a younger sibling (one-sample t-test, N = 13, t = 6.2, P < 0.001) and

396 without (one-sample t-test, N = 22, t = 3.8, P < 0.001), indicating that juveniles were more

397 responsible than their mother for maintaining their close spatial proximity. The average

398 Hinde's index was not different between both groups (N = 34, t = 1.131, P = 0.267), meaning

399 that juveniles were equally primarily responsible for maintaining close spatial proximity with

400 their mother whether they had a younger sibling or not (P2.2).

401 Juvenile self-directed behaviour

402 Finally, juveniles' self-scratch frequency was significantly influenced by the interaction

403 between sibship status and age (P3). Self-scratch frequency generally decreased with age but

404 less so for juveniles who had a younger sibling compared to those with no younger sibling

405 (Table 6, Fig. 3). Juveniles born to higher-ranking females tended to have a lower self-scratch

406 frequency than juveniles born to lower-ranking females (Table 6).

407 DISCUSSION

408   This study investigated changes in mother-juvenile relationships during the transition to

409   siblinghood in young chacma baboons. First, we showed that, contrary to our predictions,

410   mothers did not reduce their investment in terms of grooming and proximity following the

411   birth of a new infant, as their grooming probability and duration (P1.1), and their probability

412   to initiate and stay in close spatial proximity with their older juveniles remained stable (P2.1

413   and P2.2). Second, we showed that juveniles with a younger sibling increased their

414   responsibility in the maintenance of grooming and spatial relationships with their mother.

415   Indeed, they groomed two times more often and two times longer (P1.2), and approached

416   and left their mother a third more often (P2.2), even though they spent on average the same

417   amount of time in close spatial proximity with her than juveniles with no younger sibling.

418   Third, signs of anxiety decreased more slowly with age for juveniles with a younger sibling

419   compared to juveniles of similar age without a sibling (P3). Here, we discuss the implications

420   of our findings for the understanding of mother-offspring conflict and sibling competition in

421   primates.

422   Baboon mothers did not reduce their level of maternal investment in terms of

423   grooming and proximity following the birth of a new infant, while their older offspring initiated

424   interactions more often. These results contradict previous studies on TTS in macaques, which

425   reported an abrupt decrease in maternal grooming, time spent in close spatial proximity and

426   maternal approaches (Devinney et al., 2001; Holman and Goy, 1988; Schino and Troisi, 2001;

427   Singh and Sachdeva, 1977 but see DiGregorio et al., 1987). In these macaques, these changes

428   were also driven by the juveniles themselves, who decreased the rate at which they initiated

429   interactions with their mother (Devinney et al., 2001; Holman & Goy, 1988; Schino & Troisi,

430   2001; Singh & Sachdeva, 1977). These differences with our findings could relate to several,

431   non-mutually exclusive factors. First, the macaque studies were conducted on captive

432   populations (from free-ranging to laboratory housing). Captivity and provisioning could affect

433   mother-offspring relationships and specifically accelerate maternal reproductive pace

434   (Altmann & Alberts, 2003b). Second, and perhaps because of their different environments,

435   young macaques were on average 12 months old at the birth of their younger sibling, while

436   young chacma baboons were on average 23 months old in this study. Although this age

437   difference is partly due to species differences in reproductive pace, it may also reflect

438   differences in juveniles' independence. Indeed, juvenile macaques were still nursing in the few

439   months preceding the birth of their siblings, while our study subjects had stopped suckling

440   long before their sibling was born (Dezeure, Baniel, et al., 2021). In addition, isotopic analyses

441   showed that milk intake ceases around 12 months in our study population (Carboni et al.,

442   2022). Subsequently, weaning and the birth of a younger sibling were simultaneous and

443   impossible to disentangle in the macaque studies, while we were able to measure the effects

444   of TTS on mother-offspring relationships independently of weaning.

445   Our results recall previous findings in human studies. Indeed, in western industrialised

446   societies, children became more responsible for initiating interactions with their mother,

447   including more demanding and clinging behaviour and more signs of anxiety (Dunn et al.,

448   1981; Dunn & Kendrick, 1980; Stewart et al., 1987; Volling, 2012), following the birth of a

449   sibling. Yet, in humans – as in captive macaques – this pattern was associated with a decrease

450   in maternal care and an increase in maternal rejections. The lack of changes in maternal

451   behaviour we observe in our study may be expected in natural populations, as mothers may

452   space births in a way that allows them to provide the care needed by their offspring at

453   different stages of their lives. When a newborn arrives, older juveniles are fully weaned and

454   lactation may not substantially affect mothers' ability to maintain their relationship with their

455   juvenile offspring via proximity, grooming, co-feeding, and occasional acts of social support.

456   Thus, adjustments in maternal behaviour after the birth of new infants may be relatively small,

457   contrasting with patterns reported in (at least some) human societies, where mothers care for

458   multiple dependent offspring at the same time. Overall, studies across species and

459   populations may reveal how flexible maternal strategies are, and the associated range of

460   juveniles' behavioural reactions to TTS, widening our understanding of family ecology.

461   Although juvenile baboons with and without a younger sibling received as much care

462   from their mother, juveniles with a younger sibling approached, left and initiated grooming

463   with their mother more often than those without. These results may first reflect their

464   attraction to the newborn, which is commonly observed across primate species, where non-

465   mother individuals, mainly females, frequently touch or handle newborns (Dunayer &

466   Berman, 2018; Hrdy, 1976; Meredith, 2015). Non-mother females often access the infant by

467   initiating grooming with the mother, resulting in new mothers receiving increased levels of

468   grooming and attention (Caselli et al., 2021; Frank & Silk, 2009; Henzi & Barrett, 2002; Jiang

469   et al., 2019). However, if the increase in juveniles' initiation of interactions with their mother

470   was exclusively triggered by infant attraction, we would expect juvenile females to initiate

471   more interactions with their mother than males following the birth of a younger sibling, which

472   was not supported by our results. Moreover, when approaching their mother, juveniles

473   immediately interacted with their younger sibling in only 13% of cases, while they interacted

474   with their mother in 35% of cases (see Appendix 1). Overall, these results suggest that infant

475   handling was not the primary motivation for juveniles to approach their mother.

476   Second, such behavioural changes driven by juveniles may reflect changes in mother-

477   offspring relationship following TTS, which may contribute to accelerate a juvenile's

478   developmental trajectory. They may develop greater independence and autonomy following

479 their sibling's birth, thus increasing their own responsibility in maintaining the mother-

480 offspring spatial and grooming relationships. TTS may also translate into a rescheduling of

481 mother-juvenile interactions, where juveniles would be conditioned to request maternal care

482 only in convenient times so that it does not interfere with infant care (in a similar manner to

483 the rescheduling during the weaning period proposed by (Altmann, 1980; Bateson, 1994)).

484 Finally, juveniles may solicit their mother more frequently to seek maternal attention and

485 obtain the same 'pre-sibling arrival' level of care, if the birth of a younger sibling leads to lower

486 maternal responsiveness and greater mother-offspring conflict over maternal care. Although

487 most studies on primates have focused on mother-offspring conflicts during weaning or when

488 mothers resume cycling (Maestripieri, 2002), which often manifest through highly

489 conspicuous tantrums (Barrett & Henzi, 2000), conflicts can arise at other developmental

490 stages (Bateson, 1994) and over any type of maternal investment that can be monopolised.

491 As infants grow older and stop throwing tantrums (as was the case of our study baboons),

492 mother-offspring conflict could be expressed through more subtle behaviours, such as who

493 takes the responsibility in maintaining spatial proximity, or other signs of anxiety, such as self-

494 directed behaviours (Maestripieri, 2002).

