**Supplementary Material**

**Use and function of multi-articulator versus multi-sensory acts in the close-range communication of orang-utans**

Marlen Fröhlich, Natasha Bartolotta, Caroline Fryns, Colin Wagner, Laurene Momon, Marvin Jaffrezic, Tatang Mitra Setia, Maria van Noordwijk, Carel P. van Schaik

**Additional information**

**Results**

*Use of specific modalities.*We found that communicative acts were purely visual in 23% of cases, contained salient tactile components in 75 %, salient auditory components in 3%, and salient seismic components in 0.9%. (see Tab. 2). The full model was a better fit than the null model for visual and tactile acts only (LRT for visual acts: *χ*27 = 54.085, P < 0.001; tactile acts: *χ*27 = 50.647, P < 0.001; *N* = 7587). More specifically, there was a significant interaction between species and setting for visual and tactile acts: wild Bornean orang-utans employed more tactile and fewer purely visual acts than any other species-setting combination (Tab. S4, Fig. S1). Tactile acts were significantly more common in mother-infant interactions (Fig. S1) at the expense of purely visual acts (Tab. S4). In addition, tactile acts were more often directed at younger partners at the expense of purely visual acts. For effects of the control variables see Table S4.

*Use of specific articulators.*With regard to the use of specific articulators, results showed that communicative acts involved manual acts in 66% of observed cases, bodily acts in 24%, facial acts in 2%, and vocal acts in 3% of cases (see Tab. 2). Gaze was involved in 61 % of communicative acts. The full model was a better fit than the null model for the response variables manual, bodily and gaze acts (LRT for manual acts: *χ*27 = 34.338, *P* < 0.001; bodily acts: *χ*27 = 28.565, *P* < 0.001; gaze: *χ*27 =33.087, *P* < 0.001). More specifically, we found a significant interaction between species and setting for the use of bodily acts and gaze: bodily acts played a larger role in captive Sumatrans compared to the other species-setting classes (Tab. S4, Fig. S2), whereas gaze accompanied interactions significantly less often in captive (and especially Bornean) compared to wild orang-utans (Tab. S4, Fig. S3). We also found a significant impact of kinship: manual acts were significantly more common in interactions among mother-infant dyads (Tab. S4) and other maternal kin, whereas communicative acts among mother-infant dyads were less likely to involve gaze (Tab. S4, Fig. S3) than those among other interaction dyads. The proportion of manual acts was significantly more common in interactions with younger individuals. For effects of non-significant key predictors and those of control variables see Table S4.

**Tables**

**Tab. S1** Information in study subjects and sample size (Bor = Bornean orang-utan, Sum = Sumatran orang-utan, Ad = adult, Im = older immature, Dp = young immature).

