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The role of intentional communication in monkeys: evidence from gestural signalling in common marmosets in the wild

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Human communication relies on a distinct capacity for social interaction, underpinned by cognitive skills like intentionality. To communicate intentionally, signallers produce signals with the explicit goal of influencing the behaviour or the mental states of receivers. Although long thought to be uniquely human, comparative studies have provided evidence consistent with first-order intentional communication (i.e. the signaller intends to change the recipient's behaviour) in great apes and some monkey species. Despite being cooperative breeders like humans and renowned for their sophisticated vocal and cognitive skills, common marmosets, *Callithrix jacchus*, are still largely unstudied with respect to the intentional nature of their gestural communication. Here, we thus aimed to increase our understanding of common marmosets' intentional abilities by studying communicative interactions of 20 adult individuals living in four different groups in a semiarid environment in Brazil. We especially focused on the context of grooming, a crucial context for the exchange of signals, and investigated the presence and role of gestures and whether these were aligned with intentional communication patterns. From focal animal sampling and video footage, we found that marmosets produced three different gestures (Touch, Roll-over and Present) both to initiate grooming and during ongoing interactions. These findings suggest that intentional communication plays a crucial role in the cooperative interactions of common marmosets, showing that flexible, goal-directed signalling is not restricted to the vocal domain or great apes, but may be a convergent trait driven by the demands of a cooperative social lifestyle.
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Human language (hereafter language) is widely regarded as one of the most distinctive human traits (Lim & Snyder, 2015; Tattersall, 2014), although its evolutionary origins remain a scientific puzzle (Knight et al., 2000). To further understand the development of language, comparative scholars have investigated a set of sociocognitive abilities proposed to underpin language, including turn taking (Levinson, 2016; Sacks et al., 1974), joint attention (Tomasello et al., 2005) and intentionality (Dennett, 1983). By adopting a comparative approach that examines these sociocognitive components across species, researchers have identified similarities and differences between language and nonhuman communication systems, allowing inferences to be drawn regarding the communicative abilities of extinct ancestors (Fitch, 2017; Pika & Bugnyar, 2011).

One sociocognitive component that has received particular attention in this context is the intentionality of communicative signals (Dennett, 1983), which refers to the deliberate use of signals to influence the behaviour or mental states of others (Bretherton & Beeghly, 1982; Dennett, 1983). Dennett (1983) proposed a hierarchy of intentionality ranging from automatic, zero-order responses to increasingly complex forms of mental state attribution: first- and second-order intentionality involves recognizing others' desires and beliefs, third-order enables prediction based on others' mental states and fourth order encompasses more complex reflective capacities and self-awareness. This framework provides a foundation for studying intentional signalling in nonhuman animals and for comparing it with human communicative abilities (Ben Mocha & Pika, 2019; Fitch, 2017; Hauser & Nelson, 1991; Pika, 2015).

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ethogram developed for common marmosets (Schiel & Souto, 2017; Stevenson & Poole, 1976). When the focal animal was within 3 m of another animal, potential grooming events were recorded using a digital camera (Sony FDR-AX43A Handycam 4K).

Data Extraction and Coding

Data collection resulted in approximately 540 h of direct observation, with an average of 25.0 ± 4.1 h per focal animal (range 18–40 h). From a total of 235 raw video recordings obtained during this period, we selected 126 videos for further analysis based on two predefined criteria applied uniformly across all individuals: (1) the presence of another individual within approximately 3 m of the focal animal (a proximity threshold permitting social contact), which resulted in at least a dyadic grooming interaction, and (2) sufficient visibility to clearly identify the individuals involved and observe their behaviours. This filtering step followed the protocols established during data collection and was applied independently of whether the videos showed any markers of intentionality. The final data set comprised those 126 videos from 20 focal individuals (mean = 6.3 videos per individual), yielding a total of 188 distinct grooming interactions (mean = 9.4 interactions per individual). Of these grooming interactions, 44 were recorded in the House group (mean = 7.33 per individual, $N = 6$), 55 in the Star Wars group (mean = 9.17 per individual, $N = 6$), 39 in the Coqueiro group (mean = 7.8 per individual, $N = 5$) and 50 in the Pomar group (mean = 16.7 per individual, $N = 3$).