495   This increased mother-offspring conflict likely translates into sibling rivalry, which

496 could be mediated, at a proximate level, by jealousy, and may explain the increase in juveniles'

497 initiation of association and grooming with the mother. Jealousy is a complex emotional state

498 that arises in a social triangle that consists of the jealous individual (here, the older sibling), a

499 beloved (here, the mother), and a rival (here, the younger infant), and is elicited when the

500 jealous individual perceives the relationship between their beloved and a rival as a threat to

501 their own bond with the beloved one (Volling et al., 2010, 2014). Children undergoing TTS

502 display two main types of jealous reactions when their mother interacts with their sibling:

503   negative/distress behaviours (protesting, disrupting the interactions, directing aggression at

504   the mother), and social approach behaviours (e.g. watching, maintaining proximity and

505   seeking comfort) (Volling et al., 2014). The latter category—social approach— could match

506   the behavioural patterns observed in this study. In humans, sibling jealousy is generally

507   considered as a form of competition for parental attention (Volling et al., 2010), a behaviour

508   that is generally not recognized as a form of parental care *per se* in other species but could be

509   adaptive where parental attention improves offspring survival by preventing risks such as

510   accidents or predation, or by promoting information transmission. In non-human primates,

511   maternal attention could be a form of maternal care that siblings could compete over, but this

512   would require testing whether juveniles who attract more maternal attention experience

513   fitness benefits, such as a greater probability to secure maternal support during conflicts,

514   protection against predators, etc.

515   Finally, further dimensions of TTS should be investigated to foster its description in

516   monotocous species. In modern societies, children's adjustment to TTS is highly variable and

517   is associated with several traits such as children's sex, age, personality or their attachment

518   style (Dunn et al., 1981; Volling, 2012, 2017; Volling et al., 2014). Insecurely attached or

519   younger children typically show more negative reactions to the birth of a younger sibling

520   (Dunn et al., 1981; Volling, 2017). Maternal traits, such as maternal style, could also influence

521   how juvenile primates cope with TTS (Fairbanks, 1996; Maestripieri, 2018). Moreover,

522   throughout this transition, mother and offspring are generally part of a larger social system

523   not restricted to their dyad. In humans, which are often described as communal or cooperative

524   breeders (Mace & Sear, 2005), the presence of other kin such as the father, grandmother and

525   older siblings can also influence how children cope with this transition by developing strong

526   bonds with others to compensate for the weakening of the maternal bond (Gottlieb &

527 Mendelson, 1990; Legg et al., 1974; Stewart et al., 1987; Volling et al., 2014). This could also

528 be the case in baboons to some extent, as juvenile primates primarily associate with their

529 siblings, and can keep benefitting from their father's presence as long as they co-reside

530 (Charpentier et al., 2008; Lynch et al., 2020).

531   Our study is among the first to investigate behavioural changes in mother-juvenile

532 relationships following the birth of a new sibling in wild nonhuman primates. In chacma

533 baboons, the birth of a newborn does not translate into decreased maternal affiliation or

534 association towards the older sibling but it does push juveniles to increase solicitations

535 towards their mother and seems to generate anxiety, which overall suggests that juveniles

536 have to make more effort to maintain the same level of attention and care from their mother.

537 From an ultimate perspective, these results raise the important question of the adaptive

538 significance of maternal attention that siblings seem to compete over. From a proximate

539 perspective, the juveniles' behavioural changes reported here may resemble the jealous

540 reactions commonly observed in young humans during TTS, and may thus offer a relevant

541 context to study emotional development in young primates. Finally, our results, which are

542 distinct from findings in captive primates, show both similarities and differences to human

543 patterns. As such, they emphasize the need to investigate broader aspects of this intriguing

544 developmental milestone in the wild, and across populations and species showing a diversity

545 of life histories and ecologies.

546 ## DATA AVAILABILITY

547 Data sets and scripts used in this study are available on the following public repository:

548 https://gitlab.com/AxelleDelaunay/transition-to-siblinghood-in-a-wild-chacma-baboon-

549 population

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883   *Figure 1 Influence of the birth of the younger sibling on mother-juvenile grooming interactions.*
884   *In all panels, "Sibling status" refers to whether juveniles have recently experienced the birth of*
885   *a younger sibling ("With"), or not ("Without"). (a) Predicted probability that a juvenile grooms*
886   *its mother during a focal observation depending on its "sibling status". (b) Predicted*
887   *probability that a juvenile is being groomed by its mother depending on its "sibling status". (c)*
888   *Predicted grooming time (in seconds) given by a juvenile to its mother during a focal*
889   *observation depending on its "sibling status". (d) Predicted grooming time (in seconds)*
890   *received by a juvenile from its mother during a focal observation depending on its "sibling*
891   *status". The violin plots show the distribution of the fitted values and the boxplots show the*
892   *median of the distribution of the fitted values (black horizontal bar), the 25th and 75th*
893   *quartiles (bottom and top of the boxes, respectively) and the whiskers include a maximum of*
894   *1.5 times the interquartile range. The effect of the predictor "Presence of a younger sibling"*
895   *and the associated p-values are shown. "ns": not significant (P>0.05); * : P<0.05; ** : P <0.01;*
896   **** : P <0.001*