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **No subject** | **Setting** | **Species** | **Group** | **ID** | **Age group** | **Sex** | **N Comm. acts** | |
| 1 | captive | Bor | Apenheul | BAJ | Dp | M | 65 |
| 2 | captive | Bor | Cologne | BUD | Im | M | 25 |
| 3 | captive | Bor | Cologne | CAJ | Ad | F | 42 |
| 4 | captive | Bor | Cologne | CIR | Dp | F | 86 |
| 5 | captive | Bor | Cologne | CIT | Dp | F | 60 |
| 6 | captive | Bor | Cologne | COR | Ad | F | 31 |
| 7 | captive | Bor | Apenheul | KAW | Im | M | 59 |
| 8 | captive | Bor | Munster | MAN | Ad | F | 34 |
| 9 | captive | Bor | Munster | MIY | Dp | M | 79 |
| 10 | captive | Bor | Munster | NIA | Im | F | 12 |
| 11 | captive | Bor | Munster | SAR | Ad | F | 17 |
| 12 | captive | Bor | Apenheul | WAT | Ad | F | 67 |
| 13 | captive | Sum | Munich | BRU | Ad | M | 11 |
| 14 | captive | Sum | Zurich | CAH | Ad | F | 82 |
| 15 | captive | Sum | Zurich | DJA | Ad | M | 22 |
| 16 | captive | Sum | Zurich | HAD | Im | M | 103 |
| 17 | captive | Sum | Munich | ISO | Im | F | 132 |
| 18 | captive | Sum | Munich | JAH | Ad | F | 58 |
| 19 | captive | Sum | Munich | JOL | Im | F | 70 |
| 20 | captive | Sum | Zurich | MAL | Im | M | 342 |
| 21 | captive | Sum | Munich | MAT | Ad | F | 70 |
| 22 | captive | Sum | Zurich | MIM | Dp | F | 208 |
| 23 | captive | Sum | Zurich | PAN | Dp | F | 199 |
| 24 | captive | Sum | Munich | QUE | Dp | M | 287 |
| 25 | captive | Sum | Munich | QUI | Dp | M | 102 |
| 26 | captive | Sum | Zurich | RIA | Dp | F | 99 |
| 27 | captive | Sum | Munich | RON | Dp | F | 197 |
| 28 | captive | Sum | Munich | SIT | Ad | F | 129 |
| 29 | captive | Sum | Zurich | TIM | Ad | F | 50 |
| 30 | captive | Sum | Zurich | XIR | Ad | F | 52 |
| 31 | wild | Bor | Tuanan | JAN | Dp | F | 320 |
| 32 | wild | Bor | Tuanan | JUN | Ad | F | 96 |
| 33 | wild | Bor | Tuanan | ANA | Dp | F | 16 |
| 34 | wild | Bor | Tuanan | CAK | Dp | M | 124 |
| 35 | wild | Bor | Tuanan | CIA | Ad | F | 45 |
| 36 | wild | Bor | Tuanan | DAN | Im | M | 17 |
| 37 | wild | Bor | Tuanan | DAR | Dp | M | 330 |
| 38 | wild | Bor | Tuanan | DES | Ad | F | 144 |
| 39 | wild | Bor | Tuanan | IBU | Ad | F | 1 |
| 40 | wild | Bor | Tuanan | KEC | Dp | M | 54 |
| 41 | wild | Bor | Tuanan | KER | Ad | F | 223 |
| 42 | wild | Bor | Tuanan | KET | Dp | M | 467 |
| 43 | wild | Bor | Tuanan | KON | Ad | F | 69 |
| 44 | wild | Bor | Tuanan | MAW | Im | F | 46 |
| 45 | wild | Bor | Tuanan | MER | Dp | M | 418 |
| 46 | wild | Bor | Tuanan | MIL | Ad | F | 119 |
| 47 | wild | Bor | Tuanan | MIN | Ad | F | 100 |
| 48 | wild | Bor | Tuanan | MOB | Dp | F | 390 |
| 49 | wild | Bor | Tuanan | TIN | Ad | F | 59 |
| 50 | wild | Bor | Tuanan | TUK | Dp | M | 125 |
| 51 | wild | Bor | Tuanan | UNF | Ad | M | 67 |
| 52 | wild | Sum | Suaq | FRI | Ad | F | 44 |
| 53 | wild | Sum | Suaq | AMO | Dp | M | 5 |
| 54 | wild | Sum | Suaq | BEO | Ad | M | 6 |
| 55 | wild | Sum | Suaq | CIN | Dp | F | 225 |
| 56 | wild | Sum | Suaq | CIS | Ad | F | 41 |
| 57 | wild | Sum | Suaq | EDE | Dp | F | 391 |
| 58 | wild | Sum | Suaq | ELL | Ad | F | 113 |
| 59 | wild | Sum | Suaq | FRA | Dp | M | 371 |
| 60 | wild | Sum | Suaq | KRO | Im | M | 45 |
| 61 | wild | Sum | Suaq | LIL | Ad | F | 43 |
| 62 | wild | Sum | Suaq | LIS | Ad | F | 34 |
| 63 | wild | Sum | Suaq | LOI | Dp | M | 164 |
| 64 | wild | Sum | Suaq | LUT | Dp | M | 313 |
| 65 | wild | Sum | Suaq | NIB | Ad | M | 6 |
| 66 | wild | Sum | Suaq | PEP | Dp | M | 38 |
| 67 | wild | Sum | Suaq | PIN | Ad | F | 13 |
| 68 | wild | Sum | Suaq | TIA | Ad | F | 22 |
| 69 | wild | Sum | Suaq | TOR | Dp | M | 92 |
| 70 | wild | Sum | Suaq | UNF | Ad | M | 6 |
| 71 | wild | Sum | Suaq | YUL | Im | F | 8 |