All selected videos were coded using software ELAN (version 6.7) following a predefined coding scheme based on parameters established in previous primate gesture research (e.g. Liebal et al., 2006; Pika et al., 2003; Pika et al., 2005; Table S1). Coding was based on repeated video review at reduced playback speed to allow fine-scale annotation of bodily movements and associated recipient responses during grooming interactions. We specifically examined the grooming context (manual picking through fur of another individual with hands or mouth; Lazaro-Perea et al., 2004; Stevenson & Poole, 1976) dividing it into an initiation phase (opening, characterized by the production of signals to solicit grooming) and a grooming phase (ongoing, defined as a continuous period of unidirectional grooming; Kolff & Pika, 2025). An interaction was operationalized as a continuous dyadic exchange involving either attempts to initiate grooming or ongoing grooming bouts. Interactions started when partners were within approximately 3 m (a proximity threshold permitting social contact) and were considered concluded when they moved apart (> 3 m) or when social activity ceased for more than 10 s (Kolff & Pika, 2025). When a role reversal occurred (i.e. the signaller and recipient switched roles) a new interaction was coded. The onset of bodily signals was defined as the first preparatory movement of the signaller's body or limb towards a specific posture or contact (e.g. extending the head towards the partner; see a video example at 10.6084/m9.figshare.31123822), and the offset as the return to a neutral position, a transition to another behavioural state or relaxation of the posture after received grooming (Hobaiter & Byrne, 2011).

Following coding, bodily signals were further identified as gestures based on the definition proposed by Pika (2008): movements of the extremities or head and body postures that are directed to a social partner, are mechanically ineffective (i.e. not producing a direct physical effect on the recipient) and potentially elicit a response from the recipient. These signals are produced with the goal of influencing the behaviour of others and require the active participation of the recipient. Gestures were further categorized following established classifications in gesture research (e.g. Byrne et al., 2017; Hobaiter & Byrne, 2011; Pika et al., 2003; Schel et al., 2022; Villa-Larenas et al., 2024) as either (1) visual gestures, produced without physical contact and relying primarily on the recipient's visual attention, or (2) tactile gestures, involving physical contact but remaining mechanically ineffective. Gestures could involve the head, upper or lower limbs, body side or postural changes and were classified only when directed towards a recipient located within 3 m of the signaller. The individual producing the gesture was defined as the signaller, and the nearby individual potentially attending to the gesture as the recipient. After all gestures were identified and classified, a gesture accumulation curve was generated (Fig. S1). The potential intentionality of gestures was then assessed by applying five widely used intentionality markers and the associated decision flow (Schel et al., 2022; Townsend et al., 2017; Table 2).

Statistical Analysis

First, we provide a descriptive overview of gesture production in grooming contexts, reporting counts and proportions of gesture categories and modalities, as well as the distribution of gesture events across individuals and groups. Gesture durations are summarized using means, interquartile ranges and ranges (minimum - maximum).

To address our hypothesis, we analysed the occurrence of intentionality markers using generalized linear mixed models (GLMMs) with a binomial error structure and logit link function. Intentionality markers were treated as binary response variables, and signaller identity (ID) was included as a random intercept in all models to account for repeated observations of the same individuals. We assessed four of the five behavioural markers: audience checking, sensitivity to the recipient's attentional state, response waiting and persistence. To characterize the overall prevalence of each marker across gesture events, we fitted intercept-only GLMMs for each marker. To test whether signallers adjusted the gesture modality to the recipient's attentional state and whether signallers persisted when a grooming response was not immediately obtained, we fitted two GLMMs. In the first model, gesture modality (visual versus tactile) was included as the response variable and the recipient attentional state as the predictor. In the second model, persistence (persisted versus not persisted) was modelled as a function of interaction outcome (response obtained versus no response). In both models, signaller ID was included as a random intercept to account for the repeated measures.