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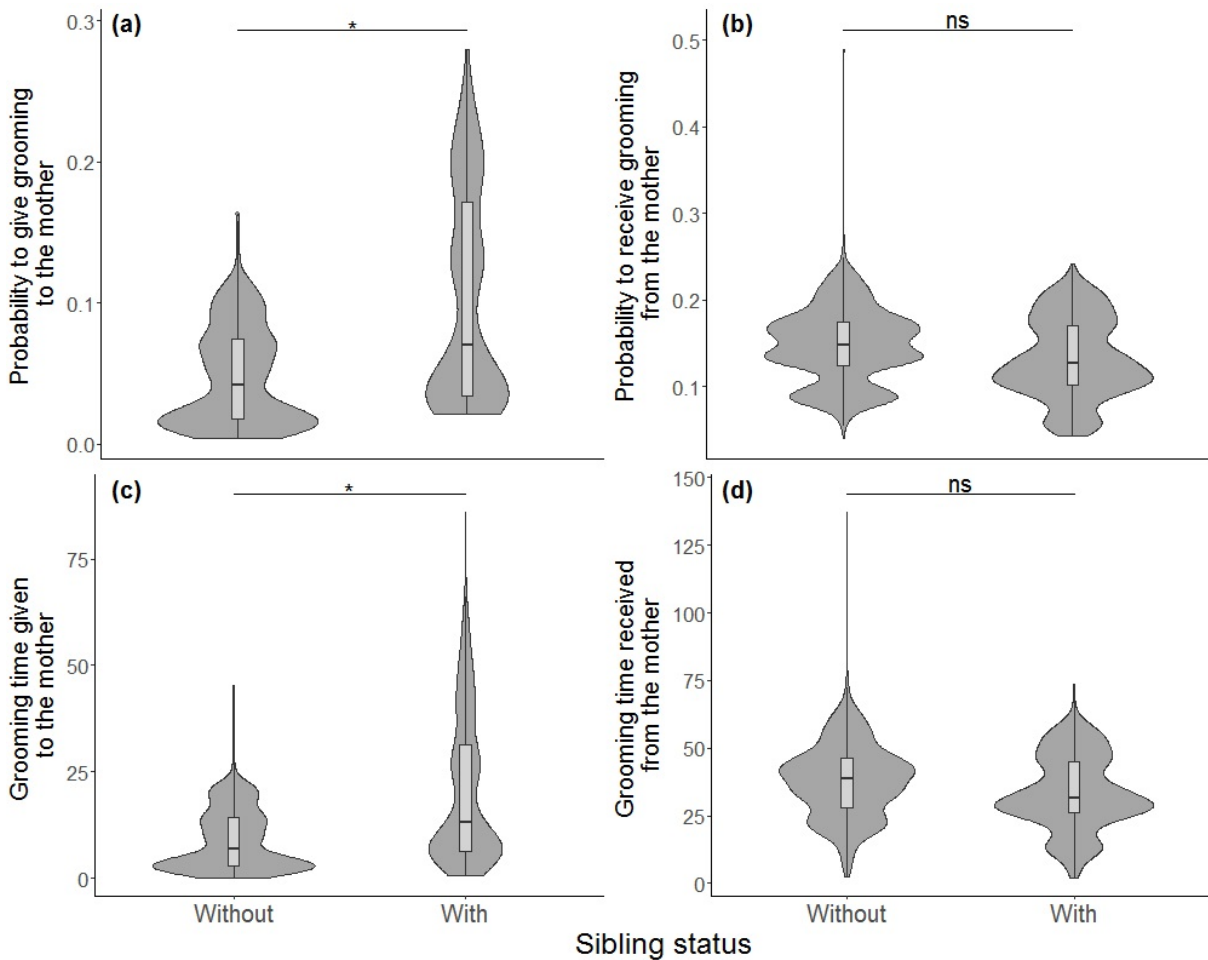
Figure 2: Influence of the birth of the younger sibling on mother-juvenile spatial association (within 1m). In all panels, "Sibling status" refers to whether juveniles have recently experienced the birth of a younger sibling ("With"), or not ("Without"). The four panels show the effect of sibling status on (a) the predicted probability that a juvenile approaches its mother during a focal observation; (b) the predicted probability that a juvenile leaves its mother; (c) the predicted probability that a juvenile is approached by its mother in interaction with juvenile's sex; and (d) the predicted probability that a juvenile is left by its mother. The violin plots show the distribution of the fitted probabilities. The boxplots show the median of the distribution of the fitted values (black horizontal bar), the 25th and 75th quartiles (bottom and top of the boxes, respectively) and the whiskers include a maximum of 1.5 times the interquartile range. The effect of the predictor "Presence of a younger sibling" and the associated p-values are shown. "ns": not significant ($P>0.05$); * : $P<0.05$; ** : $P<0.01$; *** : $P<0.001$. Note that panel C shows the predicted values of the model including a significant interaction between sibling status and juvenile's sex (model 8), but post-hoc pairwise mean comparisons were not significant
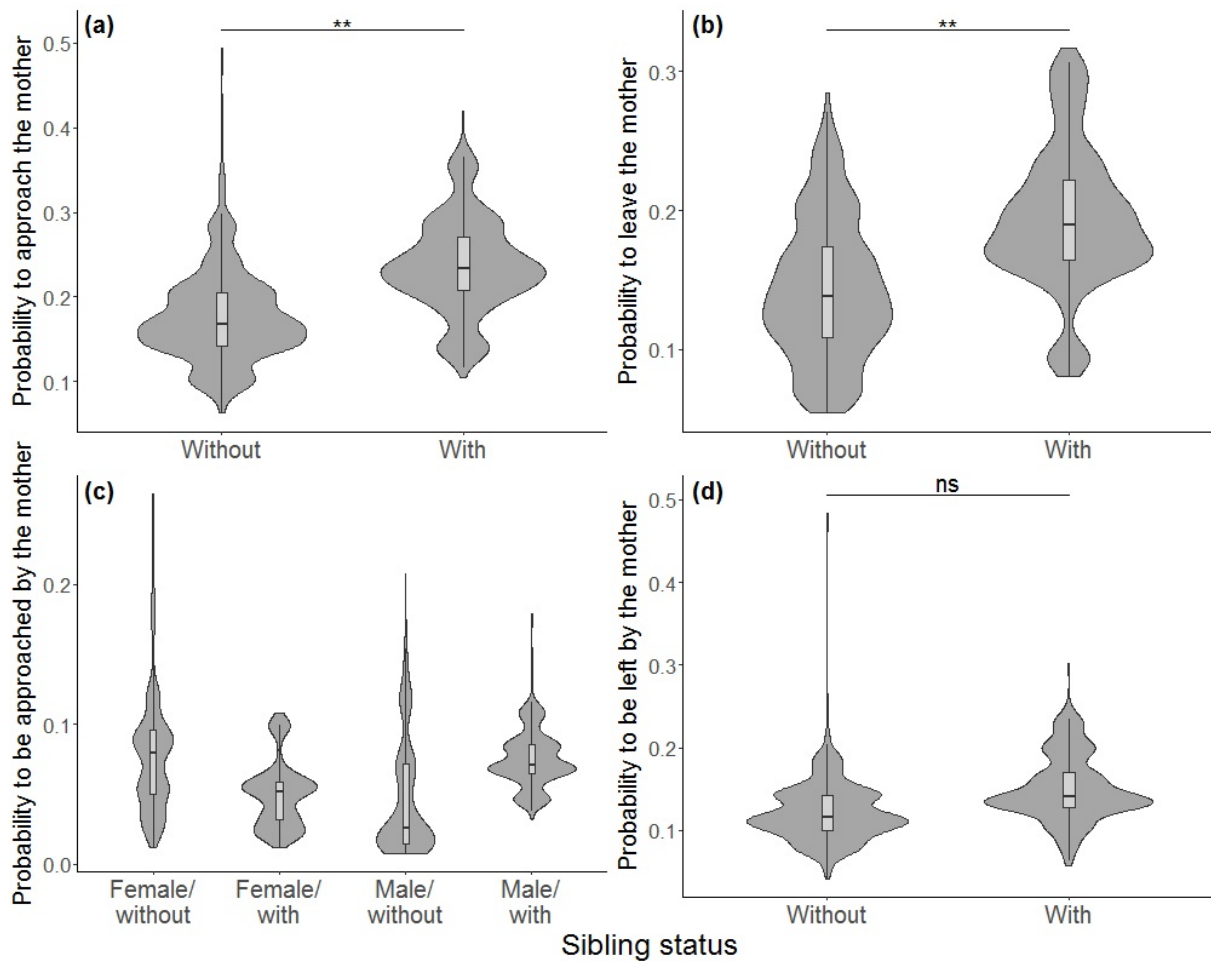
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916   *Figure 3: Variation in the frequency of self-scratches according to juvenile's age and the birth*
917   *of a younger sibling.* *"With" refers to juveniles who recently experienced the birth of a*
918   *younger sibling, "Without" refers to juveniles who did not experience the birth of a younger*
919   *sibling yet. Dots represent the model's adjusted predicted values and the curves show the*
920   *linear predicted fit from the corresponding mixed model. Predicted values were computed*
921   *using the function "ggeffect" from the ggeffect package, averaging the values of all the other*
922   *variables in the model. The darker area around each curve represents the confidence interval*
923   *of the fitted curve*
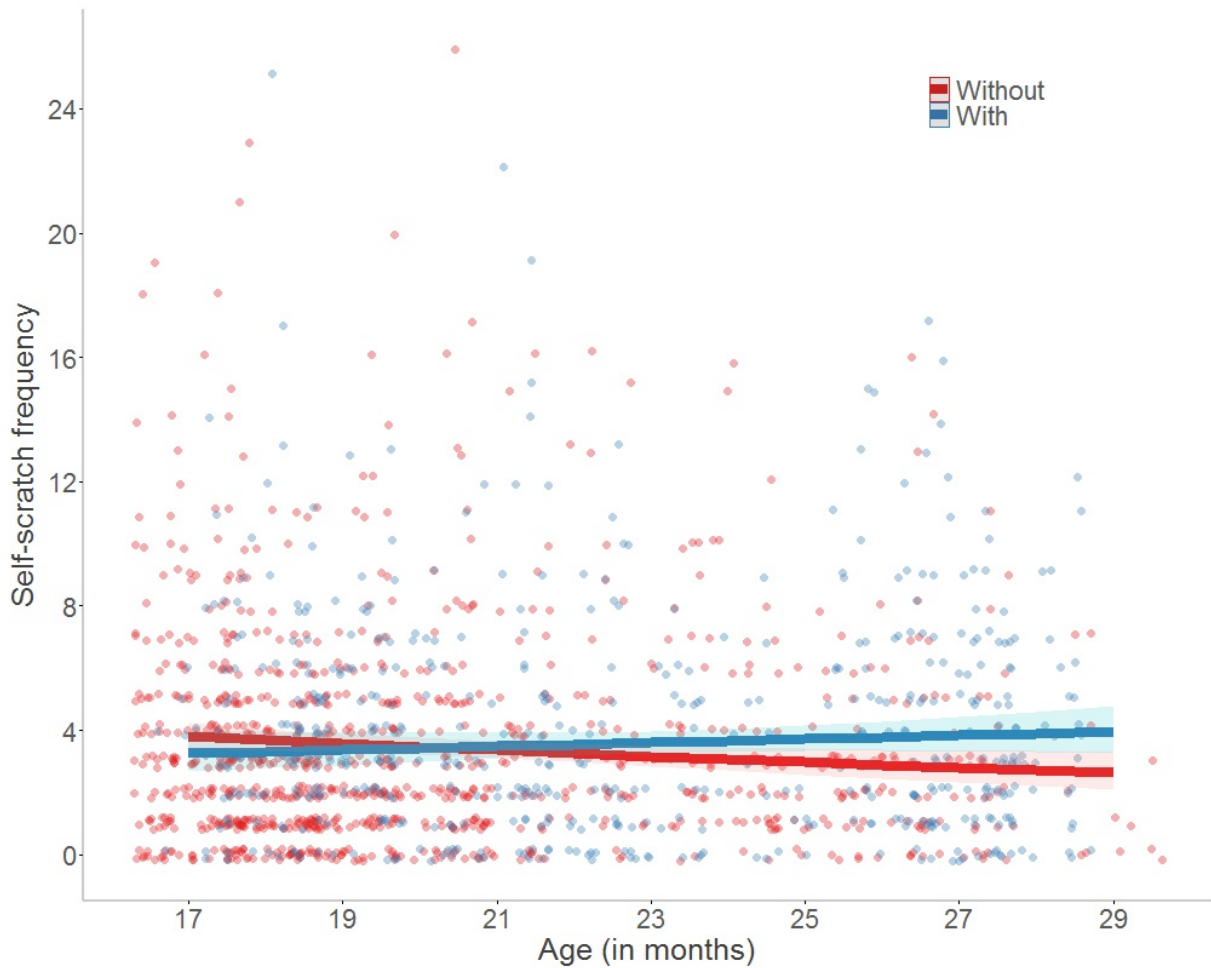
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925 # TABLES

