Fond farewells or bitter ends? An exploration of leave-taking in wild chacma baboons (*Papio ursinus*)



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Abstract

Leave-taking is a common behaviour in humans, an assumed universal, occurring at the end of interactions. Despite significant comparative interest in exploring human universals, including leave-taking's counterpart greeting, there is very little empirical work on behaviours that occur at the end of interactions. This is especially the case for comparative investigation, which remains almost untouched and would help answer questions of evolutionary origin and function. This thesis explores leave-taking from a comparative angle, presenting the first evidence of the behaviour in a wild non-human species (chacma baboons, *Papio ursinus*) and investigating its proximate and ultimate drivers.

Chapter 1 reviews the current state of leave-taking literature, highlighting the strengths of previous publications, alongside the lacunae that still exists. While several authors have written about leave-taking, this is often alongside a greater focus on greeting, and most studies neglect to test leave-taking empirically. Furthermore, of the leave-taking studies that do exist, there is great discrepancy in the number on humans versus those on non-humans: while human studies cross disciplines from psychology, linguistics, and ethology, non-human mentions are brief, and few in number. A framework for investigating leave-taking is also presented here, drawing on insights from across the literature including a considered definition, control conditions, and levels of separation. In Chapter 2 we extend this reflection on leave-taking to illustrate the disparate nature of the literature, which could have contributed to the hinderance of it "taking off" as a field. Chapter 3 outlines the methods which are used across all empirical chapters, drawing on the suggestions made in Chapter 1.

Chapter 4 represents the first empirical study: a test of leave-taking by comparing behaviours at the end of social interactions with asocial separations. The results illustrate that leave-taking exists under our definition in this population of wild chacma baboons, in the form of orientation shifting prior to social separation. They also provide support for our framework of understanding leave-taking, and give support to the idea of social versus asocial separation as a useful metric for determining leave-taking. In Chapter 5 we extend these findings to investigate the possible intentionality of this orientation shifting behaviour. Using a well-established intentionality framework, the results show that leave-taking does fulfil some of these criteria and could indeed be considered intentional. This chapter also highlights potential pitfalls with applying such a framework to leave-taking and makes suggestions for adjustments that could be made to better investigate intentionality in contexts where eye gaze is confounded. Chapter 6 begins to situate these results in an evolutionary context, exploring the proximate driver/s of leave-taking. By revisiting a landmark paper by Albert and Kessler from 1976, this chapter investigates internal and external drivers of leave-taking, concluding that internal factors are the main proximate driver in this population of baboons. These results also suggest that the evolution of elaborate leave-taking in humans, facilitated by the development of complex language, could have been driven by the increasing importance of external events in managing social relationships, and humans' ability to refer to them. The final empirical chapter, Chapter 7, compares functions of leave-taking by using an information theory approach. Using suggested hypotheses from the disparate literature, the analysis ranks each hypothesis according to its likelihood based on the best fit with the data. The results suggest that risk management is the most likely driver of leave-taking in this population of baboons, and that the behaviour could be important in managing costly competition and mitigating aggression. The results also suggest that leave-taking could vary across social systems and species and pave the way for future exploration of leave-taking in other populations.

In Chapter 8 we synthesise these results, drawing on evidence of both the proximate and ultimate evolutionary drivers of leave-taking, and situating it in the existing sparse literature. We revisit the disparate map of key publications from Chapter 2 and reflect on the contributions of this thesis to our understanding of leave-taking. Furthermore, the levels of separation from Chapter 1 are adapted to become "dimensions of separation" where the unit, time, and distance of separation should be considered in relation to leave-taking.

Statement of Authorship

This thesis follows the integrated thesis format. Chapter One was published in *Humanities and Social Science Communications* in February 2022. Chapter Four was published in the journal *Animals* in September 2022. Chapter Six has been submitted to the peer reviewed *Journal of Social* Sciences and Chapter Seven to the peer reviewed journal *Scientific Reports.* Chapters Five is in preparation for submission to the peer-reviewed journal *Evolutionary Human Sciences*. With the exception of Chapter One, which I published as a solo author, all of these chapters are the product of collaboration with my supervisor and with support of the team at Gorongosa National Park who made the work possible. I am responsible for the work presented in each chapter including the conceptualisation, methodological design, data collection and analysis, interpretation of the results, and writing up. For all chapters, I benefitted from feedback from my supervisor and co-author Susana Carvalho, to guide and revise the documents. All empirical chapters have been written in the first-person plural ahead of submission to journals as collaborative pieces of research. The published versions of Chapter One and Chapter Four can be found in the appendices of the thesis (Appendix 1 and Appendix 2 respectively), included under the terms of a Creative Commons Attribution License.

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“How lucky am I to have something that makes saying goodbye so hard.”

— A.A. Milne

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Chapter 1: Saying "goodbye" to the conundrum of leave-taking: a cross-disciplinary review

This chapter is an adapted and extended version of the published manuscript "Saying "goodbye" to the conundrum of leave-taking: a cross-disciplinary review"
(Published version available as Appendix 1)

1.1 Abstract

Leave-taking behaviours habitually occur before separation from social interaction in most human societies. It is thought to be a human universal, providing ritual brackets around interaction. Despite Knapp's claim that leave-taking can tell us a good deal about human interaction, the topic remains critically overlooked from an evolutionary perspective. Cross-species data on leave-taking would be key to unveiling its evolutionary history and its role in sociality, but studies focusing on non-human species are rare. Here, leave-taking is reviewed using an evolutionary approach, pitting it against its symmetrical counterpart, greeting, and emphasising the lacunae in research on leave-taking. It is argued that leave-taking is overdue for serious, empirical attention regarding the ways in which leave-taking could contribute to understanding social evolution. Finally, methods are outlined to operationalise the study of leave-taking and propose the use of "levels of separation" to allow comparison of human and non-human species and to expand research efforts.

1.2 Greeting and leave-taking: bookends of interaction?

As widely recurrent features of the human ritual repertoire (Adato, 1975), greeting and leave-taking have been considered "bookends of human interaction" (Eibl-Eibesfeldt, 1970). Despite the scientific literature considering these phenomena in parallel, greeting is well-studied across human and non-human species, while studies of leave-taking are rarely empirical and almost non-existent for non-human species.

Greeting occurs when individuals are about to have increased access to other individuals and is claimed to be a universal across all human societies (Duranti, 1997; Goffman, 1971), as well as being present in many animal species including primates (Okamoto et al., 2001), cetaceans (Rendell and Whitehead, 2001), birds (Danchin, 1987) and fish (Sogabe and Yanagisawa, 2007). Although cross-cultural studies are limited, both greeting and leave-taking appear to show variation in form, e.g. how much the positive or emotional aspect of greeting is emphasised, and the relative importance of verbal and non-verbal greetings (Firth, 1972).

Despite the assumption that greeting, and leave-taking should be considered in unison (Eibl-Eibesfeldt, 1970; Goffman, 1971), there seems little theoretical reason that this should be the case. Besides the positioning on either side of interaction, the two are likely to require different cognitive abilities (McGrew and Baehren, 2016). Factors such as age, sex, status, and context may influence greeting behaviour (Rababah and Malkawi, 2012) and leave-taking (Goffman, 1971; Knapp, 1973; Akindele, 2007) but they are likely 'socially charged' in different ways; serving different social functions (McGrew and Baehren, 2016). For instance, greeting by definition occurs at the beginning of an interaction, and thus the behaviours and associated functions set the stage for the anticipated interaction, e.g. mediating aggression (Okamoto et al.,

2001), increasing group cohesion (Aureli et al., 2007) and encouraging social bonding (Nishida et al., 1999). On the other hand, leave-taking occurs at the end of the interaction and may have evolved to meet distinct functions such as dismissal, concluding the interaction, or maintaining the relationship throughout separation.