**Tab. S2** Information on variables coded using BORIS

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Variable and levels** | **Coding type** | **Description** |  |  |
| **Presumed goal** | single-select | Apparent aim of the signaller (S), based on the individuals involved and the immediate social context in which the interaction occurs |  |  |
| Food/object share |  | Share/hand over food item or object with signaller |  |  |
| Groom |  | Groom S |  |  |
| Move away |  | Move away from S |  |  |
| Play/affiliate |  | Play or physically affiliate |  |  |
| Sexual contact |  | Engage in sexual contact |  |  |
| Stop action |  | Stop a certain behaviour (e.g. begging) from R |  |  |
| Joint travel |  | Initiate or coordinate joint travel |  |  |
| **Body part** | multi-select | Body part(s) used by the signaller to execute behaviour/gesture/etc. |  |  |
| Arm-R |  | Right arm |  |  |
| Arm-L |  | Left arm |  |  |
| Hand-R |  | Right hand |  |  |
| Hand-L |  | Left hand |  |  |
| Leg-R |  | Right leg |  |  |
| Leg-L |  | Left leg |  |  |
| Foot-R |  | Right foot |  |  |
| Foot-L |  | Left foot |  |  |
| Head |  | Head and eyes |  |  |
| Front |  | Front |  |  |
| Torso |  | Torso |  |  |
| Mouth/lips |  | Mouth/lips |  |  |
| Other |  | Other |  |  |
| NA |  | Na |  |  |
| **Modality** | multi-select | Sensory modaility in which the signal is perceived by the recipient |  |  |
| Auditory |  | S's behaviour produces a sound and is perceived through hearing |  |  |
| Visual |  | S's behaviour is perceived via eye sight |  |  |
| Seismic |  | S's behaviour is perceived through substrate movement *(like vibration = indirect mechanic modality)* |
| Tactile |  | S's behaviour is perceived through body contact |  |  |
| **Distance** | single-select | Physical distance between S and R BEFORE signal/behaviour is executed (g.g. Before R is touched) |
| Body contact |  | S and R are in body contact |  |  |
| Within arm's reach |  | No body contact, but S could (theoretically) touch R if he stretches out arm/leg | |  |
| Same tree/substrate |  | S and R sit on/are attached to same substrate (e.g. Branch, liana, tree log) | |  |
| Different tree/substrate |  | S and R sit on/are attached to different substrate (e.g. Branch, liana, tree log) | |  |
| NA |  | Not clearly visible, unknown |  |  |
| **Objects** | single-select | Objects involved by signaller in behaviour/interaction |  |  |
| None |  | No object involved |  |  |
| Immobile |  | Immobile object involved, e.g. tree branch that is still attached to tree |  |  |
| Mobile |  | Mobile object involved, e.g. loose branch, stone, stick, leaf…. |  |  |
| NA |  | Not clearly visible, unknown |  |  |
| **Gaze direction** | single-select | Visual orientation of signaller as determined by head/eye direction |  |  |
|  |  |  |  |  |
| At recipient |  | S’s head directed towards R |  |  |
| Mutual gaze |  | S’s head directed towards R and vice versa |  |  |
| At object |  | S’s head directed towards object (e.g. food item, toy) held/eaten by R |  |  |
| Alt between obj and rec | | S alternates head direction between R and object |  |  |
| Other |  | S’s head directed neither towards R nor towards object held/eaten by R |  |  |
| NA |  | Not clearly visible, unknown |  |  |
| **Attentional state** | single-select | Visual orientation of recipient (R) during S's behaviour |  |  |
| In visual field |  | S is in the R’s visual field, i.e. The R can see the S without moving his or her head | |  |
| 90 degrees |  | S is in the periphery of the R’s visual field (ca. 90 degrees), i.e. R can see the S from the corner of his/her eye. |
| Rec turned away |  | S is not in the R’s visual field, that is the R would have to make a major turn with his/her head or body to see the S |
| NA |  | Not clearly visible, unknown |  |  |
| **Interaction outcome** | single-select | Response of recipient in reaction to S's behaviour |  |  |
| No reaction |  | No discernible response by R |  |  |
| ASO |  | "Apparently Satisfactory Outcome": R responds in a way that seems to satisfy S, in that no more communicative acts are produced |
| Responds w/ comm. Act |  | R responds with a signal - "negotiation" |  |  |
| Visual attention | | R’s head directed towards S, but no other response |  |  |
| Move away |  | R moves away from S |  |  |
| Agonistic |  | R reacts in an aggressive or agonistic way to S's behaviour |  |  |
| NA |  | Not clearly visible, unknown |  |  |