926 *Table 1: Determinants of the occurrence of grooming between the mother and the juvenile*

Response variable	Fixed factor	Levels	Estimate	CI		LRT	P-value
				2.5 %	97.5 %		
Model 1: Probability to groom the mother	Intercept		-2.524	-3.063	-1.985	-	-
	Presence of a younger sibling (No)	Yes	**0.539**	**0.023**	**1.054**	**4.107**	**0.043**
	Juvenile's age		**0.397**	**0.117**	**0.678**	**9.026**	**0.003**
	Juvenile's sex (Female)	Male	**-1.476**	**-2.106**	**-0.846**	**20.622**	**<0.001**
	Juvenile's birth rank (Later-born)	First-born	0.184	-0.534	0.901	0.246	0.620
	Mother's rank		0.060	-0.222	0.342	0.171	0.679
	Troop (J)	L	0.133	-0.491	0.758	3.294	0.193
		M	-0.889	-2.035	0.257		
	Focal observation duration		0.065	-0.137	0.266	0.394	0.530
	Full –Null model comparison: X^2_2 = 46.605, $P < 0.001$ (AIC full = 711.11, AIC null = 741.71)						
Model 2: Probability to be groomed by the mother	Intercept		-1.632	-1.993	-1.270	-	-
	Presence of a younger sibling (No)	Yes	-0.114	-0.495	0.268	0.350	0.554

Juvenile's age		-0.179	-0.371	0.013	3.693	0.055
Juvenile's sex (Female)	Male	-0.234	-0.601	0.133	1.828	0.176
Juvenile's birth rank (Later-born)	First-born	-0.189	-0.679	0.301	0.603	0.437
Mother's rank		-0.017	-0.199	0.166	0.042	0.838
Troop (J)	L	0.099	-0.306	0.504	5.373	0.068
	M	-0.638	-1.291	0.016		
Focal observation duration		0.141	-0.009	0.292	3.515	0.061

Full-Null model comparison: X^2_2 = 17.211, P = 0.028 (AIC full = 1252.8, AIC null = 1254.0)

927 *Table 1: Results of the mixed models analyzing the probability for a juvenile to groom (model 1) or to receive (model 2) a grooming from its mother during a focal observation. Estimates, 95%*
928 *confidence intervals (CI), LRT statistics and p-values of the predictors were estimated using 1525 focal observations on 38 juveniles (N=18 with a younger sibling, N=28 without). Juvenile*
929 *identity was included as random effect. For categorical predictors, the reference category is indicated between parentheses. Significant effects are indicated in bold. We provided AIC values to*
930 *clarify which model performed best in case the full-null model comparison was significant.*

931

932   *Table 2: Determinants of the grooming time exchanged between the mother and the juvenile*

Response variable	Fixed factor	Levels	Estimate	CI 2.5 %	97.5 %	LRT	*P-value*
Model 3: Time spent	Intercept		-4.460	-5.147	-3.773	-	-
grooming the mother	**Presence of a younger sibling (No)**	**Yes**	**0.519**	**0.032**	**1.007**	**4.284**	**0.038**
	Juvenile's age		**0.394**	**0.128**	**0.660**	**9.957**	**0.002**
	Juvenile's sex (Female)	**Male**	**-1.454**	**-2.068**	**-0.840**	**21.161**	**<0.001**
	Juvenile's birth rank (Later-born)	First-born	0.147	-0.540	0.834	0.172	0.678
	Mother's rank		0.061	-0.212	0.334	0.187	0.665
	Troop (J)	L	0.152	-0.448	0.752		
		M	-0.879	-2.002	0.244	3.544	0.170

Full-Null model comparison: X^2_2 = 48.106, P < 0.001 (AIC full = 2135.7, AIC null = 2169.8)

Response variable	Fixed factor	Levels	Estimate	CI 2.5 %	97.5 %	LRT	*P-value*
Model 4: Time spent	Intercept		-3.357	-3.793	-2.922	-	-
being groomed by the	Presence of a younger sibling (No)	Yes	-0.126	-0.459	0.207	0.552	0.458
mother	Juvenile's age		-0.167	-0.338	0.003	3.650	0.056
	Juvenile's sex (Female)	Male	-0.229	-0.546	0.087	1.902	0.168

		Estimate	CI lower	CI upper	LRT	P
Juvenile's birth rank (Later-born)	First-born	-0.171	-0.589	0.247	0.667	0.414
Mother's rank		-0.015	-0.171	0.142	0.033	0.855
Troop (J)	L	**0.142**	**-0.209**	**0.493**	**6.098**	**0.047**
	M	**-0.615**	**-1.206**	**-0.024**		

Full-Null model comparison: X^2_2 = 14.867, P = 0.038 (AIC full = 4368.7, AIC null = 4369.6)

933   *Table 1 : Results of the mixed models analyzing the grooming time (in seconds) given to the mother (Model 3) or received from the mother (Model 4) by the juvenile during a focal observation.*
934   *Estimates, 95% confidence intervals (CI), LRT statistics and p-values of the predictors were estimated using 1525 focal observations on 38 juveniles (N=18 with a younger sibling, N=28 without).*
935   *Juvenile identity was included as a random effect. For categorical predictors, the reference category is indicated between parentheses. Significant effects are indicated in bold. We provided AIC*
936   *values to clarify which model performed best in case the full-null model comparison was significant.*