Evidently, there is discrepancy in the research efforts of these two supposedly parallel behaviours when considering non-human primates. Interest in the greeting behaviours of non-human primates is long-standing, presumably because of some striking parallels with human greeting (van Lawick-Goodall, 1968). Some of these behaviours seem to have similar functions, e.g. extending the hand as a gesture of reassurance, or a deep bow and nodding of the head as an act of submission (Simpson, 2009). Greeting is thought to have deep evolutionary roots because it is widespread across human cultures and its occurrence across non-human species includes baboons (Smuts and Wantanabe, 1990), spider monkeys (Schaffner and Aureli, 2004), hyenas (Smith et al., 2010), chimpanzees (Laporte and Zuberbuhler, 2010), howler monkeys (Dias et al., 2008) and macaques (De Marco et al., 2014). It is unclear whether leave-taking is similarly widespread given the lack of literature (Goffman, 1971); its absence in non-human primates would suggest leave-taking is a more recently derived behaviour in hominins, not paralleling the evolution of greeting (Eibl-Eibesfelt, 1970). The use of primates as models for human evolutionary processes is powerful; they share genetic, physical, and social traits with humans (Muller et al., 2017), including aspects of communication (Seyfarth et al., 2018) and as such can be used to quantitatively test *a priori* predictions of evolutionary hypotheses. As such, our extant primate relatives may offer crucial insights into processes and timescales on which leave-taking may have evolved. Even if behaviours differ across species, there may be components showing continuity and reflecting evolutionary precursors to leave-taking in humans.

Currently, such cross-cultural and cross-species empirical studies on leave-taking are lacking. Descriptive reports exist (e.g. Rababah and Malkawi, 2012; DuFon, 2010; Akindele, 2007), but there are almost no systematic or quantitative data on how people or non-human species end interactions (Albert and Kessler, 1978; Knapp, 1973). This contrast in the richness of scientific literature between greeting and leave-taking is striking (Figure 1.1). The apparent recent increase in greeting publications may reflect a general growth in publication rates. However, the contrast of 618 publications concerning greeting, compared to 61 for leave-taking, shows an approximately ten-fold greater relative publishing frequency.

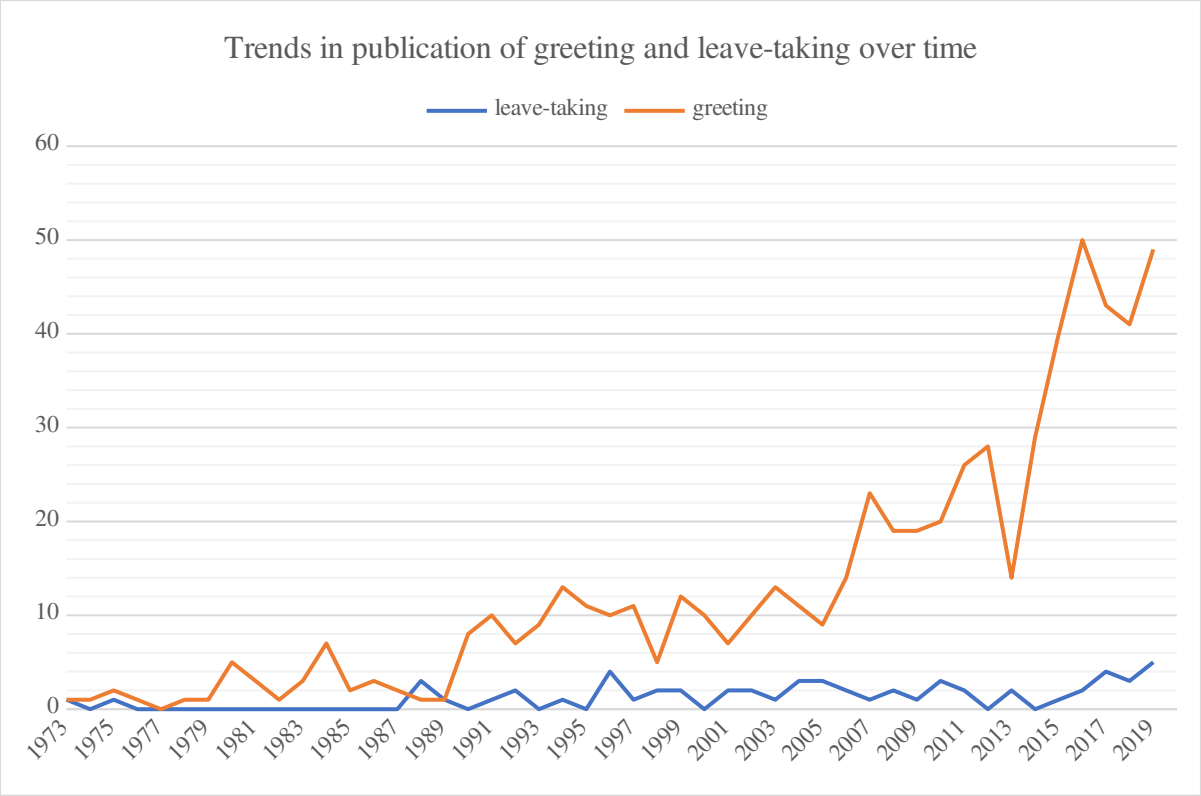


Figure 1.1: Trends in publications of greeting and leave-taking. Data extracted from Web of Science using "greet*", and "leave-take* in selected fields of Anthropology, Behavioural Sciences, Communication, Ecology, Linguistics, Psychology, Biology, Zoology. Text-mining limited to disciplines relating to behaviour and communication ensures including only publications in which these terms are used with the same meaning as defined in this review.

The lack of research on leave-taking is further highlighted when the types of publication are considered. Many of these publications have only brief mentions of leave-taking or short anecdotes, making the number of studies actually concerning leave-taking even fewer (Figure 2). This distinction between greeting and leave-taking remains stark when disaggregated by discipline (Figure 1.3). Disciplines taking an ethological approach have largely ignored leave-taking, despite taking a strong interest in greeting behaviour. Contrastingly, linguistic, and ethnographic areas of research have shown more interest in leave-taking, though still minimal compared to studies on greeting behaviour. Part of this discrepancy between fields can be explained by the conclusion that leave-taking does not exist in non-humans, e.g. researchers at ten wild chimpanzee sites reported that each of their sites showed greeting, but none showed leave-taking (McGrew and Baehren, 2016). In addition, we are told that "although many animals have greetings similar to ours in both form and function, an animal version of goodbye is much harder to establish" (Goffman, 1971: 79).

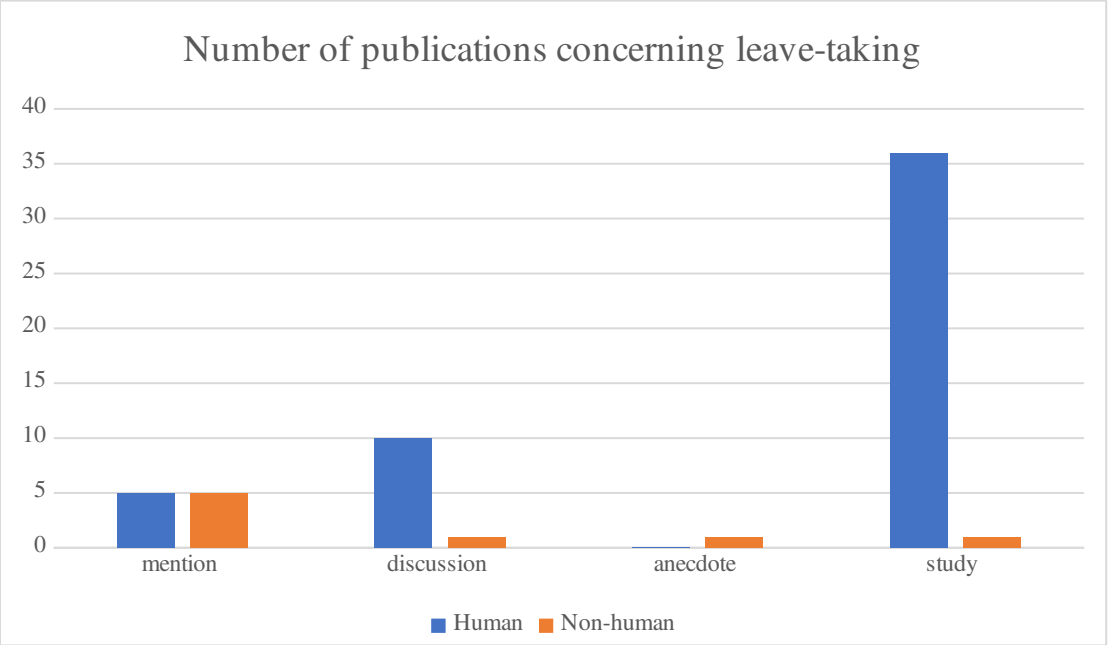


Figure 1.2: Frequency of publications concerning leave-taking (N=60). 'Mentions' are publications that had one or two sentences about leave-taking. 'Discussions' are lengthier texts that focussed heavily on leave-taking. 'Anecdotes' briefly mentioned examples of leave-taking, while 'studies' contained data, either measuring leave-taking empirically or a qualitative description.