Finally, to examine whether the expression of intentionality markers varied across interaction phases, we evaluated the markers expressed during the opening phase and those expressed during the ongoing phase of grooming interactions. This analysis allowed us to assess whether the probability of each marker (audience checking, sensitivity to the recipient's attentional state, response waiting and persistence) differed between phases. We fitted separate GLMMs for sensitivity to attention, response waiting and persistence (included as response variables), with interaction phase (opening versus ongoing) included as a fixed effect, and ID as a random effect. For audience checking, a ceiling effect (near-ubiquitous occurrence) resulted in insufficient variance for GLMM convergence. Therefore, we compared the proportion of gesture events between phases using a paired Wilcoxon signed-rank test on individual-level means.

Across the analyses, we report effect estimates from the fitted models and present model-based predicted probabilities with 95% confidence intervals (CI). Model adequacy was assessed using simulation-based residual diagnostics, and statistical significance was evaluated at $P \leq 0.05$. All statistical analyses were performed in R (version 4.5.0; R Core Team, 2025). GLMMs were implemented

Table 2
Criteria used for assessing intentional communication, along with their respective intentionality markers and definitions

Intentionality criteria	Intentionality marker	Definition and usage criteria
Audience effects	Audience presence	At the time of bodily signal production, the signaller was (1) alone (the only individual within 1 m of any other individual) or (2) social (other animals were present within 1 m of the signaller)
	Audience checking	In the 5 s preceding the bodily signal, the signaller (1) turned its head directly or approximately 0–45 degrees towards the recipient or (2) did not turn its head towards the recipient
Flexibility in production	Sensitivity to the recipient's attentional state	In the 5 s preceding the bodily signal, the recipient was (1) attentive (turned its head directly at 0 - 45 degrees towards the signaller or (2) not attentive (did not turn its head towards the signaller)
Goal directedness	Response waiting	The signaller was (1) waiting (maintained its body or head position used in the production of the bodily signal for at least 1 s) or (2) not waiting (did not maintain the movement used in the bodily signal for at least 1 s). Waiting for a response was terminated when the signaller began to perform a movement other than the bodily signal
	Goal persistence	The signaller (1) stopped producing bodily signals or (2) continued producing bodily signals (either repeating the same bodily signal or performing a new one)

using the lme4 package (Bates et al., 2015). Residual diagnostics were conducted using the DHARMa package (Hartig, 2016), and the estimated marginal means were derived using the emmeans package (Lenth & Piaskowski, 2017).

Interobserver Reliability Test

We conducted an interobserver reliability test with another researcher unaware of the study hypothesis and objectives (McHugh, 2012), who coded 20% of selected videos ($N = 26$). We evaluated the following variables: audience presence, audience checking, sensitivity to the recipient's attentional status, response waiting and persistence. To test the interobserver agreement between the two coders, we performed Cohen's kappa (k) tests for each variable (Landis & Koch, 1977). Our results showed excellent agreement for sensitivity to the recipient's attentional status (Cohen's kappa: $k = 0.84$) and persistence ($k = 0.89$). We found substantial agreement for response waiting ($k = 0.78$) and audience checking ($k = 0.65$). For audience presence, we found simple percentage agreement (96.2%; 25/26 for each coder), as the lack of variance made Cohen's kappa inapplicable.