937

938 *Table 3: Determinants of the spatial proximity between the mother and the juvenile*

Response variable	Fixed factor	Levels	Estimate	CI		LRT	*P-value*
				2.5 %	**97.5 %**		
Model 5: Probability	Intercept		-1.913	-2.238	-1.588	-	-
to be within 1m from	Presence of a younger sibling (No)	Yes	-0.080	-0.427	0.266	0.405	0.524
the mother	Juvenile's age		**-0.208**	**-0.383**	**-0.033**	**5.480**	**0.019**
	Juvenile's sex (Female)	Male	**-0.629**	**-0.970**	**-0.288**	**13.242**	**<0.001**
	Juvenile's birth rank (Later-born)	First-born	-0.240	-0.693	0.213	1.161	0.281
	Mother's rank		0.103	-0.064	0.271	1.810	0.179
	Troop (J)	L	-0.015	-0.397	0.367		
		M	-0.412	-0.978	0.154	2.623	0.269

Full-Null model comparison: X^2_2 = 27.008, P < 0.001 (AIC full = 1607.7, AIC null =1620.7)

Model 6: Probability	Intercept		-1.695	-1.967	-1.423	-	-
to be within 5m from	Presence of a younger sibling (No)	Yes	0.115	-0.175	0.405	0.632	0.427
the mother	Juvenile's age		**-0.223**	**-0.365**	**-0.081**	**10.120**	**0.001**
	Juvenile's sex (Female)	Male	**-0.331**	**-0.598**	**-0.064**	**5.432**	**0.020**
	Juvenile's birth rank (Later-born)	First-born	0.036	-0.320	0.392	0.040	0.842

Mother's rank		**0.189**	**0.055**	**0.323**	**6.408**	**0.011**
Troop (J)	L	0.034	-0.283	0.352		
	M	0.443	0.074	0.812	5.178	0.075

Full-Null model comparison: X^2_2 = 25.398, P < 0.001 (AIC full = 2195.2, AIC null =2206.6)

939 *Table 2 : Results of the mixed models analyzing the probability for a juvenile to be within 1 meter (model 5) or within 5 meters (model 6) from its mother during a scan observation. Estimates,*
940 *95% confidence intervals (CI), LRT statistics and p-values of the predictors were estimated using 2562 and 2532 scan observations respectively, on 38 juveniles (N=18 with a younger sibling,*
941 *N=28 without). Juvenile identity was included as random effect. For categorical predictors, the reference category is indicated between parentheses. Significant effects are indicated in bold. We*
942 *provided AIC values to clarify which model performed best in case the full-null model comparison was significant.*

943

944   *Table 4: Determinants of proximity maintenance by the juvenile*

Response variable	Fixed factor	Levels	Estimate	CI		LRT	*P-value*
				2.5 %	97.5 %		
Model 7: Probability to approach the mother	Intercept		-1.572	-1.906	-1.237	-	-
	Presence of a younger sibling (No)	Yes	**0.552**	**0.225**	**0.879**	**10.628**	**0.001**
	Juvenile's age		**-0.207**	**-0.374**	**-0.039**	**5.864**	**0.015**
	Juvenile's sex (Female)	Male	-0.160	-0.479	0.159	0.973	0.324
	Juvenile's birth rank (Later-born)	First-born	-0.099	-0.540	0.342	0.197	0.657
	Mother's rank		**0.175**	**0.019**	**0.330**	**4.430**	**0.035**
	Troop (J)	L	**-0.123**	**-0.502**	**0.257**		
		M	**0.571**	**0.113**	**1.029**	**7.373**	**0,025**
	Focal observation duration		**0.139**	**0.003**	**0.275**	**4.148**	**0.042**

Full-Null model comparison: X^2_2 = 26.202, *P* < 0.001 (AIC full = 1505.2, AIC null = 1515.4)

Response variable	Fixed factor	Levels	Estimate	CI		LRT	*P-value*
Model 8: Probability to leave the mother	Intercept		-1.726	-2.087	-1.365	-	-
	Presence of a younger sibling (No)	Yes	**0.538**	**0.186**	**0.891**	**9.402**	**0.002**
	Juvenile's age		**-0.185**	**-0.366**	**-0.003**	**4.534**	**0.033**

		Estimate	CI lower	CI upper	LRT	p-value
Juvenile's sex (Female)	Male	**-0.421**	**-0.770**	**-0.072**	**6.168**	**0.013**
Juvenile's birth rank (Later-born)	First-born	-0.089	-0.565	0.388	0.099	0.753
Mother's rank		**0.194**	**0.024**	**0.364**	**5.493**	**0.019**
Troop (J)	L	**-0.119**	**-0.521**	**0.284**	**9.065**	**0.011**
	M	**0.665**	**0.173**	**1.157**		
Focal Observation duration		0.069	-0.075	0.213	0.916	0.338

Full-Null model comparison: X^2_2 = 25.193, P = 0.001 (AIC full = 1340.8, AIC null = 1350.0)

945 *Table 3 : Results of the mixed models analyzing the probability for a juvenile to approach (model 7) or to leave (model 8) its mother within 1 meter during a focal observation. Estimates, 95%*
946 *confidence intervals (CI), LRT statistics and p-values of the predictors were estimated using 1525 focal observations on 38 juveniles (N=18 with a younger sibling, N=28 without). Juvenile*
947 *identity was included as random effect. For categorical predictors, the reference category is indicated between parentheses. Significant effects are indicated in bold. We provided AIC values to*
948 *clarify which model performed best in case the full-null model comparison was significant.*

949

Table 5: Determinants of proximity maintenance by the mother

Response variable	Fixed factors	Levels	Estimate	CI		LRT	P-value
				2.5 %	97.5 %		
Model 9: Probability to	Intercept		-3.177	-3.758	-2.596	-	-
be approached by the	Presence of a younger sibling (No)	Yes	-0.512	-1.201	0.177	-	-
mother	Juvenile's age		0.050	-0.211	0.311	0.100	0.752
	Juvenile's sex (Female)	Male	-0.557	-1.189	0.075	-	-
	Juvenile's birth rank (Later-born)	First-born	0.233	-0.448	0.914	0.484	0.486
	Mother's rank		**0.556**	**0.286**	**0.827**	**18.123**	**<0.001**
	Troop (J)	L	**0.792**	**0.203**	**1.382**	**17.726**	**<0.001**
		M	**1.430**	**0.743**	**2.117**		
	Focal observation duration		0.156	-0.062	0.373	1.943	0.163
	Presence of a younger sibling (No)*Juvenile's sex (Female)	Yes, Male	**1.138**	**0.156**	**2.119**	**6.070**	**0.014**

Full-Null model comparison: X^2_2 = 30.352, $P < 0.001$ (AIC full = 712.29, AIC null = 724.65)

	Intercept		-1.919	-2.295	-1.544	-	-

Model 10: Probability to be left by the mother	Presence of a younger sibling (No)	Yes	0.254	-0.121	0.629	1.751	0.186
	Juvenile's age		-0.134	-0.325	0.056	1.943	0.163
	Juvenile's sex (Female)	Male	-0.273	-0.638	0.093	2.034	0.154
	Juvenile's birth rank (Later-born)	First-born	-0.370	-0.893	0.153	2.066	0.151
	Mother's rank		0.011	-0.169	0.190	0.014	0.907
	Troop (J)	L	0.171	-0.260	0.602	1.531	0.465
		M	0.339	-0.203	0.882		
	Focal observation duration		**0.188**	**0.028**	**0.347**	**5.557**	**0.018**

Full-Null model comparison: X^2_2 = 13.902, P = 0.084 (AIC full = 1197.5, AIC null = 1195.4)