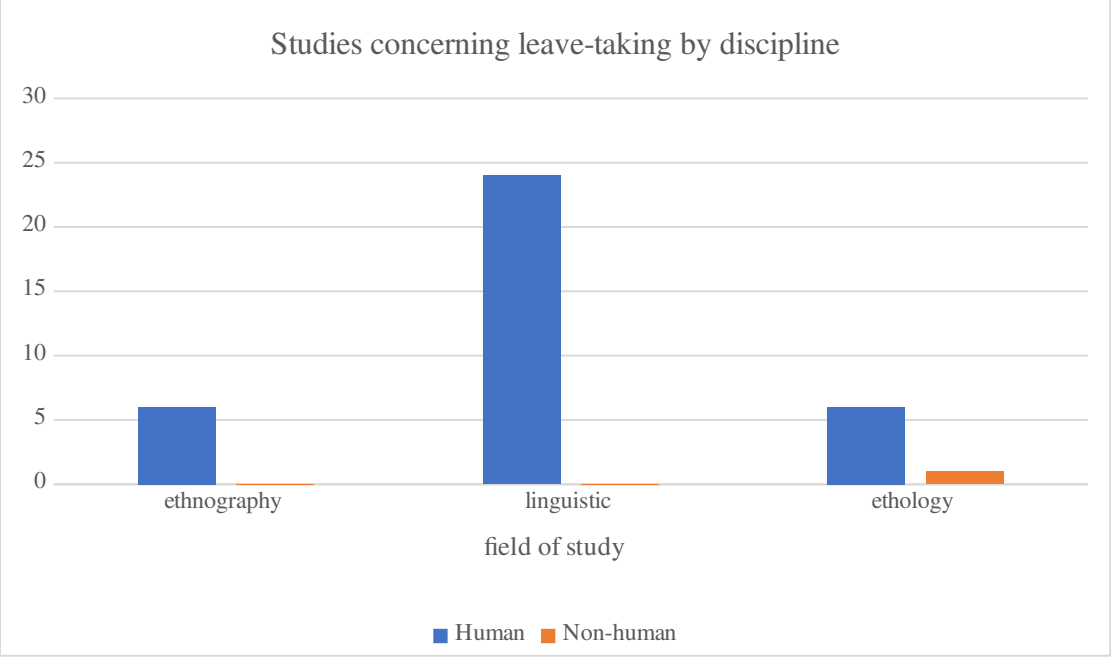


Figure 1.3: Frequency of studies by discipline n= 38, as a subset of Figure 2. Some studies (n=5) referenced both humans and non-humans, thus the data points n=33. Studies were classified as ethnographic if they had detailed description of the behaviour, linguistic if they included empirical conversational analysis and language structure, and ethological if they measured behaviour (empirically), including non-verbal elements. Ethology also includes studies classified as psychology.

For humans and non-human primates, at least part of this discrepancy can be attributed to ritualised greeting behaviours. These contrast with the less elaborate, subtle, and in the case of non-humans possibly non-existent, leave-taking behaviours. One example is illustrated by descriptions of greeting and leave-taking in Andaman Islanders (Brown, 1922), in which reunion of friends or relatives after some period of separation results in a ritualised form of wailing and weeping. In contrast, the behaviour before separation involves one person lifting the hand of the other towards their mouth and gently blowing on it: which is less elaborate than the greeting behaviour. As such, the rationale for conceptualising leave-taking within the bracketing framework no longer seems self-evident and it is worthwhile to consider leave-taking in its own right.

Leave-taking may not occur beyond humans: research on other primates, social animals, both wild and captive, yields few and vague reports of leave-taking. Firth (1972: 3) suggested that in both human greeting and parting, formal conventions of use of body (posture) and limbs (gesture) play such a major role that *"animal parallels easily come to mind",* although he gave no examples of such parallels. Similarly, Lockard (1980) suggested that the ethological method used in her earlier study could be extended for cross-species comparisons, where leave-taking could act as a way to signal intention to depart in social animals. However, neither study

elaborates on these ideas. Social anthropologists have also attempted to establish an understanding of rituals (Brown, 1922) and rites (Van Gennep, 1960) that involve separation, although work specifically on leave-taking behaviours is lacking. Although the (purported) absence of leave-taking in non-humans might explain the discrepancy in leave-taking studies between disciplines (e.g. lacking in primatology compared to linguistics) this fails to explain why other human-oriented fields (e.g. anthropology) have paid so little attention to leave-taking.

Several scholars have contributed to the topic of leave-taking, particularly Goffman (1952; 1955; 1967; 1971; 1974), and Kessler (Albert and Kessler, 1976; Albert and Kessler, 1978) but the topic failed to "take off" with other researchers and in other fields. Albert and Kessler (1978) suggested that this paucity of research may be due to the difficulties in studying properties of interpersonal endings, which are often brief and occur at high speed, making them hard to record or experimentally induce. They argued that to study leave-taking researchers need to: a) be sensitized to fleeting nuances of behaviour; and b) use technology to create a permanent record which can be retrospectively examined. We now have such powerful and low-cost technology, but perhaps the short popularity of leave-taking seen in the '70s and '80s faded before these practical solutions became available.

1.3 From the literature

a) Definitions of leave-taking

Research on human leave-taking has received greater attention than it has in its non-human counterparts. Nevertheless, the available research spans several disciplines without attempting to integrate knowledge on the topic and often seems to be considered as an afterthought to greeting, receiving subsidiary attention. Operational definitions of leave-taking vary markedly

by field and by variable studied. Linguistic studies use measures such as the final words in spoken exchange, whereas ethological studies include broader non-linguistic definitions, such as the end of a dyadic exchange, or the finishing of an interaction. Additionally, many papers that discuss leave-taking do not include a precise and workable definition, but subjectively refer to endings, partings, leaving, closings, etc. This vagueness has more serious consequences for research as it has led to incongruity in what is considered leave-taking, and a disparate and disjointed literature. Table 1.1 summarises a selection of definitions extracted from the scientific literature to: a) illustrate their variety and discrepancies, and b) aggregate the key values to suggest a universal definition. The definitions are not intended to be exhaustive but give a sense of the variation present.

Table 1.1: Original definitions of leave-taking with reference to species and empirical measure used when available (n=30).

Reference	**Species**	**Definition of leave-taking**	**Empirical Measure**
Adato 1975	Human	"Ritually" required way of departing	Absent
Akindele 2007	Human	Closing sequence of a conversation	Absent
Albert and Kessler 1978	Human	Cessation of all verbal and nonverbal communication between two previously interacting individuals	Absent
Ameka 1999	Human	Events that occur in terminating social encounters	Absent
Berne 1968	Human	Stereotyped series of simple complementary transactions	Absent
Betholia 2009	Human	Break in social contact	Absent
Blurton Jones and Leach 1972	Human (children)	Maternal and child patterns of behaviour at separation	Absent
Clark 1985	Human	Summarize the content of the contact they have just had; justify ending their contact at	Absent

		this time; express pleasure about each other; indicate continuity in their relationship by planning, specifically or vaguely, for future contact; and wish each other well·	
Clark and French 1981	Human	Reaffirm their acquaintance before breaking contact	Absent
Corsaro 1979	Human (children)	Withdrawal strategy- ending of an interactive episode	Absent
De Waal 2007	Chimpanzee	"Before separated"	Absent
DuFon, 2010	Human	"Occurs at the end of an interaction"	"Words that ask for permission to leave"
Firth 1972	Human	"Patterned routine which is highly conventionalised" suggestion of parting after an encounter	Absent
Fitch 1990	Human	Conversational exchange at the end of social gathering	Absent
Gleason and Weintraub 1976	Human (children)	Last nuclear utterance in a routine	Absent
Goffman 1971	Human - mentions animal	State of decreased access	Absent
Gräfenhain et al.,2009	Human (children)	Acknowledge their leaving	When child left the main game to play competing game, did they acknowledge their leaving a) verbally or non-verbally, b) acknowledged they were now playing a different game only after they had left, c) whether they instead left without acknowledging
Hassall 2006	Human	Act intended by the speaker to convey to the hearer that the speaker regards the encounter as at an end	Absent
Heesen et al.,2021	Chimpanzee	The exit phase comprises all the	The moment all body movements