**Tab. S3** Distribution of coded interactions across settings, species and interaction dyads (mother-offspring: interactions among mothers and their dependent unweaned offspring; interactions among maternal kin other than mother-dependent offspring, other: all other interaction dyads).

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Captive | | Wild | | Total |
| Interaction dyad | Bornean | Sumatran | Bornean | Sumatran |  |
| mother-offspring | 330 | 465 | 2208 | 1263 | 4266 |
| maternal kin | 131 | 933 | 517 | 226 | 1807 |
| Other | 116 | 788 | 187 | 423 | 1514 |
| **Total** | **577** | **2186** | **2912** | **1912** | **7587** |

**Tab. S4** Effects of research setting, orang-utan species, age difference, kinship and control predictors on the employment of different sensory modalities (a-c) and articulators (d-g), derived using GLMMs with a binomial error structure (a-e, g: N = 7578, f with N = 7096). Significant effects (P < 0.05) are depicted in italics.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **(a) Visual** | Estimate | | SE | *χ*21 | *P* |
| Intercept | 0.129 | 0.36 | | — | — |
| Setting [wild] | -2.29 | 0.318 | | — | — |
| Species [Sumatran] | -0.542 | 0.274 | | — | — |
| Age group [dependent] | -0.628 | 0.307 | | 0.539 | 0.463 |
| Age group [immature] | -0.558 | 0.301 | | 2.804 | 0.094 |
| *Sex [male]* | *-0.338* | *0.159* | | *4.774* | *0.029* |
| *Age diff. [younger]* | *-0.417* | *0.285* | | *11.092* | *0.001* |
| Age diff. [older] | 0.03 | 0.203 | | 0.654 | 0.419 |
| *Kinship [mother]* | *-0.953* | *0.188* | | *17.938* | *<0.001* |
| Kinship [mat. kin] | -0.175 | 0.194 | | 0.126 | 0.722 |
| Context [share] | 0.877 | 0.181 | | 0.051 | 0.821 |
| *Context [play]* | *0.011* | *0.142* | | *5.059* | *0.024* |
| *Setting x species* | *2.594* | *0.39* | | *19.112* | *<0.001* |
| **(b) Tactile** |  | |  |  |  | |
| Intercept | -0.208 | | 0.41 | — | — | |
| Setting [wild] | 2.235 | | 0.358 | — | — | |
| Species [Sumatran] | 0.24 | | 0.33 | — | — | |
| Age group [dependent] | 0.528 | | 0.343 | 2.363 | 0.124 | |
| *Age group [immature]* | *0.675* | | *0.327* | *4.360* | *0.037* | |
| *Sex [male]* | *0.466* | | *0.185* | *6.452* | *0.011* | |
| Age diff. [younger] | 0.61 | | 0.318 | 3.633 | 0.057 | |
| Age diff. [older] | -0.034 | | 0.224 | 0.023 | 0.878 | |
| *Kinship [mother]* | *0.896* | | *0.2* | *18.188* | *<0.001* | |
| Kinship [mat. kin] | 0.248 | | 0.221 | 1.261 | 0.261 | |
| *Context [share]* | *-0.641* | | *0.187* | *10.481* | *0.001* | |
| Context [play] | 0.072 | | 0.151 | 0.224 | 0.636 | |
| *Setting x species* | *-2.735* | | *0.437* | *21.225* | *<0.001* | |
| **(c) Multi-sensory** |  | |  |  |  | |
| Intercept | -4.168 | | 0.367 | — | — | |
| Setting [wild] | 2.864 | | 0.299 | — | — | |
| Species [Sumatran] | 1.732 | | 0.298 | — | — | |
| Age group [dependent] | 0.208 | | 0.231 | 0.811 | 0.368 | |
| Age group [immature] | 0.105 | | 0.218 | 0.232 | 0.630 | |
| Sex [male] | 0.057 | | 0.124 | 0.213 | 0.645 | |
| Age diff. [younger] | 0.196 | | 0.211 | 0.867 | 0.352 | |
| Age diff. [older] | 0.351 | | 0.18 | 3.655 | 0.056 | |
| Kinship [mother] | -0.042 | | 0.173 | 0.059 | 0.808 | |
| *Kinship [mat. kin]* | *-0.427* | | *0.162* | *6.885* | *0.009* | |
| *Context [share]* | *1.2* | | *0.161* | *35.880* | *<0.001* | |