Ethical Note

The study was entirely observational, and noninvasive, and was approved by the Ethics Committee for the Use of Animals of the Federal Rural University of Pernambuco (CEUA Licence No. 1712281122/2022) and SISBio (Licence No. 82271-1). It was conducted in accordance with the Brazilian laws for vertebrate animals and followed the recommendations of the U.K. Animals (Scientific Procedures) Act 1986, and the American Society of Primatologists' Principles of Ethical Treatment of Non-Human Primates (https://asp.org/2021/04/20/principles-for-the-ethical-treatment-of-non-human-primates/). As observational studies of free ranging primates may involve potential welfare concerns related to human presence and behavioural disturbance, all methodological procedures were designed to minimize any possible impact on the animals. Data were developed exclusively through noninvasive passive and respectful observation, without experimental manipulation, provisioning or elicitation of behavioural responses. Although these animals have already been the subjects of various behavioural studies since 2012 (Abreu et al., 2016; De la Fuente et al., 2014; De la Fuente et al., 2022), to enable the collection of natural and spontaneous behavioural interactions while minimizing human impact, we conducted a 6-month habituation process. Video recordings were then carried out from a minimum distance of 2 m, following protocols used in previous studies on the same animals (Ngo et al., 2022).

RESULTS

We observed a total of 188 bodily signals in 126 analysed videos. All focal individuals performed at least four (minimum) and a maximum of 17 bodily signals. On average, each focal individual produced 8.5 ± 4.1 bodily signals. Of the 188 bodily signals, 167 (89%) were visual and 21 (11%) were tactile; 143 (75%) were produced using the head, 32 (18%) using the back and 13 (7%) with other parts of the body (e.g. ventral area).

Gesture Description

The bodily signals were categorized as one visual (Present; Table 3, see a video example at https://dx.doi.org/10.6084/m9.figshare.31123822) and two tactile gestures (Roll-over and Touch; see a video example at https://dx.doi.org/10.6084/m9.figshare.31123822), frequently used by all individuals. More specifically, Present was produced by all individuals, Roll-over by eight individuals and Touch by eight individuals. The visual gesture Present was defined as an individual offering a specific body part (head, back or side) towards the partner, while the tactile gestures Roll-over and Touch were defined as the initiation of bodily contact using the head, face or side of the body (Table 3, Fig. 2). Mean

Table 3
Description of gestures used by common marmosets during the grooming context

Gesture	Description
Present	The signaller exposed a specific body part to the recipient and directed its body towards it. The signaller could use different parts of its body (including ventral and dorsal portions, head, side of the body)
Touch	Gentle and short (>1 and < 3 s) contact with head, hands, body part or feet
Roll-over	The signaller made physical contact with the recipient's body using the side of its body to lie under the other