	and bonobo	coordinative actions necessary to get out of a social encounter once the main business of the encounter has been completed.	typical of the activity ceased (e.g. movements of the hands on the body of the partner typical for grooming, and wrestling with, tickling or chasing each other for social play) until the moment that at least one partner gazed at the other before or while leaving (and at most after each partner gazed at each other once before or while separating), and if the interaction was not followed by a renewed interaction or attempt to re-engage partner within 2 min.
Hong 1985	Human	Personal expression of parting	Absent
Knapp et al.,1973	Human	How interpersonal transactions are terminated closing of interaction	"Concluding remarks" "Analysis of non-verbal cues began 45 seconds prior to the subject's rising from a seated position and continued until the subject had left the interviewing room"
Lockard et al.,1978	Human (discussed in context of other species)	End of a dyadic exchange	45s to 5mins before departure
McGrew and Baehren 2016	Human and chimpanzee	Show leave-taking/farewell behaviour when they part after being together	(Purposefully not given)
Rababah and Malkawi 2012	Human	"Greetings are the general rituals of beginning and finishing an encounter"	Absent
Schegloff and Sacks 1973	Human	Proximate solution to life utterance completion - a terminal exchange composed of conventional parts	Absent
Scheumann and Zimmermann 2017	Grey mouse	Mother and infant were together at sleep	Vocal behaviour 60 seconds before a

	lemur	site before mother left the nest	mother leaves the infant in nest
Sukwiwat and Fieg 1987	Human	Closing of a conversation	Absent
van der Hart and Goossens 1987	Human	Ceremony used as a strategy in mourning therapy	Absent
Wang 2005	Human	Art of saying “goodbye”, extracting oneself from a communication event	Point that one of the parties signals his intention to leave to the final termination exchange
Whittaker et al.,1994	Human	Interaction closings	Formal farewells (bye", "see you"). verbal or visual orienting signs (e.g. turning away) given to indicate conversations were about to close: these only occurred on 21 % of occasions.

I used the following key words for the search in *Google Scholar, Search Oxford Libraries Online* and *Web of Science*: “leave-taking”, “leaving behaviour” “greeting and parting”, “parting behaviour”, “farewell(s)”. I included publications from different academic disciplines such as anthropology, psychology, animal behaviour, linguistics, but excluded papers relating to other kinds of “taking leave” e.g. parental leave, medical leave, leaving abusive relationships etc. Articles were included only if they presented a clear, novel definition. Although it seems at first that leave-taking is a simple behaviour that should be intuitively understood, the variation in definitions across the literature highlights the challenge in identifying what this behaviour involves.

These definitions differ in crucial ways: (1) several are broad and theoretical, particularly those featuring a general discussion of leave-taking, e.g. Adato (1975), Albert and Kessler (1978), Goffman (1971), but failing to give examples of how to measure behaviour. Contrastingly, (2)

other studies use narrow definitions, suitable only in a specific context, such as child-parent separation (e.g. Blurton Jones, 1976; Field et al., 1984), "mother-infant parking" (Scheumann and Zimmerman, 2017), or mourning customs (van der Hart et al., 1987). While this specificity may help an empirical test in these contexts, the measurable variables (see far-right column of Table 1.1) vary greatly. I argue for the need to adopt a definition that is both broad enough to allow cross-species comparisons and includes specific variables to be measured to allow for empirical and comparative investigations (e.g. Knapp et al., 1973).

Additionally (3) associating leave-taking with departure, using terms such as "separation", "breaking contact" and "state of decreased access" seems valid, but a crucial distinction (4) is whether or not there is also reference to "routine", "ritual", "stereotyped" or "conventionalised" nature of leave-taking; which some see as critical (e.g. Adato, 1973; Firth, 1972; Berne, 1968). Some regard leave-taking as being specific to the end of conversational spoken word (5), which is applicable only in linguistic studies. Other studies (6) refer more generally to termination: "social contact", "dyadic exchange", "ending of an interaction", "encounter", "transaction", "episode". A broader definition beyond spoken language is useful when looking for behavioural comparisons with non-human species, such as Albert and Kessler (1978: page 541): "By ending, we mean the cessation of all verbal and nonverbal communication between two previously interacting individuals". Finally (7), some definitions refer to functionality in leave-taking: "act intended by the speaker", "regard the encounter at an end", "withdrawal strategy", "proximate solution to utterance completion". Should behaviour be defined in terms of its functionality? What if the cause for leave-taking is opaque, is behaviour at the end of interaction necessarily leave-taking? In studies of animal behaviour (e.g. Horner et al., 2010), it is argued that definitions seek to reduce disagreements about interpretation, and not exclude other interesting, potentially relevant behaviours. One must distinguish the necessary properties

of leave-taking from contingent causal properties. Accordingly, I have not included function in my definition of leave-taking as this remains unknown, even for humans where leave-taking occurs. Similarly in greeting studies, the behaviours are identified without necessarily investigating function (e.g. focusing just on the behaviour occurring at the start of a sequence, Kummer, 1968), and from this initiation, function is then investigated (Aureli et al., 2007).

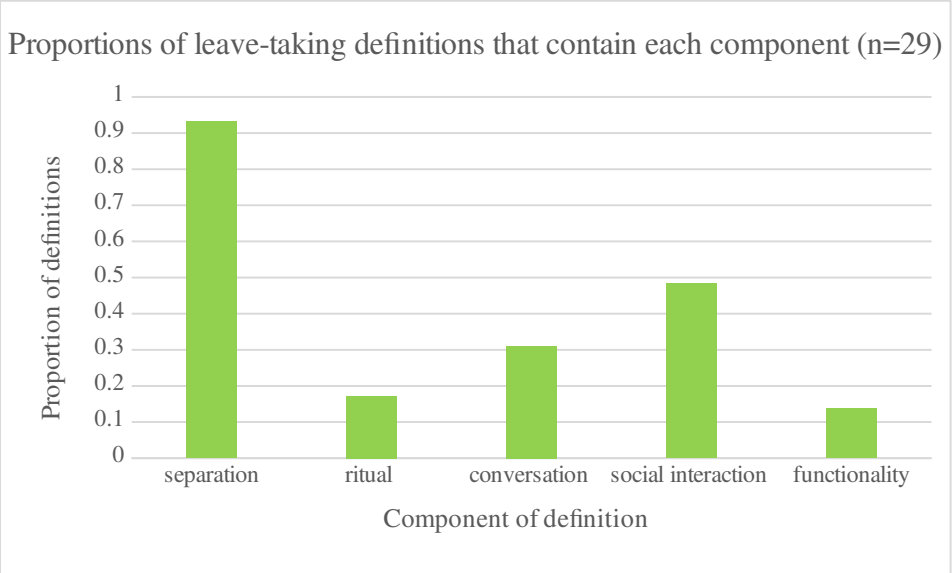


Figure 1.4: Proportions of leave-taking definitions that contain each identified component (n=30). Components are not mutually exclusive, e.g. some contain both separation and social interaction components. *Separation* includes the terms departure, ending, or parting; *ritual* includes the terms stereotyped behaviour, pattern, or routine; *conversation* includes the terms verbal interaction and spoken word; *social interaction* includes the terms social encounter, exchange, contact; *functionality* includes reference to leave-taking as a strategy or solution to achieve a goal/solve a problem.