| *Context [play]* | *0.248* | | *0.106* | *5.609* | *0.018* | |
| *Setting x species* | *-2.032* | | *0.347* | *19.691* | *<0.001* | |
| **(d) Manual** |  | |  |  |  | |
| Intercept | 0.34 | | 0.336 | — | — | |
| Setting [wild] | 0.373 | | 0.229 | 2.588 | 0.108 | |
| Species [Sumatran] | -0.245 | | 0.226 | 1.173 | 0.279 | |
| Age group [dependent] | 0.49 | | 0.3 | 2.619 | 0.106 | |
| Age group [immature] | 0.322 | | 0.262 | 1.449 | 0.229 | |
| Sex [male] | 0.23 | | 0.177 | 1.686 | 0.194 | |
| *Age diff. [younger]* | *0.605* | | *0.247* | *5.834* | *0.016* | |
| Age diff. [older] | -0.422 | | 0.247 | 2.758 | 0.097 | |
| *Kinship [mother]* | *0.798* | | *0.21* | *13.909* | *<0.001* | |
| *Kinship [mat. kin]* | *0.488* | | *0.218* | *4.749* | *0.029* | |
| *Context [share]* | *-0.945* | | *0.171* | *21.822* | *<0.001* | |
| *Context [play]* | *-0.393* | | *0.15* | *6.544* | *0.011* | |
| **(e) Bodily** |  | |  |  |  | |
| Intercept | -1.817 | | 0.37 | — | — | |
| Setting [wild] | -0.723 | | 0.288 | — | — | |
| Species [Sumatran] | 0.68 | | 0.289 | — | — | |
| Age group [dependent] | -0.439 | | 0.316 | 1.979 | 0.159 | |
| Age group [immature] | -0.338 | | 0.289 | 1.427 | 0.232 | |
| Sex [male] | 0.071 | | 0.18 | 0.151 | 0.698 | |
| Age diff. [younger] | -0.412 | | 0.278 | 2.275 | 0.131 | |
| Age diff. [older] | 0.326 | | 0.22 | 2.179 | 0.140 | |
| Kinship [mother] | -0.116 | | 0.181 | 0.401 | 0.526 | |
| Kinship [mat. kin] | 0.085 | | 0.204 | 0.175 | 0.676 | |
| *Context [share]* | *1.485* | | *0.185* | *35.675* | *<0.001* | |
| *Context [play]* | *0.816* | | *0.146* | *29.008* | *<0.001* | |
| *Setting x species* | *0.96* | | *0.3* | *8.535* | *0.003* | |
| **(f) Gaze** |  | |  |  |  | |
| Intercept | -1.902 | | 0.515 | — | — | |
| Setting [wild] | 3.586 | | 0.539 | — | — | |
| Species [Sumatran] | 2.735 | | 0.478 | — | — | |
| Age group [dependent] | -0.014 | | 0.35 | 0.002 | 0.967 | |
| Age group [immature] | 0.397 | | 0.308 | 1.654 | 0.198 | |
| Sex [male] | 0.21 | | 0.249 | 0.734 | 0.391 | |
| Age diff. [younger] | 0.078 | | 0.287 | 0.074 | 0.785 | |
| Age diff. [older] | 0.073 | | 0.244 | 0.091 | 0.763 | |
| *Kinship [mother]* | *-0.832* | | *0.227* | *12.549* | *<0.001* | |
| Kinship [mat. kin] | -0.131 | | 0.227 | 0.333 | 0.564 | |
| *Context [share]* | *-1.598* | | *0.218* | *38.199* | *<0.001* | |
| *Context [play]* | *0.648* | | *0.156* | *14.869* | *<0.001* | |
| *Setting x species* | *-2.432* | | *0.655* | *7.704* | *0.006* | |
| **(g) Multi-articulator** |  | |  |  |  | |
| Intercept | -2.377 | | 0.341 | — | — | |
| Setting [wild] | 2.224 | | 0.293 | — | — | |
| Species [Sumatran] | 2.196 | | 0.285 | — | — | |
| Age group [dependent] | -0.459 | | 0.277 | 2.796 | 0.095 | |
| Age group [immature] | -0.007 | | 0.232 | 0.001 | 0.976 | |
| Sex [male] | -0.117 | | 0.169 | 0.464 | 0.496 | |
| Age diff. [younger] | -0.105 | | 0.217 | 0.235 | 0.628 | |
| Age diff. [older] | -0.084 | | 0.204 | 0.168 | 0.682 | |
| *Kinship [mother]* | *-0.86* | | *0.175* | *21.716* | *<0.001* | |
| Kinship [mat. kin] | -0.16 | | 0.179 | 0.727 | 0.394 | |
| *Context [share]* | *-0.54* | | *0.166* | *10.699* | *0.001* | |
| Context [play] | 0.186 | | 0.129 | 1.928 | 0.165 | |
| *Setting x species* | *-1.521* | | *0.336* | *12.775* | *<0.001* | |