951 *Table 4 : Results of the mixed models analyzing the probability for a juvenile to be approached (model 9) or left (model 10) within 1 meter by its mother during a focal observation. Estimates,*
952 *95% confidence intervals (CI), LRT statistics and p-values of the predictors were estimated using 1525 focal observations on 38 juveniles (N=18 with a younger sibling, N=28 without). Juvenile*
953 *identity was included as random effect. For categorical predictors, the reference category is indicated between parentheses. Significant effects are indicated in bold. Whenever an interaction is*
954 *significant, LRT and* p-values *for the simple predictors are not shown. We provided AIC values to clarify which model performed best in case the full-null model comparison was significant.*

955

956   *Table 6: Determinants of the juvenile's anxiety*

Fixed factor	Levels	Estimate	CI 2.5 %	97.5 %	LRT	*P-value*
Intercept		-5.814	-5.966	-5.661	-	-
Presence of a younger sibling (No)	Yes	0.040	-0.102	0.183	-	-
Juvenile's age		-0.110	-0.197	-0.023	-	-
Juvenile's sex (Female)	Male	0.050	-0.082	0.182	0.536	0.464
Juvenile's birth rank (Later-born)	First-born	-0.105	-0.286	0.075	1.266	0.260
Mother's rank		-0.065	-0.132	0.001	3.498	0.061
Troop (J)	L	**0.008**	**-0.138**	**0.154**	**10.806**	**0.005**
	M	**-0.358**	**-0.565**	**-0.150**		
Year (2017)	2018	**-0.317**	**-0.518**	**-0.115**	**14.086**	**0.001**
	2019	**0.085**	**-0.059**	**0.228**		
Presence of a younger sibling (No)*juvenile's age	Yes	**0.166**	**0.036**	**0.296**	**5.873**	**0.015**

Full-Null model comparison: X^2_2 = 26.07, *P* = 0.004 (AIC full = 7158.1, AIC null = 7164.1)

957   *Table 5 : Results of the mixed models analyzing the frequency of self-scratches during a focal observation (model 11). Estimates, 95% confidence intervals (CI), LRT statistics and p-values of the*
958   *predictors were estimated using 1523 focal observations on 38 juveniles (N=18 with a younger sibling, N=28 without). Juvenile identity was included as random effect. For categorical*
959   *predictors, the reference category is indicated between parentheses. Significant effects are indicated in bold. Whenever an interaction is significant, LRT and p-values for the simple predictors*
960   *are not shown. We provided AIC values to clarify which model performed best in case the full-null model comparison was significant.*

Table A1: Summary of all models included in the study

Model Number	Response variable	Model type	Sample size (number of observations/number of juveniles)	Fixed effects	Random effects	Offset
1	Probability to groom the mother	Binomial GLMM	1525/38	Presence of a younger sibling, juvenile's age, sex and birth rank, maternal rank, troop, focal duration	Juvenile identity	NA
2	Probability to be groomed by the mother	Binomial GLMM	1525/38	Presence of a younger sibling, juvenile's age, sex and birth rank, maternal rank, troop, focal duration	Juvenile identity	NA
3	Total time grooming the mother	Negative binomial GLMM	1525/38	Presence of a younger sibling, juvenile's age, sex and birth rank, maternal rank, troop	Juvenile identity	Focal duration
4	Total time being groomed by the mother	Negative binomial GLMM	1525/38	Presence of a younger sibling, juvenile's age, sex and birth rank, maternal rank, troop	Juvenile identity	Focal duration

5	Probability to be within 1m from the mother	Binomial GLMM	2562/38	Presence of a younger sibling, juvenile's age, sex and birth rank, maternal rank, troop, focal duration	Juvenile identity	NA
6	Probability to be within 5m from the mother	Binomial GLMM	2532/38	Presence of a younger sibling, juvenile's age, sex and birth rank, maternal rank, troop	Juvenile identity	NA
7	Probability to approach the mother	Binomial GLMM	1525/38	Presence of a younger sibling, juvenile's age, sex and birth rank, maternal rank, troop, focal duration	Juvenile identity	NA
8	Probability to leave the mother	Binomial GLMM	1525/38	Presence of a younger sibling, juvenile's age, sex and birth rank, maternal rank, troop, focal duration	Juvenile identity	NA
9	Probability to be approached by the mother	Binomial GLMM	1525/38	Presence of a younger sibling, juvenile's age, sex and birth rank, maternal rank, troop, focal	Juvenile identity	NA

				duration, presence of a younger sibling*juvenile's sex		
10	Probability to be left by the mother	Binomial GLMM	1525/38	Presence of a younger sibling, juvenile's age, sex and birth rank, maternal rank, troop, focal duration	Juvenile identity	NA
11	Frequency of self-scratch	Negative binomial GLMM	1523/38	Presence of a younger sibling, juvenile's age, sex and birth rank, maternal rank, troop	Juvenile identity	Focal duration

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Table A2: Determinants of the occurrence of grooming between the mother and the juvenile

Response variable	Fixed factor	Levels	Estimate	CI		LRT	*P-value*
				2.5 %	97.5 %		
Model S1: Probability to groom the mother	Intercept		-2.522	-3.071	-1.973	-	-
	Presence of a younger sibling (No)	Yes	0.542	0.001	1.082	3.829	0.050
	Juvenile's age		**0.395**	**0.077**	**0.712**	**6.344**	**0.012**
	Juvenile's sex (Female)	Male	**-1.477**	**-2.109**	**-0.845**	**20.623**	**<0.001**
	Juvenile's birth rank (Later-born)	First-born	0.175	-0.690	1.039	0.153	0.695
	Mother's rank		0.060	-0.222	0.343	0.172	0.678
	Number of immature older siblings		-0.006	-0.357	0.344	0.001	0.971
	Troop (J)	L	0.132	-0.495	0.759	3.228	0.199
		M	-0.893	-2.059	0.273		
	Focal observation duration		0.065	-0.137	0.266	0.391	0.532

Full-Null model comparison: $X^2_2 = 46.607$, $P < 0.001$ (AIC full = 713.11, AIC null = 741.11)

Model 1-Model S1 comparison: $X^2_2 = 0.0013$, $P = 0.971$ (AIC Model 1 = 711.11, AIC Model S1 = 713.11)

	Intercept		-1.648	-2.018	-1.277	-	-

Model S2: Probability to be groomed by the mother	Presence of a younger sibling (No)	Yes	-0.137	-0.537	0.263	0.476	0.490
	Juvenile's age		-0.154	-0.387	0.079	1.854	0.173
	Juvenile's sex (Female)	Male	-0.229	-0.596	0.137	1.770	0.183
	Juvenile's birth rank (Later-born)	First-born	-0.118	-0.734	0.498	0.125	0.723
	Mother's rank		-0.021	-0.205	0.162	0.066	0.798
	Number of immature older siblings		0.048	-0.209	0.305	0.168	0.682
	Troop (J)	L	0.107	-0.299	0.512	4.428	0.109
		M	-0.596	-1.285	0.093		
	Focal observation duration		0.142	-0.009	0.292	3.545	0.060

Full-Null model comparison: $X^2_2 = 17.379$, $P < 0.043$ (AIC full = 1254.6, AIC null = 1254.0)

Model 2-Model S2 comparison: $X^2_2 = 0.168$, $P = 0.682$ (AIC Model 2 = 1252.8, AIC Model S1 = 1254.6)

965 *Table A2: Results of the mixed models analyzing the probability for a juvenile to groom (model 1) or to receive (model 2) a grooming from its mother during a focal observation. Estimates, 95%*
966 *confidence intervals (CI), LRT statistics and p-values of the predictors were estimated using 1525 focal observations on 38 juveniles (N=18 with a younger sibling, N=28 without). Juvenile*
967 *identity was included as random effect. For categorical predictors, the reference category is indicated between parentheses. Significant effects are indicated in bold. We provided AIC values to*
968 *clarify which model performed best in case the full-null model comparison was significant.*

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Table A3: Determinants of the grooming time exchanged between the mother and the juvenile