Of the thirty definitions, only seven included an empirical measure. Twenty-five included a theoretical component. Proportionally, half of the definitions assume that leave-taking is a social behaviour, referring to final behaviours before individuals spatially separate (Figure 1.4). I argue that using the aforementioned issues of definition, we should aim to be: (1) broad

enough to encompass different behaviours and contexts, but also (2) provide specific empirical measures relevant to the study, (3) should pertain to the separation, (4) have an element of routine or behavioural sequence which is recognised at the group level (5) should not be limited to linguistic studies but include non-vocal, non-linguistic behaviours, and (6) be studied in social encounters. Finally (7), I argue that we should avoid using definitions that assume function until they have been specifically tested. To this end, I define leave-taking as ***behaviours occurring before intended cessation and separation from a social interaction of two or more individuals.*** The concept of separation is discussed in greater detail in Figure 1.5 but involves as a minimum a breaking of contact e.g. turning away, but is situated along a scale of proximity and duration. Ideally, empirical measures should be specified, relevant to the study type and context allowing function, intention, development, causes and consequences to be investigated subsequently.

b) Cross-cultural insights

Studies of human leave-taking span anthropology, psychology, linguistics and ethology. This breadth testifies to the wide-ranging nature of the topic but making it challenging to critically review the literature. Initial studies of leave-taking were pioneered by Goffman, who conceptualised the topic from multiple angles including "loss" requiring defence, strategies, and consolations (1952); as access rituals (1971), and as brackets relating to frame analysis (1974). Since Goffman's work, there has been some attention paid to leave-taking, though few replicated data, and Knapp et al.,(1973) acknowledged this neglect by behavioural researchers, saying that scholarly investigations are few and far between.

Leave-taking appears in popular science literature, such as Lundmark's (2009) book "Tales of Hi and Bye". By the author's admission, his book is not a scientific work and focusses more on

the greeting than the leave-taking. Nonetheless it draws on a number of disciplines to illustrate the variety and complexity of leave-taking. It also addresses the idea of temporal changes in leave-taking; noting that handshakes are a more recent expression of leave-taking compared to greeting, using historical and literary evidence to trace early presence of this behaviour in artwork (Herrenberg Altar, 1540) and in literature (Shakespeare, 1596; *Merchant of Venice*, Act 2, Scene 8).

Discussions of leave-taking make substantial claims about the universality (Eibl-Eibesfeldt, 1971), cultural variation (Firth, 1972) and function (Lockard, 1980) of leave-taking, but without providing evidence to support the claims. It is widely understood that leave-taking has great cultural diversity in context and style (Lundmark, 2009). However, beyond 'common knowledge' about different leave-taking styles, there is little empirical evidence as to how or why cultures vary in these behaviours. Among attempts at comparison, Firth (1972) stated that some good-byes stress positive messages of well-wishing for the future, and others, sadness at parting. Ameka (1999) claimed that universalities exist in conversation closing, pre-closing, leave-taking and final departure, with varying degrees of elaboration across cultures in leave-taking.

Critical cultural variation does exist, however. Hong's (1985) comparison of leave-taking in eastern and western human cultures found that Mandarin Chinese has a greater focus on the setting of the verbal exchange and has less formulaic, religiously derived language than in English "well-wishing" (Ferguson, 1976). He found avoidance of personal pronouns that make leave-takings more personal than in English (Hong 1985). Wang (2005) investigated this using a video coding method on leave-taking from clips of Chinese TV series, concluding that contextual, personal variables are more important than in English. In another example, Atika

(2020) compares leave-taking in Sasak to English, finding that the Sasak form is more personal and demonstrates greater empathy and solidarity. Atika argues that this reflects the differences in culture, in particular reflecting Muslim values, for example using specific forms of address in leave-taking to those who have completed the *hajj*, the pilgrimage to Mecca.

Second language acquisition studies also highlight ways in which leave-taking differs linguistically and culturally. Study-abroad paradigms provide opportunities to understand the use of linguistic strategies in non-native speakers. Critically, these studies focus on language development, giving insight into stages of proficiency throughout acquisition. Understanding leave-taking conventions in one culture does not guarantee understanding in another: Conventions are highly variable, in manner and context, causing issues for language learners and leading to inappropriate address, formulas, and timing (e.g. Hassall, 2006; Cook, 1985; Sukwiwat and Fieg, 1987; Scarcella et al., 1981). In French for example, leave-takings tend to be longer than greetings (Béal, 1994) and are generally more context dependent than English, e.g. the French tend to converse only with the waiter in a café, where interaction with customers is seen as inappropriate, in contrast to English culture (Carroll, 1987). Acquisition of French by native English-speaking students supports this contrast: Native speakers reported that they would not engage with other customers in a café, whereas non-native speakers were likely to, in a light-hearted and "chatty" way (Hoffman-Hicks, 1999). Such studies highlight significant differences in leave-taking and demonstrate specific contextual, linguistic cultural variation in the behaviour. Similar studies should be replicated across other cultures, to get a broader sense of the range of variation.

c) Comparative insights

Mentions of leave-taking are almost non-existent in the non-human literature, with few acknowledgements of its absence. Goffman (1971: 79) stated that "an animal version of goodbye is much more difficult to establish", compared to greeting and Firth (1972) suggested that parallels to human leave-takings were apparent in other species. Lockard (1978) presented some non-verbal correlates of leave-taking in humans, such as eye gaze, body orientation and weight shifts, and unlike most leave-taking literature, hers was framed in an evolutionary context: It was based on the premise that social vertebrates rely on coordinating activities and suggested that postural movements may serve an analogous function in humans to signal imminent departure. Lockard (1980) mentioned that her ethological human study could serve as a comparison across species to signal intention to depart in social animals. However, these were passing comments that have not been investigated (Table 1.2).

The first example of non-human leave-taking was *ad lib*, as Gardner reported that chimpanzees in a sign language experiment began to use the "bye bye" signal to one another (cited in de Waal, 2007). De Waal (2007) also reported that a gorilla in Arnhem Zoo would pat the keepers or blow kisses to them before she went indoors, apparently foreseeing the separation. Both reports are anecdotal, but perhaps more importantly, involve captive (likely) enculturated apes seemingly mimicking human behaviour. If so, this gives little insight into naturally occurring separation behaviours present in their wild counterparts. One paper that does feature wild chimpanzees is Harrod's (2014) review of chimpanzee responses to death. Drawing on secondary data from five sites, he finds that chimpanzees responded with "farewell behaviours" e.g. turning away and glancing back, lingering for a final touch and returning to look as they leave the deceased. Although intriguing, this report seems somewhat anthropomorphic; "farewell" behaviours are described only as assumed parallels to human partings. Furthermore, it raises the question of whether leave-taking applies to situations involving a deceased

individual. Although understanding of mortality may be important in driving leave-taking (McGrew and Baehren, 2016), there could be other explanations of these behaviours, such as checking to see if the other individual is really dead. Regardless, these reports remain singular and so provide little evidence for systematic expression of leave-taking, e.g. if or how behaviours occur and vary as external factors affect them. Nevertheless, anecdotes remain important in behavioural science (Martin and Bateson, 2021), in which a single observation may call attention and lead to further observations and form the basis for experimental, systematic study.

To investigate this lack of leave-taking in the primate literature, McGrew and Baehren (2016) sought responses to a questionnaire from fieldworkers at ten wild chimpanzee field sites. The results were unanimous: greeting was universally present in chimpanzees, whereas leave-taking was universally absent. The authors did not give respondents a definition beyond "show leave-taking/farewell behaviour when they part after being together", so as not to constrain their responses, but it may be that such behaviour is not easily recognisable.

There seem to be only two empirical studies of non-human leave-taking published. The first, by Scheumann and Zimmerman (2017) report that grey mouse-lemurs (*Microcebus murinus*) reciprocally greet upon reunion of mother-infant dyads, but do not show leave-taking when separating. As a less derived primate species, the absence of leave-taking suggests a more recent origin within the primate order. Contrastingly, the presence of greeting in this prosimian indicates that it has a deeper evolutionary history in mammalian phylogeny. In this study, greeting and leave-taking were recorded in the context of mother-infant reunion and separation through "infant parking", whereby the mother forages solitarily after leaving the infant in a tree-hole. Due to their nocturnality and constraints in the gestural and facial displays of the

species, this study limited data to vocalisations. As such, it could not test non-verbal elements of leave-taking that seem important in humans and could have parallels in non-human species (Firth, 1970; Lockard 1980). Empirically, Scheumann and Zimmerman (2017) conclude that there are vocal greetings, and no parallel vocal leave-takings, in at least one primate species.