**Tab. S5** Effects of constituent parts of communicative acts (a: visual multi-sensory, b: tactile multi-sensory, c: bodily multi-articulator, d: gaze multi-articulator) and control predictors on the probability of receiving an apparently satisfactory outcome~(ASO), derived using GLMMs with a binomial error structure (a: N = 2301, b: N = 3743, c: N = 1498, d: N = 4513). Significant effects (P < 0.05) are depicted in italics.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **(a) ASO ~ Visual** | Estimate | SE | *χ*21 | *P* |
| Intercept | 0.027 | 0.656 | — | — |
| *Constituent parts [visual plus]* | *0.878* | *0.212* | *14.180* | *<0.001* |
| Setting [wild] | -0.118 | 0.491 | 0.058 | 0.811 |
| Species [Sumatran] | -1.316 | 0.523 | 3.747 | 0.053 |
| Age group [dependent] | 0.141 | 0.465 | 0.092 | 0.762 |
| Age group [immature] | 0.214 | 0.434 | 0.243 | 0.622 |
| Sex [male] | 0.464 | 0.253 | 3.394 | 0.065 |
| *Age diff. [younger]* | *0.807* | *0.313* | *6.837* | *0.009* |
| Age diff. [older] | 0.354 | 0.319 | 1.232 | 0.267 |
| *Kinship [mother]* | *0.927* | *0.404* | *5.323* | *0.021* |
| Kinship [mat. kin] | -0.291 | 0.323 | 0.771 | 0.380 |
| *Context [share]* | *-0.887* | *0.281* | *9.238* | *0.002* |
| Context [play] | 0.166 | 0.285 | 0.342 | 0.559 |
| **(b) ASO ~ Tactile** |  |  |  |  |
| Intercept | -1.057 | 0.522 | — | — |
| *Constituent parts [tactile plus]* | *0.558* | *0.162* | *10.085* | *0.001* |
| Setting [wild] | 0.699 | 0.414 | 2.563 | 0.109 |
| Species [Sumatran] | -0.556 | 0.415 | 1.686 | 0.194 |
| Age group [dependent] | 0.819 | 0.422 | 3.650 | 0.056 |
| Age group [immature] | 0.504 | 0.383 | 1.702 | 0.192 |
| Sex [male] | 0.356 | 0.253 | 2.066 | 0.151 |
| *Age diff. [younger]* | *0.55* | *0.259* | *4.529* | *0.033* |
| Age diff. [older] | 0.128 | 0.253 | 0.256 | 0.613 |
| *Kinship [mother]* | *0.879* | *0.353* | *6.142* | *0.013* |
| Kinship [mat. kin] | -0.091 | 0.301 | 0.089 | 0.766 |
| Context [share] | -0.186 | 0.194 | 0.882 | 0.348 |
| Context [play] | 0.283 | 0.229 | 1.487 | 0.223 |
| **(c) ASO ~ Bodily** |  |  |  |  |
| Intercept | -0.044 | 0.667 | — | — |
| *Constituent parts [bodily plus]* | *-0.403* | *0.192* | *4.288* | *0.038* |
| Setting [wild] | 1.515 | 0.719 | 3.733 | 0.053 |
| Species [Sumatran] | -1.039 | 0.675 | 2.022 | 0.155 |
| Age group [dependent] | 0.623 | 0.439 | 1.954 | 0.162 |
| Age group [immature] | 0.745 | 0.448 | 2.713 | 0.100 |
| Sex [male] | -0.106 | 0.293 | 0.125 | 0.723 |
| Age diff. [younger] | 0.327 | 0.289 | 1.248 | 0.264 |
| Age diff. [older] | -0.507 | 0.328 | 2.232 | 0.135 |
| Kinship [mother] | 0.381 | 0.416 | 0.809 | 0.369 |
| Kinship [mat. kin] | -0.131 | 0.31 | 0.171 | 0.679 |
| *Context [share]* | *-0.822* | *0.26* | *8.261* | *0.004* |
| Context [play] | -0.441 | 0.464 | 0.861 | 0.354 |
| **(d) ASO ~ Gaze** |  |  |  |  |
| Intercept | 0.239 | 0.445 | — | — |
| *Constituent parts [gaze plus]* | *0.472* | *0.124* | *12.813* | *<0.001* |
| Setting [wild] | 0.416 | 0.351 | 1.323 | 0.250 |
| *Species [Sumatran]* | *-0.967* | *0.362* | *4.092* | *0.043* |
| Age group [dependent] | 0.241 | 0.375 | 0.384 | 0.536 |
| Age group [immature] | 0.38 | 0.315 | 1.443 | 0.230 |
| Sex [male] | 0.169 | 0.222 | 0.563 | 0.453 |
| Age diff. [younger] | 0.454 | 0.242 | 3.595 | 0.058 |
| Age diff. [older] | -0.218 | 0.231 | 0.880 | 0.348 |
| Kinship [mother] | 0.33 | 0.294 | 1.211 | 0.271 |
| Kinship [mat. kin] | -0.188 | 0.251 | 0.514 | 0.473 |
| *Context [share]* | *-1.02* | *0.203* | *18.397* | *<0.001* |
| Context [play] | 0.01 | 0.189 | 0.002 | 0.963 |