Response variable	Fixed factor	Levels	Estimate	CI		LRT	P-value
				2.5 %	97.5 %		
Model S3: Time spent	Intercept		-4.459	-5.153	-3.765	-	-
grooming the mother	Presence of a younger sibling (No)	Yes	**0.521**	**0.009**	**1.032**	**3.978**	**0.046**
	Juvenile's age		**0.393**	**0.094**	**0.691**	**7.097**	**0.008**
	Juvenile's sex (Female)	Male	**-1.455**	**-2.071**	**-0.838**	**21.161**	**<0.001**
	Juvenile's birth rank (Later-born)	First-born	0.143	-0.683	0.969	0.112	0.738
	Mother's rank		0.061	-0.213	0.335	0.188	0.665
	Number of immature older siblings		-0.003	-0.335	0.329	0.000	0.985
	Troop (J)	L	0.152	-0.451	0.754	3.466	0.177
		M	-0.881	-2.024	0.262		

Full-Null model comparison: X^2_2 = 48.106, P < 0.001 (AIC full = 2137.7, AIC null = 2169.8)

Model 3-Model S3 comparison: X^2_2 = 0.0003, P = 0.986 (AIC Model 3 = 2135.7, AIC Model S3 = 2137.7)

	Intercept		-3.375	-3.814	-2.936	-	-
	Presence of a younger sibling (No)	Yes	-0.153	-0.500	0.194	0.749	0.387

Model S4: Time spent	Juvenile's age		-0.137	-0.342	0.067	1.730	0.188
being groomed by the	Juvenile's sex (Female)	Male	-0.226	-0.540	0.088	1.869	0.172
mother	Juvenile's birth rank (Later-born)	First-born	-0.084	-0.613	0.445	0.098	0.754
	Mother's rank		-0.020	-0.176	0.137	0.063	0.803
	Number of immature older siblings		0.058	-0.164	0.280	0.262	0.609
	Troop (J)	L	0.151	-0.197	0.499	5.062	0.080
		M	-0.566	-1.181	0.048		

Full-Null model comparison: X^2_2 = 15.129, P = 0.057 (AIC full = 4370.4, AIC null = 4369.6)

Model 4-Model S4 comparison: X^2_2 = 0.262, P = 0.609 (AIC Model 4 = 4368.7, AIC Model S4 = 4370.4)

971 *Table A3: Results of the mixed models analyzing the grooming time (in seconds) given to the mother (Model 3) or received from the mother (Model 4) by the juvenile during a focal observation.*
972 *Estimates, 95% confidence intervals (CI), LRT statistics and p-values of the predictors were estimated using 1525 focal observations on 38 juveniles (N=18 with a younger sibling, N=28 without).*
973 *Juvenile identity was included as a random effect. For categorical predictors, the reference category is indicated between parentheses. Significant effects are indicated in bold. We provided AIC*
974 *values to clarify which model performed best in case the full-null model comparison was significant.*

975

Table A4: Determinants of the spatial proximity between the mother and the juvenile

Response variable	Fixed factor	Levels	Estimate	CI		LRT	*P-value*
				2.5 %	**97.5 %**		
Model S5: Probability	Intercept		-1.896	-2.227	-1.566	-	-
to be within 1m from	Presence of a younger sibling (No)	Yes	-0.049	-0.417	0.319	0.182	0.670
the mother	Juvenile's age		**-0.240**	**-0.453**	**-0.027**	**4.948**	**0.026**
	Juvenile's sex (Female)	Male	**-0.636**	**-0.979**	**-0.292**	**13.418**	**<0.001**
	Juvenile's birth rank (Later-born)	First-born	-0.325	-0.879	0.230	1.368	0.242
	Mother's rank		0.106	-0.062	0.274	1.854	0.173
	Number of older immature siblings		-0.061	-0.288	0.166	0.251	0.617
	Troop (J)	L	-0.021	-0.407	0.364		
		M	-0.461	-1.057	0.134	2.875	0.237

Full-Null model comparison: $X^2_2 = 27.259$, $P < 0.001$ (AIC full = 1609.4, AIC null = 1620.7)

Model 5-Model S5 comparison: $X^2_2 = 0.251$, $P = 0.617$ (AIC Model 5 = 1607.7, AIC Model S5 = 1609.4)

Response variable	Fixed factor	Levels	Estimate	CI		LRT	*P-value*
Model S6: Probability	Intercept		-1.682	-1.961	-1.403	-	-
to be within 5m from	Presence of a younger sibling (No)	Yes	0.155	-0.164	0.474	0.968	0.325
the mother	Juvenile's age		**-0.256**	**-0.432**	**-0.080**	**9.135**	**0.003**

Juvenile's sex (Female)	Male	**-0.338**	**-0.610**	**-0.065**	**5.508**	**0.019**
Juvenile's birth rank (Later-born)	First-born	-0.046	-0.485	0.394	0.042	0.838
Mother's rank		**0.190**	**0.054**	**0.326**	**6.387**	**0.011**
Number of immature older siblings		-0.064	-0.256	0.128	0.439	0.508
Troop (J)	L	0.024	-0.303	0.351		
	M	0.388	-0.023	0.800	3.255	0.196

Full-Null model comparison: X^2_2 = 25.837, P = 0.001 (AIC full = 2196.7, AIC null = 2206.6)

Model 5-Model S5 comparison: X^2_2 = 0.439, P = 0.508 (AIC Model 6 = 2195.2, AIC Model S6 = 2196.7)

977 *Table A4: Results of the mixed models analyzing the probability for a juvenile to be within 1 meter (model 5) or within 5 meters (model 6) from its mother during a scan observation. Estimates,*
978 *95% confidence intervals (CI), LRT statistics and p-values of the predictors were estimated using 2562 and 2532 scan observations respectively, on 38 juveniles (N=18 with a younger sibling,*
979 *N=28 without). Juvenile identity was included as random effect. For categorical predictors, the reference category is indicated between parentheses. Significant effects are indicated in bold. We*
980 *provided AIC values to clarify which model performed best in case the full-null model comparison was significant.*

981

982 *Table A5: Determinants of proximity maintenance by the juvenile*

Response variable	Fixed factor	Levels	Estimate	CI		LRT	*P-value*
				2.5 %	97.5 %		
Model S7: Probability to	Intercept		-1.606	-1.943	-1.270	-	-
approach the mother	Presence of a younger sibling (No)	Yes	**0.503**	**0.163**	**0.844**	**8.293**	**0.004**
	Juvenile's age		-0.161	-0.356	0.034	2.655	0.103
	Juvenile's sex (Female)	Male	-0.149	-0.463	0.165	0.874	0.350
	Juvenile's birth rank (Later-born)	First-born	0.036	-0.490	0.562	0.018	0.894
	Mother's rank		**0.170**	**0.016**	**0.323**	**4.257**	**0.039**
	Number of immature older siblings		0.096	-0.123	0.315	0.734	0.392
	Troop (J)	L	**-0.104**	**-0.477**	**0.270**	**8.063**	**0,018**
		M	**0.662**	**0.168**	**1.157**		
	Focal observation duration		**0.141**	**0.005**	**0.277**	**4.275**	**0.039**

Full-Null model comparison: X^2_2 = 26.936, *P* = 0.001 (AIC full = 1506.5, AIC null = 1515.4)