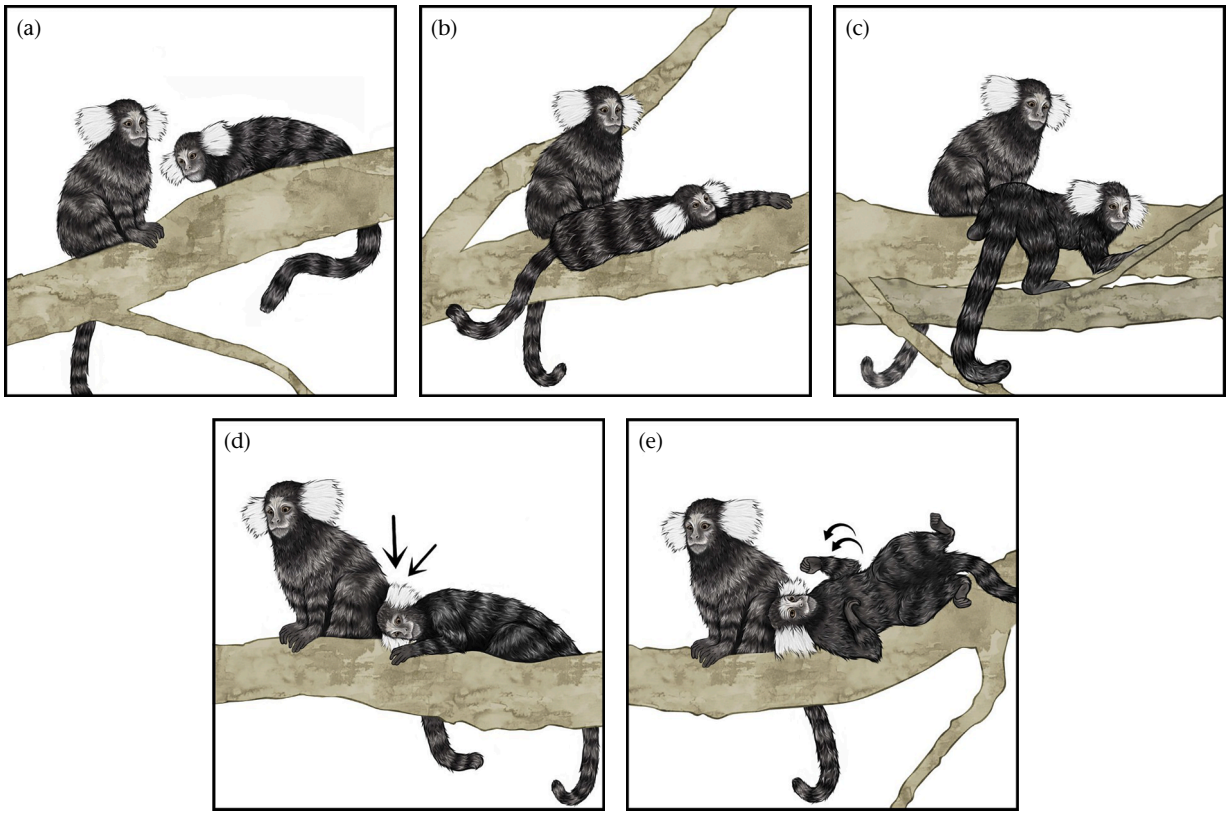

Figure 2. Illustrations of the gestures produced by common marmosets in the context of grooming. (a–c) Present gesture: (a) the head, (b) the side of the body and (c) the back. (d, e) Tactile gestures: (d) Touch and (e) Roll-over. Illustration: Luara Martins Comin.

gesture duration was 3.1 s, interquartile range 1.90 s, range 0.40–23.33 s, with mean durations of 3 s for Present, 3.2 s for Roll-over and 3.8 s for Touch.

Assessment of Gesture Intentionality

Audience effects

Audience presence showed no variation in the data set. All gestures were produced when at least one conspecific was within 1 m of the recipient, and no gestures occurred when recipients were socially isolated. Because this marker was invariant (100% social presence, $N = 188$), no inferential statistics were conducted, and audience presence was descriptively reported as a constant feature of signalling events. Moreover, we found that audience checking occurred in the vast majority of interactions. Our intercept-only binomial GLMM ($N = 177$ gesture events; 20 signallers) estimated a high overall probability of this intentional marker during grooming interactions (0.983, SE = 0.0097, 95% CI = 0.949–0.995, $P < 0.001$).

Flexibility in production

Regarding sensitivity to the recipient's attentional state marker, we found that the recipients were attentive to the signaller in most interactions. Our intercept-only binomial GLMM ($N = 186$ gesture events; 20 signallers) estimated an overall probability of recipient attention of 0.865 (SE = 0.030, 95% CI = 0.794–0.914, $P < 0.001$). Moreover, recipient attention significantly predicted gesture modality ($\beta = -2.14$, SE = 0.51, $Z = -4.19$, $P < 0.001$), showing that signallers adjusted gesture modality according to the recipient's attentional state. Tactile gestures were used more frequently when the recipient was not attentive (estimated probability = 0.385) than when the recipient was attentive (0.069; Fig. 3).

Goal directedness

Signallers paused their gestures to wait for a response ($N = 188$; 20 signallers). This marker was highly prevalent, with the model estimating an 89.9% probability of response waiting across interactions (SE = 0.242, 95% CI = 84.7–93.5, $P < 0.001$). Moreover, the interaction outcome (receiving grooming or not) significantly