**Tab. S6** Effects of constituent parts (c: bodily multi-articulator, d: gaze multi-articulator) and control predictors on the probability of a communicative acts’ presumed goal matching dominant outcome (DOM), derived using GLMMs with a binomial error structure (a: *N* = 2301, b: *N* = 3743, c: *N* = 1498, d: *N* = 4513). Significant effects (*P* < 0.05) are depicted in italics.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **(a) DOM ~ Bodily** | Estimate | SE | *χ*21 | *P* |
| Intercept | -6.034 | 1.722 | — | — |
| *Constituent parts [bodily plus]* | *-1.889* | *0.73* | *6.324* | *0.012* |
| Setting [wild] | -1.536 | 0.987 | 2.514 | 0.113 |
| Species [Sumatran] | -0.351 | 1.048 | 0.113 | 0.737 |
| Age group [dependent] | -0.773 | 1.45 | 0.290 | 0.590 |
| Age group [immature] | 0.064 | 1.394 | 0.002 | 0.965 |
| *Sex [male]* | *1.714* | *0.902* | *4.421* | *0.035* |
| *Age diff. [younger]* | *1.251* | *1.114* | *4.210* | *0.040* |
| *Age diff. [older]* | *0.95* | *1.033* | *14.860* | *<0.001* |
| *Kinship [mother]* | -2.168 | 1.301 | 3.099 | 0.078 |
| Kinship [mat. kin] | -0.273 | 1.074 | 0.065 | 0.799 |
| *Context [share]* | *17.153* | *1.468* | *191.543* | *<0.001* |
| *Context [play]* | *16.712* | *1.424* | *211.703* | *<0.001* |
| **(b) DOM ~ Gaze** |  |  |  |  |
| Intercept | -0.174 | 0.643 | — | — |
| *Constituent parts [gaze plus]* | *-0.691* | *0.265* | *6.702* | *0.010* |
| *Setting [wild]* | *-1.371* | *0.344* | *8.502* | *0.004* |
| Species [Sumatran] | 0.014 | 0.38 | 0.001 | 0.970 |
| Age group [dependent] | -0.342 | 0.511 | 0.457 | 0.499 |
| Age group [immature] | -0.585 | 0.486 | 1.506 | 0.220 |
| Sex [male] | 0.523 | 0.302 | 2.947 | 0.086 |
| Age diff. [younger] | 0.085 | 0.315 | 0.072 | 0.789 |
| *Age diff. [older]* | *1.074* | *0.359* | *8.839* | *0.003* |
| Kinship [mother] | -0.348 | 0.458 | 0.578 | 0.447 |
| Kinship [mat. kin] | 0.206 | 0.44 | 0.219 | 0.640 |
| Context [share] | 0.409 | 0.316 | 1.799 | 0.180 |
| *Context [play]* | *6.973* | *0.655* | *148.329* | *<0.001* |