A similar study in group-living primates that uses gestural communication (Frolich and Hobaiter, 2018) could give greater insight as to whether leave-taking has comparable elements across species. Using a mother-infant dyad paradigm provides opportunity to investigate parental care as a driving force to reconvene after separation that seems to be important in primate greetings (e.g. in marmosets, Takahashi et al., 2017). Leave-taking could link to attachment theory, representing an evolutionary survival instinct for offspring to stay close to the mother. However, in species such as *Microcebus murinus*, who have evolved the 'infant parking" system enabling mothers to forage, an infant vocal signal could be maladaptive and increase predation risk (Zeifman, 2001).

The second, a more recent study by Heesen et al.,(2021), finds evidence that captive chimpanzees and bonobos mark the entries and exits of joint activities with gesture and mutual eye gaze. These findings are important in our understanding of leave-taking as it provides the first published empirical evidence of non-human behaviour at the end of social interactions, where the research concluded that the apes demonstrated mutual gaze and communicative signals prior to and after engaging in joint activities with conspecifics. However, to consider this behaviour leave-taking a number of factors need to be addressed. The length of the interaction (so called "joint commitment") is argued by Lockard (1978) to be a driving factor in the production of some behaviours towards the end of social interaction, but Heesen et al., (2021) used no such controls in this study. We cannot conclude that these exit behaviours are

truly leave-taking unless they are found to occur in greater propensity in social separation, compared to solo or proximity separation. For example, we may exhibit behaviours when getting up and leaving alone, possibly gazing where we are planning to move to, e.g. making preparations such as zipping up a jacket, checking the seat to make sure we have not left anything; these behaviours occur because humans exit the scene and not because of social separation, thus should not be considered "leave-taking". The gestures and eye gaze should be shown to occur in these joint commitments compared to, for example, close proximity (see study by Gräfenhain et al., 2009). This paradigm should be further applied in free-ranging, natural settings to establish the ecological validity of the results.

d) Proximate drivers

Proximate drivers are mechanisms that directly underly the production of behaviour. Specifically, they refer to events immediately responsible for causing behaviour, and can help us understand what behavioural patterns encourage leave-taking. In humans, certain classes of verbal behaviour have been shown to increase in the terminal phase of conversation, broadly categorised into content summary statements; affective summary statements; continuity, justification, well-wishing statements; and statements of positive affect (Albert and Kessler, 1978). There is also evidence that these statements are sequentially arranged and influenced by various factors including how structured the conversation is. However, these findings are from English-speaking student subjects and so the results may not be generalisable. "Normative structures" rely on conventionalised contexts well understood by members of the society (Wang, 2005) and cross-cultural interpretation of these contexts may influence leave-taking perceptions.

One of the most extensive contributions to our understanding of the structure of leave-takings is Kessler's (1974) PhD thesis. Some of the most important findings include differences in summary statements and justification of leave-taking between structured and unstructured conversation, greater positive and well-wishing statements between strangers than friends and greater continuity between friends than strangers. This is probably the most extensive attempt to date to understand the linguistic and structural nature of verbal leave-taking seen.

Schegloff and Sacks (1973) also look at the structural organisation of ending conversations, concerned with how individuals navigate turn-taking in leave-taking. They report a pre-closing section to the conversation, including verbal markers e.g. "Well…", "Ok…", plus clearer statements that prohibit further talk, known as "adjacency pairs", where an utterance from one speaker directs the successive utterance from the other, completing the exchange. Experimentally, when one individual is instructed to give no termination cues, the other attempts to adopt leave-taking structures, e.g. buffering, to terminate the interaction (Knapp, 1973).

Laver (1984) provided another structural framework, focussing on mitigatory and consolidatory comments, providing well wishes for the future. These were often used together with some formulaic leave-taking such as "goodbye". In contrast, Kinnison (2002) classified speech acts into 13 categories with categories varying across populations, e.g. announcing, excuses and consolidating were more frequent in Chinese speakers and appreciation and compliments more common for Americans. Broadly, there seems to be significant structure to the verbal element of leave-taking, although classification itself varies.

Furthermore, several authors have described leave-taking as a multiactivity, in which behaviours are co-ordinated to bring interactions to a close. In an example from Haddington (2019) leave-taking at car drop-offs is outlined as a process with two simultaneous 'action streams', leading to the closing of the encounter and bringing the car to a stop. In a medical consultation context, Heath (1985) shows how verbal leave-taking is co-ordinated with embodied action of preparing to leave the room. Similarly, in a study of guided walking tours, Broth and Mondada (2013) describe the role of orientation during sequence closings. Haddington (2019) argues that these examples demonstrate how physical action is reflexively co-ordinated with the leave-taking itself, and that movement can help achieve the closing of a sequence. Thus, the expression of leave-taking seems to be multimodal across different contexts.

Ethnographic studies of leave-taking point to influential factors in its expression in different populations. Akindele's (2007) study of discourse in the South African language Sesotho found that age, sex, context, and time of day are all important in leave-taking, usually expressed as reason to leave and well-wishes. Similarly, DuFon (2010) highlights importance of status and hierarchy in leave-taking in Indonesian. Rababah and Malkawi (2012) report similar patterns in partings in Jordanian Arabic: age, sex, context, and time of day are important, although their main focus is greeting with little explanation of leave-taking. How precisely these factors influence behaviour given their descriptive nature is difficult to determine, though Laver (1981) consolidated this as "politeness-oriented linguistic routines", in which the formulaic phrases should be consistent with social status, degree of acquaintance and nature of the situation.

The importance of contextual variables and in-person cues is also highlighted in linguistic literature on telephone and computer mediated communication, where speech is the only

medium for communication. For example, Tang's (2007) study focused on the lack of non-verbal cues in phone conversations, and the subsequent lack of information about status and interpretability of the other individual. He reported that phone conversations have extra verbal cues compared to in-person interactions, to compensate for this lack of information. More acquainted individuals are more likely to say "goodbye", but this is optional for those less acquainted (Clark and French, 1981). The percentage of "goodbyes" in the terminal exchange also increases if some useful information was exchanged, or when operators revealed more about themselves. This suggests that verbal leave-takings are mediated by social relationship and contextual information about the interaction. Major drawbacks of these language-only approaches involve the omitting of non-verbal behaviours and focussing only on a few developed populations, limiting generalisability of the results to the evolution of species-typical leave-taking.

e) Adaptive value and function

The functions of leave-taking may not be mutually exclusive. One possible recurrent function is social bonding, to signal the continuance of social ties (Lockard 1980). For instance, Goffman (1967) stated that a farewell is needed to sum up the effect of the encounter on the relationship and outline expectations for the next meeting. Many definitions stress social interaction as a necessary pre-condition for leave-taking, then maintaining the relationship throughout separation and reassuring that contact will commence at some point (Betholia, 2009). A positive and successful leave-taking could send a relational message regarding feelings and attitudes that bolsters the relationship for the time apart (DuFon, 2010) and could even be adaptive in facilitating social relationships (Firth, 1972). These hypotheses remain to be tested.

Studies on emotional attachment have demonstrated that separation from the caregiver results in anxiety and distress in children, contrasting pleasure and security when in physical presence. Bowlby's (1969) attachment theory states that attachment to a primary caregiver aids survival and acts to provide a continuing emotional tie and ensure the relationship continues, inspired by earlier studies of imprinting across species (Lorenz, 1935). Attachment behaviours are activated when proximity is threatened, for example, by separation. As infant survival depends on proximity to the caregiver, and human infants are altricial and unable to follow, the act of crying has evolved as a signal to alert the caregiver, whereas smiling acts as a way to reinforce bonding (Newson and Newson, 1963). This pattern is found across primate species, where Bowlby argues that chimpanzees and baboons can be seen as the template for how infant care evolved in humans, and that the dread of separation is the motivating factor in the lives of all young primates (1969). Furthermore, more responsive mothers increase offspring survival (Hrdy, 2011). Once young children progress beyond the phase of specific attachment around 3 years of age, separation no longer risks survival (Bowlby, 1969), but attachment mechanisms could remain at separation to maintain social bonds in close relationships. Parallels in infant distress at separation and expression of leave-taking (for example, crying, holding out arms, following) could suggest that a function to increase social bonding is a result of attachment innately present to increase survival chance. Hrdy (2011) argues that there is no universal pattern of infant care across primates and suggests that babies for whom care is shared between adults could develop behaviours to manage this, such as seeking eye contact and looking at their surroundings earlier. This connection between infant attachment and separation and ritualised leave-taking in adults also remains to be studied.