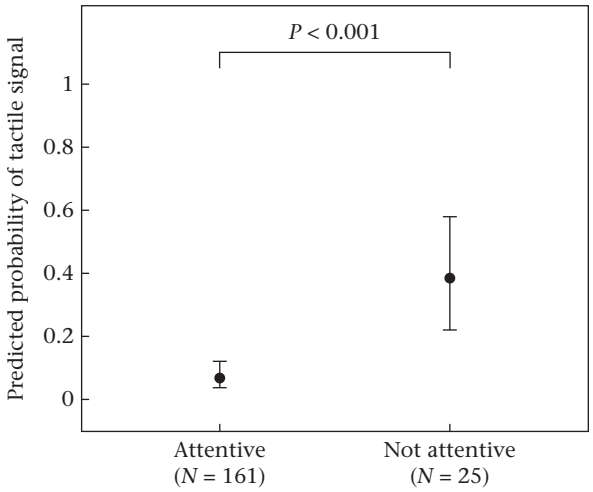

Figure 3. Influence of recipient's attentional state on gesture modality. Predicted probability of producing a tactile signal when the recipient was attentive or not attentive. Error bars indicate 95% confidence intervals.

predicted persistence ($N = 187$; 20 signallers; $\beta = 5.14$, SE = 1.05, $Z = 4.90$, $P < 0.001$), indicating that signallers actively continued signalling when their partner did not respond or the response was not satisfactory. Overall, signallers were much more likely to persist when no response was received, with an estimated probability of 0.545 (95% CI = 39.9–68.5), compared to only 0.007 when a response was obtained (95% CI = 0.1–4.8; Fig. 4).

Comparison Between Opening and Ongoing Interaction Phases

Overall, the expression of intentionality markers did not differ between the opening and ongoing grooming interaction phases. Audience checking showed no significant differences between the phases (paired Wilcoxon test: $W = 0$, $P = 1$). Similarly, no phase effect was detected for recipient attention ($\beta = 0.015$, $P = 0.978$), response waiting ($\beta = -0.011$, $P = 0.984$) or persistence ($\beta = 0.357$, $P = 0.641$).

DISCUSSION

Our study investigated the production and role of gestures in the communicative interactions of common marmosets with a special focus on the gestures and the intentionality markers involved. We also explored whether the intentionality markers varied during both the initiation (opening phase) and the course of grooming interactions (ongoing phase). Our findings revealed that common marmosets frequently used gestures in grooming interactions, with individuals using three different gestures, regardless of the grooming phase. To better understand how these markers were expressed in combination, we analysed fulfilment patterns based on whether the interaction received grooming as a response. The most frequent pattern was the combination of the four markers: (1) presence of an audience, (2) audience checking, (3) recipient attentional status and (4) response waiting. This combination suggested that when a gesture was successful, intentionality was manifested through a direct and efficient communication strategy that did not require repetition. However, in the unsuccessful interactions that did not elicit an immediate response, the pattern with the combination of all five markers occurred in fewer than half of those interactions. This challenges the binary interpretation of these markers, where either all are present (intentional) or none are (nonintentional), and instead suggests the need for a deeper discussion on intentionality as a graded, context-dependent phenomenon rather than an absolute state (Rodrigues & Fröhlich, 2024).

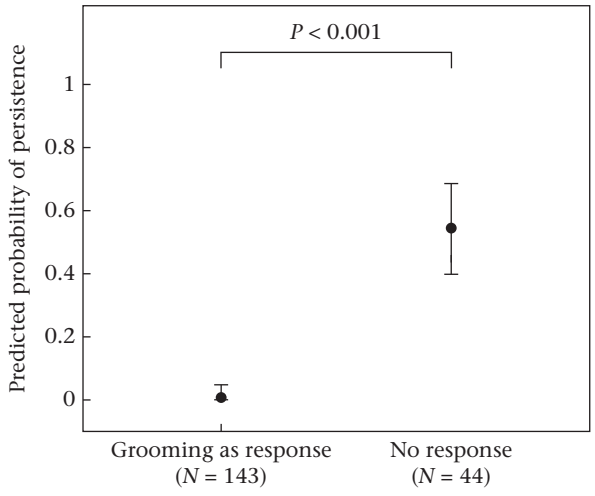

Figure 4. Predicted probability of persistence according to the immediate outcome of the interaction. Signaller's persistence when the initial gesture resulted in grooming as response or no response. Error bars indicate 95% confidence intervals).