**Tab. S7** Information on corresponding variable and level names in R script (ESM 3)

|  |  |
| --- | --- |
| **Variable name** | **Names in R script** |
| Setting (captive, wild) | setting (captive, wild) |
| Species (Bornean, Sumatran) | species (Bor, Sum) |
| Age group: dependent | age.dep (0,1) |
| Age group: immature | age.imm (0, 1) |
| Sex: female, male | sex.code (0, 1) |
| Age difference: younger | age.diff.yo (0, 1) |
| Age difference: older | age.diff.ol (0, 1) |
| Kinship: mother | kinship.mo (0, 1) |
| Kinship: maternal kin | kinship.mk (0, 1) |
| Presumed goal: share object/food | context\_fs (0, 1) |
| Presumed goal: share object/food | context\_pl (0, 1) |
| Constituent parts: visual multi-sensory, tactile multi-sensory, gaze multi-articulator, bodily multi-articulator, manual multi-articulator, | vis\_mm (0,1), tac\_mm (0, 1), gaze\_mp (0, 1), bodily\_mp (0, 1), manual\_mp (0, 1) |
| Articulators: multi-articulator, bodily, manual, gaze | multiplex (0, 1), manual (0, 1) , bodily, gaze |
| Modalities: multi-sensory, visual, tactile | multimod (0, 1), visual (0, 1), tactile (0, 1) |
| Effectiveness (ASO) | effect (0, 1) |
| Dominant outcome match (DOM) | match\_tight (0, 1) |

**Figures**



**Fig. S1** Proportion of tactile communicative acts as a function of research setting, species and interaction dyad. Indicated are individual means (circles), population means (filled diamonds), medians (horizontal lines), quartiles (boxes), percentiles (2.5% and 97.5%, vertical lines) and outliers (filled dots).

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**Fig. S2** Proportion of bodily acts as a function of research setting, species and interaction dyad. Indicated are individual means [circles), population means [filled diamonds), medians [horizontal lines), quartiles [boxes), percentiles [2.5% and 97.5%, vertical lines) and outliers [filled dots).



**Fig. S3** Proportion of communicative acts involving gaze as a function of research setting, species and interaction dyad. Indicated are individual means (circles), population means (filled diamonds), medians (horizontal lines), quartiles (boxes), percentiles (2.5% and 97.5%, vertical lines) and outliers (filled dots).