Further insight into the social importance of leave-taking comes from Gräfenhain et al.'s (2009) study of joint commitments in children. By two years of age, children join in group games and

co-ordinate roles, with results suggesting that children are more likely to demonstrate leave-taking in joint games, as opposed to when playing solo games alongside another individual. This demonstrates an emerging understanding of joint commitments, but also provides evidence that leave-taking manages shared commitments and is intrinsically social: Joint activity relates to leave-taking in children, and this could be a useful paradigm to investigate leave-taking across species.

Several mentions of leave-taking describe it as norm-bound (Knapp, 1973), for example its definition as a "ritual of a stereotyped series of complementary transactions programmed by external social forces" (Berne, 1968: 34), or Betholia's (2009) description of leave-taking as a ritualistic event. This stereotyped sequence provides evidence that leaving without proper leave-taking violates social expectation (Adato, 1975), e.g. leave-taking that is too abrupt or too prolonged can leave participants ill at ease with one another (Dufon, 2010), and casual leave-taking from subordinates to high-ranking officials is problematic (Goffman, 1971). Goffman's "failed departure" examples further illustrate this: When two individuals' part but then reconnect, e.g. say goodbye but walk in the same direction, the behaviour seems improperly profuse. Similarly, when children wave as they leave a public place, it is amusing because it fails to qualify as proper leave-taking (Adato, 1975). These examples exemplify the "social expectations" (Adato, 1975) and "norm bound" (Knapp, 1973) nature of leave-taking rituals. Dulaney and Fiske (1994) provide an overview of the similarities between features of rituals and behaviours of Obsessive Compulsive Disorder (OCD) patients. One of these features, "attention to threshold", refers to thresholds of interactions i.e., entrances and exits. They argue that this feature, along with others, is significantly represented in rituals such as birthing and initiation ceremonies and is also a symptom of OCD. Rather than arguing that rituals are in any way pathologic, this suggests a shared psychological mechanism, distorted or hyperactive in

pathological individual ritual, and could help to explain the widespread human concern with parting and thresholds.

Corsaro (1979) found that two-thirds of child-child interactions have no withdrawal and concludes that children do not need to mark the cessation of activity ritualistically, compared to adults. Simultaneously, children focus more on the access ritual (greeting) than the withdrawal (leave-taking). Gleason and Weintraub (1976: 134) offered insight into this, suggesting that for "termination routines", there is importance of training by adults, following performance, "only later, long after he has learned to say bye-bye or thank-you - might the child come to know what, if anything, it all means". They also stated that "bye-bye" is one of the earliest routines in development, non-verbal in its first performances, altogether suggesting that elaborate leave-taking may not be important for children, but that the non-verbal ritual develops even before verbalising referential language. This gives an important insight into the development of leave-taking, possibly relevant also for non-vocal behaviour in non-humans, and the role of adults in shaping early social rituals.

Leave-taking requires not only social interaction, but also the expected separation afterwards, or "decreased access" under Goffman's (1971) framework, and thus another possible function could be to inform conspecifics of imminent departure. He predicted that the lengthier and more absolute the separation, the more expansive the ritual, an idea reiterated by DuFon (2010). Longer separations have higher investment leave-taking; farewell parties only precede extended time apart. For example, Wang (2005) shows that in television interactions, concise and efficient farewells occur when the separation is very brief, as opposed to longer term separations. This idea is evident in "real life contexts", where temporary leave-takings during the comings and goings of the workday are fewer, briefer and less formal (Whittaker et al.,

1994). Lockard et al.,(1978) presented a short study of human postural changes preceding departure, reporting that increased frequency of unequal weight stances and weight shifts signal imminent departure, especially when combined. These behaviours were apparent when individuals left a place together but were more exaggerated when the pair actually separated, suggesting a social signal driven by impending separation. This is one of the few ethological studies focused on non-verbal behaviour that also controlled for other factors, e.g. length of interaction. Although small in sample size, this provides the start of an ethological framework from which to further investigate how these behaviours contribute to leave-taking (Table 1.2).

Comparing differing separation lengths with associated behaviour also gives an insight into the effects of separation. Betholia (2009) gives an example of temporal change in the Meitei of Bangladesh, a previously close-knit society in highly cohesive groups, where continuing relations were expected, and leave-taking was not an elaborate behaviour. The longitudinal study showed that as the society's complexity and separations increased over time, leave-taking became more elaborate. This gives particularly powerful support to the idea that leave-taking is driven by the separation experienced in most social groups.

Despite such studies on the importance of separation to leave-taking, it remains unclear why separation should drive such behaviour. Studies on leave-taking at death are relevant, as final leave-takings take place at death and mourning (van der Hart and Goossens, 1987). This is compatible with the theory that leave-taking in its human form is possible due to our conceptualisation of time and the future (Firth, 1972), understanding of separation, and the permanent separation of mortality (McGrew and Baehren, 2016). However, such possibility does not necessitate selective pressure. Field et al.,(1984) described leave-taking behaviours of children and parents, highlighting distressed behaviours, especially in younger children,

supported by a similar study (Blurton-Jones, 1972), where behaviours included crying, holding out arms and gesturing to be picked up. They suggest that the leave-taking behaviours function as a survival instinct: to stay close to the care giver, not to become separated, and to protect young children by favouring proximity, whilst allowing independence in older children through more positive separation. Furthermore, developmental psychology literature suggests that adult and peer training is critical in children's acquisition of leave-taking (Corsaro, 1979). As with the grey mouse lemurs, this parent-offspring interaction might only be adaptive when leave-takings do not alert predators to the presence of solitary infants. Studying parent-infant dyads limits the potential to understand more general leave-taking and how it becomes established ontogenetically. These suggestions could explain the negative results of the grey mouse-lemur study. Interesting questions arise from these results: What species should we investigate with regards to leave-taking? What contexts are appropriate to investigate? What behavioural measures might give most insight? Does this behaviour occur intentionally to transfer information? These questions have not, as far as I am aware, been investigated in any human or non-human species and thus the adaptive value remains unknown.

A third possible function of leave-taking could be to reduce aggression. This idea comes primarily from the literature relating to the Violence Inhibition Mechanism (VIM) (Blair, 1993). Previous work across many species suggests that there are universal appeasement behaviours that reduce the risk of aggression or even end aggressive attacks from other individuals (Lorenz, 1963). These behaviours are mediated by the VIM in which conspecifics use distress signals to inhibit violent or threatening behaviour (Blair, 1995). A similar pattern has also been found in human infants (Murray, 1980) and young children (Camras, 1977) where sad facial expressions in 4–7-year-olds result in the termination of aggression. Some of these behaviours e.g. turning of the head, bowing, are submissive as they expose vulnerable

parts of the body to the conspecific (Lorenz, 1963). However, others have been argued to reflect a threat of breaking off contact (Eibl-Eibesfeldt, 1989) as aggression blocking behaviours can include turning away and breaking eye contact. This threat of breaking contact, as well as demonstrating submissive behaviours, could provide an alternative theory for the function of leave-taking as a way to minimise aggression.

1.4 Evolutionary perspectives

Knapp et al.,(1973) shows that although leave-taking may seem mundane and ordinary, it could tell us a good deal about human interaction "since unique and terribly human interpersonal forces are unleashed when people say goodbye to one another" (1973: 182). This point highlights both the importance and presumed uniqueness of human leave-taking. The need for studying leave-taking is not just warranted from the absence of literature; plenty of phenomena remain unstudied purely because they are mundane or self-evident. However, the plausible universality of human leave-taking, which is likely integral to most social interactions, merits investigation.