Regarding audience presence, our results demonstrated that common marmosets performed gestures more frequently than expected by chance when they were within less than 1 m of another individual. These gestures were often preceded by the signaller orienting its head towards a potential recipient, demonstrating audience checking. These results align with studies on Afro-Asian primates, which showed that gestures used intentionally occurred more frequently when an audience was present, approaching (e.g. gorillas: Genty et al., 2009; red-capped mangabeys: Schel et al., 2022) or after the signaller checked for audience presence (e.g. olive baboons: Molesti et al., 2020; bonobos: Pika et al., 2005). For instance, red-capped mangabeys were four times more likely to produce gestures in social contexts when within approximately 1.2 m of other group members (Schel et al., 2022). Similarly, Molesti et al. (2020) showed that olive baboons produced gestures more frequently after having checked whether there was an audience present before signalling. Altogether, our results seem to suggest that common marmosets' gestures were directed towards specific group members. As suggested by other studies, social production is a fundamental criterion for intentional communication, as the transmission of a signal requires the presence of an audience (Tomasello & Moll, 2010).

We also found that gestures were produced more frequently when the recipient was attentive, aligning with sensitivity to recipient attentional status. Common marmosets were more likely to perform gestures involving physical contact (tactile gestures) when the recipient was not attentive, that is, did not have its head directed towards the signaller within the 5 s preceding a gesture. These findings are also consistent with observations in great apes, such as chimpanzees (Hobaiter & Byrne, 2011; Tomasello et al., 1994), bonobos (Pika et al., 2005) and gorillas (Genty et al., 2009; Pika et al., 2003). For instance, chimpanzees in both wild and captive settings were more likely to use visual gestures when an audience was looking at them (attentive) and tactile gestures when the audience was not looking (nonattentive; Hobaiter & Byrne, 2011). Bonobos and gorillas showed comparable behaviour, producing visual gestures more frequently than tactile gestures when the recipient was attentive (Genty et al., 2009; Pika et al., 2003, 2005). Moreover, a similar pattern was reported in spider monkeys, a South American monkey, in which tactile gestures were more frequently produced when the recipient was not attentive (Villa-Larenas et al., 2024). Hence, our findings show that common marmosets appear to be capable of adjusting their gestural production to the attentional state of recipients, with the goal of enhancing communicative efficiency. Overall, our study adds to the growing evidence that gestures fulfil different functions (Kitcher & Dennett, 1990; Liebal, Call, & Tomasello, 2004; Pika et al., 2003).

The apparent ability of common marmosets to adjust their gestures during grooming interactions highlights their cognitive capacity and flexibility in responding to social situations (Santana et al., 2012). This adaptability is comparable to that observed in great apes (Genty et al., 2009; Hobaiter & Byrne, 2011). Based on our findings and previous studies of other primate species (Cartmill & Byrne, 2010; Pika et al., 2003, 2005), the adjustments in gesture production suggest that common marmosets can intentionally modify their gestures to convey information. Thus, the observed gestures met several criteria for intentional communication, similar to those reported in other primates. However, it remains unclear how widespread these mechanisms are across the primate lineage, which should be the focus of future studies.

Finally, our results showed that after producing gestures, common marmosets waited for a response, paused their behaviour and maintained their posture until an outcome occurred, such as being groomed. Additionally, when they did not receive a satisfactory response, one that was not grooming, individuals showed persistence by either repeating the same gesture or performing a new one. Our findings align with those from other non-South American primates that intentionally produce gestures, such as persistence observed in chimpanzees (Leavens et al., 2005) and response waiting in red-capped mangabeys (Schel et al., 2022). The cessation of communication by primates once a desired behavioural context is achieved and waiting for a response prior to persisting if the communication is unsuccessful may indicate that primates understand how their gestures influence the recipient. Therefore, the presence of these criteria suggests a level of intentionality that requires the ability to anticipate and interpret the responses of others (Kitcher & Dennett, 1990). By meeting these criteria, common marmosets appear capable of taking into account the 'means – end' disassociation of their gestures during grooming, and potential responses from recipients as seen in other primates (e.g. Call & Tomasello, 2007; Liebal et al., 2006; Pika et al., 2003; Pika et al., 2005; Tomasello et al., 1994), suggesting some degree of goal-directed signalling (Bezerra & Souto, 2008; Halsey et al., 2006; Kitcher & Dennett, 1990).