Model 7-Model S7 comparison: X^2_2 = 0.0003, *P* = 0.734 (AIC Model 7 = 1505.2, AIC Model S7 = 1506.5)

| | Intercept | | -1.778 | -2.144 | -1.413 | - | - |

			Estimate	CI low	CI high	LRT	P
Model S8: Probability to leave the mother	Presence of a younger sibling (No)	Yes	**0.468**	**0.101**	**0.835**	**6.758**	**0.009**
	Juvenile's age		-0.116	-0.327	0.096	1.426	0.232
	Juvenile's sex (Female)	Male	**-0.407**	**-0.752**	**-0.062**	**5.915**	**0.015**
	Juvenile's birth rank (Later-born)	First-born	0.120	-0.452	0.692	0.223	0.637
	Mother's rank		**0.187**	**0.019**	**0.356**	**5.244**	**0.022**
	Number of immature older siblings		0.152	-0.088	0.393	1.691	0.194
	Troop (J)	L	**-0.100**	**-0.497**	**0.296**	**10.745**	**0.005**
		M	**0.803**	**0.269**	**1.338**		
	Focal Observation duration		0.073	-0.071	0.217	1.039	0.308

Full-Null model comparison: $X^2_2 = 26.884$, $P = 0.002$ (AIC full = 1341.1, AIC null = 1350.0)

Model 8-Model S8 comparison: $X^2_2 = 1.691$, $P = 0.196$ (AIC Model 8 = 1340.8, AIC Model S8 = 1341.1)

983 *Table A5: Results of the mixed models analyzing the probability for a juvenile to approach (model 7) or to leave (model 8) its mother within 1 meter during a focal observation. Estimates, 95%*
984 *confidence intervals (CI), LRT statistics and p-values of the predictors were estimated using 1525 focal observations on 38 juveniles (N=18 with a younger sibling, N=28 without). Juvenile*
985 *identity was included as random effect. For categorical predictors, the reference category is indicated between parentheses. Significant effects are indicated in bold. We provided AIC values to*
986 *clarify which model performed best in case the full-null model comparison was significant.*

987

Table A6: Determinants of proximity maintenance by the mother

Response variable	Fixed factors	Levels	Estimate	CI		LRT	P-value
				2.5 %	97.5 %		
Model S9: Probability to	Intercept		-3.163	-3.749	-2.577	-	-
be approached by the	Presence of a younger sibling (No)	Yes	-0.498	-1.191	0.195	-	-
mother	Juvenile's age		0.017	-0.292	0.325	0.006	0.941
	Juvenile's sex (Female)	Male	-0.585	-1.234	0.064	-	-
	Juvenile's birth rank (Later-born)	First-born	0.145	-0.659	0.949	0.155	0.694
	Mother's rank		**0.565**	**0.290**	**0.840**	**18.241**	**<0.001**
	Number of immature older siblings		-0.075	-0.438	0.289	0.141	0.707
	Troop (J)	L	**0.807**	**0.210**	**1.404**	**15.725**	**<0.001**
		M	**1.378**	**0.645**	**2.111**		
	Focal observation duration		0.154	-0.064	0.372	1.893	0.169
	Presence of a younger sibling (No)*Juvenile's sex (Female)	Yes, Male	**1.190**	**0.171**	**2.210**	**6.184**	**0.013**

Full-Null model comparison: X^2_2 = 30.493, $P < 0.001$ (AIC full = 714.15, AIC null = 724.65)

Model 9-Model S9 comparison: $X^2_2 = 0.141$, $P = 0.707$ (AIC Model 9 = 712.29, AIC Model S9 = 714.15)

Model S10: Probability to be left by the mother	Intercept		-1.977	-2.355	-1.599	-	-
	Presence of a younger sibling (No)	Yes	0.175	-0.213	0.563	0.779	0.377
	Juvenile's age		-0.055	-0.281	0.172	0.225	0.636
	Juvenile's sex (Female)	Male	-0.253	-0.612	0.107	1.788	0.181
	Juvenile's birth rank (Later-born)	First-born	-0.147	-0.763	0.470	0.222	0.638
	Mother's rank		0.000	-0.178	0.178	0.000	0.998
	Number of immature older siblings		0.157	-0.096	0.411	1.482	0.223
	Troop (J)	L	0.204	-0.214	0.623	2.578	0.276
		M	0.481	-0.095	1.057		
	Focal observation duration		**0.190**	**0.031**	**0.349**	**5.726**	**0.017**

Full-Null model comparison: $X^2_2 = 15.384$, $P = 0.081$ (AIC full = 1198.0, AIC null = 1195.4)

Model 10-Model S10 comparison: $X^2_2 = 1.482$, $P = 0.223$ (AIC Model 10 = 1197.5, AIC Model S10 = 1198.0)

989 *Table A6: Results of the mixed models analyzing the probability for a juvenile to be approached (model 9) or left (model 10) within 1 meter by its mother during a focal observation. Estimates,*
990 *95% confidence intervals (CI), LRT statistics and p-values of the predictors were estimated using 1525 focal observations on 38 juveniles (N=18 with a younger sibling, N=28 without). Juvenile*
991 *identity was included as random effect. For categorical predictors, the reference category is indicated between parentheses. Significant effects are indicated in bold. Whenever an interaction is*
992 *significant, LRT and p-values for the simple predictors are not shown. We provided AIC values to clarify which model performed best in case the full-null model comparison was significant.*

993

Table A7: Determinants of the juvenile's anxiety

Fixed factor	Levels	Estimate	CI		LRT	P-value
			2.5 %	97.5 %		
Intercept		-5.813	-5.971	-5.656	-	-
Presence of a younger sibling (No)	Yes	0.041	-0.113	0.194	-	-
Juvenile's age		-0.110	-0.209	-0.012	-	-
Juvenile's sex (Female)	Male	0.050	-0.083	0.182	0.529	0.467
Juvenile's birth rank (Later-born)	First-born	-0.106	-0.325	0.112	0.880	0.348
Mother's rank		-0.065	-0.132	0.001	3.476	0.062
Number of older immature siblings		-0.001	-0.090	0.089	0.000	0.989
Troop (J)	L	**0.008**	**-0.140**	**0.156**	**9.775**	**0.008**
	M	**-0.358**	**-0.578**	**-0.138**		
Year (2017)	2018	**-0.316**	**-0.519**	**-0.114**	**13.809**	**0.001**
	2019	**0.085**	**-0.060**	**0.230**		
Presence of a younger sibling (No)*juvenile's age	Yes	**0.166**	**0.036**	**0.296**	**5.866**	**0.015**

Full-Null model comparison: X^2_2 = 26.07, P = 0.006 (AIC full = 7160.1, AIC null = 7164.1)

Model 11-Model S11 comparison: X^2_2 = 0.0002, P = 0.989 (AIC Model 11 = 7158.1, AIC Model S11 = 7160.1)

995 *Table A7: Results of the mixed models analyzing the frequency of self-scratches during a focal observation (model S11). Estimates, 95% confidence intervals (CI), LRT statistics and p-values of*
996 *the predictors were estimated using 1523 focal observations on 38 juveniles (N=18 with a younger sibling, N=28 without). Juvenile identity was included as random effect. For categorical*
997 *predictors, the reference category is indicated between parentheses. Significant effects are indicated in bold. Whenever an interaction is significant, LRT and p-values for the simple predictors*
998 *are not shown. We provided AIC values to clarify which model performed best in case the full-null model comparison was significant.*

999

Appendix 1: Test of the newborn attraction hypothesis

To estimate if juveniles were approaching their mother to access the newborn, we used focal data on the 18 juveniles who experienced the birth of a younger sibling within the last three months. Each time the juvenile approached their mother within 1m, we calculated whether the juvenile initiated an interaction with the newborn and/or the mother (yes=1, no=0) within one minute following the approach, or until one of them left if a leave happened less than one minute after the approach. We considered the following interactions: grooming, playing (with the newborn only), affiliative and aggressive interactions. For interactions with the newborn, we considered only the interactions initiated by the juvenile because young baboon infants tend to touch or climb on individuals interacting with their mother. For interactions with the mother, we considered interactions initiated both by the juvenile and its mother. We then calculated the percentage of approach followed by an interaction with the newborn (whether the juvenile interacted with the newborn only or both with the mother and the newborn) or with the mother (the juvenile interacted with the mother only).