We found that the intentionality markers did not vary between the initiation (opening phase) and the course of a grooming interaction (ongoing phase). The markers audience checking, sensitivity to recipient attentional status, response waiting and persistence were equally prevalent throughout the interaction. This consistency suggests that social coordination during grooming interactions of common marmosets may be supported by cognitive mechanisms that extend beyond simply initiating an interaction. Instead, these mechanisms may operate as a continuous feedback system, which is consistent with the joint commitment framework proposed by Heesen et al. (2021). Therefore, common marmosets probably use gestures throughout an interaction to monitor the partner's engagement and stabilize the social bonds, (Campennì et al., 2015). Given the reciprocal nature of grooming in this species (Lazaro-Perea et al., 2004), in which roles often switch and cooperation must be maintained, the ongoing phase may represent both a passive state of receiving grooming and an active engagment of the individual being groomed. Thus, flexible gesturing during this phase is likely to ensure continued participation in the cooperative activity.

Overall, our results indicate that common marmosets are capable of intentional communication during grooming interactions. We identified three gesture types that were consistently associated with the investigated criteria for intentionality: (1) audience effects (presence and checking), (2) flexibility in production (sensitivity to recipient's attentional state) and (3) goal-directed behaviour (response waiting and persistence). These findings suggest that intentional communication plays an important role in interactions of common marmosets in the context of grooming. However, because our study focused exclusively on grooming, research is needed to determine whether this flexible signalling extends to other social contexts, such as food sharing or play, and verify the cross-contextual validity of these communicative abilities. Despite that, comparative evidence from great apes and other monkeys demonstrates that intentional gestural signalling is typically deployed across multiple behavioural domains, rather than being restricted to single contexts (Hobaiter & Byrne, 2011; Liebal et al., 2006; Pika et al., 2005; Schel et al., 2022). Nonetheless, common marmosets produced their gestures in a socially adaptive manner, adjusted to the recipient's state and directed towards a specific goal in line with previous studies in larger primate species such as chimpanzees (Fröhlich et al., 2019) gorillas (Genty et al., 2009; Pika et al., 2003) orang-utans, *Pongo pygmaeus* (Cartmill & Byrne, 2010; Liebal et al., 2006), bonobos (Demuru et al., 2015; Pika et al., 2005), mangabeys (Schel et al., 2022) and olive baboons (Bourjade et al., 2014). Crucially, our observations in a South American primate suggest that intentional communication is not unique to the ape lineage. Instead, our findings support the hypothesis that the complex sociocognitive demands of a cooperative breeding lifestyle, which is a characteristic of both humans and marmosets, may have contributed to the convergent evolution of flexible, goal-directed communicative abilities, with variation likely occurring in how these abilities are expressed rather than in their presence or absence.

Author Contributions

Vinícius da Cunha Melo: Writing – review & editing, Writing – original draft, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Filipa Abreu:** Writing – review & editing, Supervision, Methodology, Investigation, Data curation, Conceptualization. **Simone Pika:** Writing – review & editing, Methodology, Funding acquisition, Conceptualization. **Antonio Souto:** Writing – review & editing. **Nicola Schiel:** Writing – review & editing, Supervision.

Data Availability

The data supporting this study are available at https://dx.doi.org/10.6084/m9.figshare.31123822. The repository includes the raw data, R scripts used for analyses, a ReadMe file describing all variables and example videos of the gestures analysed.

Declaration of Interest

The authors declare there are no conflicts of interest.

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Supplementary Material

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