Investigating the behaviours that occur at the end of interactions could have implications for the evolution of sociality, in understanding why departing intention is important. As argued by Albert and Kessler (1976), studying interpersonal endings is important to theories of social psychology, such as consistency models and exchange theories. Such research would complement theories of human behaviour which describe motivational intention for ending a social encounter, e.g. dissonance (Festinger, 1957) or imbalance (Heider, 1958), but not the mechanism for doing so. Furthermore, understanding leave-taking variation across human societies should provide new insights into the similarities and differences in the expression in this behaviour: Are there similar patterns that suggest leave-taking as a primitive trait ancestral

to *Homo sapiens?* Or has leave-taking converged across species to solve common challenges that entail separation, such as fission-fusion societies? By contrast, evidence of leave-taking in more distantly related non-human species would suggest deeper evolutionary roots for this social behaviour.

The desire to understand how species have evolved to manage social separation is not new. However, that leave-taking could be a way to synchronise movement or to signal intention to depart in social animals (Lockard, 1980) challenges an important point: that leave-taking is inherently *different* from synchronized, collective cohesion. The former refers to a separation of individuals and an ending of social contact, whereas the latter relates to co-ordination that aims to keep the group together. The latter is also well-studied across the animal kingdom, in birds, social insects and fish (King and Cowlishaw, 2009). For primates, Schamberg et al.,(2017) described bonobo branch-dragging before long group travel, and Rowe (2017) examined factors influencing collective decision-making on group movement in Tibetan macaques. This is inherently *different* to leave-taking because there is no separation and is usually referred to as group movement (Schamberg et al., 2017), group travel (Rowe, 2017), or group co-ordination (King and Cowlishaw, 2009). This highlights the need to distinguish leave-taking (i.e. notification of social separation) from intention to depart, where other individuals notify of a joint cohesive departure, moving away together.

Many species have fission-fusion group structures of varying degrees (Aureli et al., 2008), evolved to balance the benefits of group living in environments in which resources are clumped and dispersed (Lehmann et al., 2007). The costs and benefits of group living vary between individuals and across species (Kappeler and van Schaik, 2002) which leads to variation in group size and cohesiveness. Specific ecological factors also influence the extent and patterns

of fission-fusion, such as variable availability of key resources (Ramos-Fernandez and Morales, 2014). Consequently, the extent of group cohesion affects the evolution of communication patterns. For example, in highly cohesive species, communication is expected to be advantageous for high information acquisition and to reduce competition resulting from the constant presence of conspecifics (Aureli et al., 2008) and to maintain cohesion through coordinated movement (e.g. Boinski, 1996; Rowe 2017; Cords and Killen, 1998). On the other hand, fission-fusion species are expected to have developed signals that re-establish relationships and resolve uncertainty, as well as cognitive skills that help interpret indirect information about conspecifics when not in view (Aureli et al., 2008). Aureli et al.'s predictive framework generates a series of testable hypotheses about communication, which could, but currently do not, include leave-taking. For example, this framework hypothesizes that chimpanzees might have evolved signals to resolve the uncertainties associated with low cohesion, whereas more cohesive primate species, such as baboons, would be expected to have signals that maintain cohesion. In this sense, we can think about fission-fusion in terms of a gradient that varies within and between taxa, and subsequently could predict the differing need to use signals to manage separation. Research efforts into leave-taking across the radiation of baboon species could provide a particularly fruitful avenue of enquiry; allowing us to compare the effects of their varied social systems in phylogenetically close species.

We might predict that leave-taking is more likely to exist in those species that exhibit classic "fission-fusion" (e.g. chimpanzees, spider monkeys, hyenas, Aureli et al., 2008), driven by their regular extended periods of separation. However, even within cohesive societies, such as the genus *Papio*, distancing between individuals exists (Patzelt et al., 2011). Although there is no definitive fissioning of subgroups, individuals socialise with multiple conspecifics, break into smaller distinct groups, and are most cohesive at night and early mornings, as they aggregate to

sleep in trees (Anderson and McGrew, 1984). By recognising that fission-fusion exists to some extent in all social groups and abandoning the fluid versus cohesive dichotomy (Aureli et al., 2008), I reveal a potentially important factor to study leave-taking: the level of study. How we collect data is a crucial decision when studying behaviour, as it impacts what questions we are able to answer, and which patterns are revealed (Martin and Bateson, 2021). For example, behaviour at occasional short-term "fission events", e.g. in chimpanzees (Aureli, 2008) would set the stage for studying subgroup leave-taking (Figure 1.5). However, these events do not seem comparable to most studies of human leave-taking that focus on frequent, daily interaction endings between individuals (Albert and Kessler, 1978; Schegloff and Sacks, 1973; Lockard et al., 1978). Instead, they seem more similar to extended periods of separation (Goffman, 1971; Firth, 1972). There could be much potential in studying the recurrent daily separations that happen often in other species, when brief interactions between individuals come to an end. Comparatively, these interaction endings seem more similar to ethological studies of interaction analysis in humans (Gräfenhain et al., 2009; Knapp et al., 1973; Lockard et al., 1978). Conversely, examples of permanent departure in other species are perhaps more akin to human separations before emigrating, leaving to enter risky circumstances such as war, or even before death (van der Hart and Goossens, 1987; Brown, 1922). Similar to the gradient of cohesion seen across species and contexts, we might expect to see a gradient of leave-taking, in which different forms of impending absence drive different patterns of behaviour, although defined in distinct levels for the purpose of this framework. I propose that levels of separation should reflect the social entity that is being departed from, where low level reflections separation from individual interactions, medium level reflects subgrouping of small social groups, and high level reflects departure from an entire social group. This may often parallel duration and distance, e.g. separation from an entire social group is more likely to be extended than separation from a social interaction where one stays within the main group and likely

encounters the same individuals repeatedly. However, the relationship between separation of social unit, duration and distance remains poorly understood; such levels should be used as guidance to establish what level of social unit is separating, and on what scale.

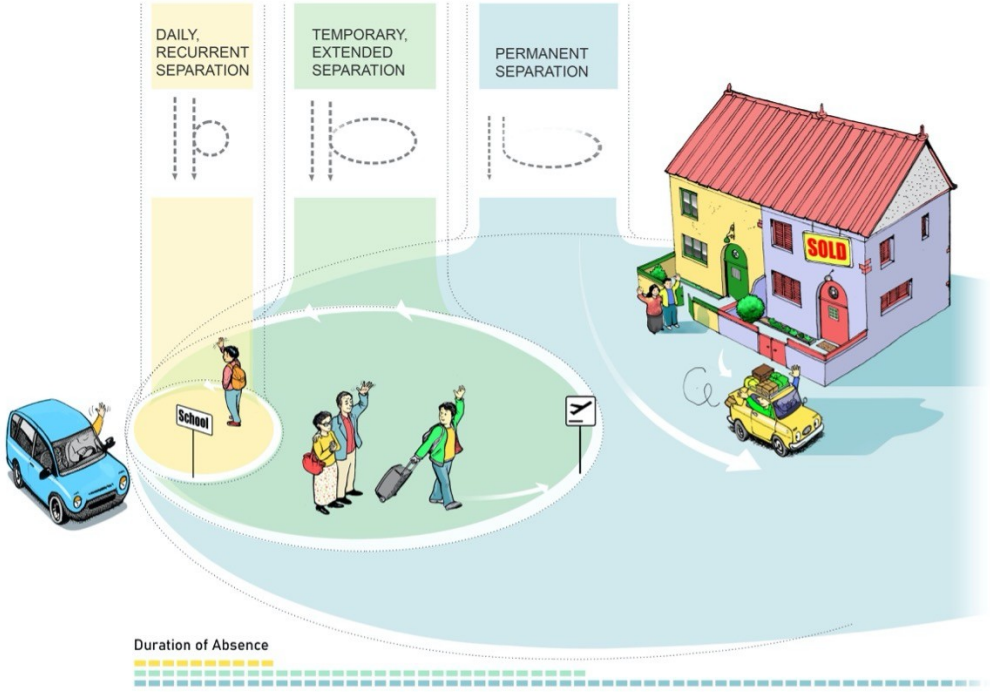


Figure 1.5: Levels of separation across different durations of absence.

At present, our understanding of leave-taking is limited by lack of data across species (Table 1.2). Despite the apparent similarities between humans and other species in factors that cause leave-taking, such as status recognition (Chiao, 2010), strengthening of social bonds (Lehmann et al., 2007) and understanding of separation (De Marco et al., 2011), Firth (1972) argues that humans have greater flexibility, length of time, conceptualisation of the future, formality, and correctness. Some non-human species show propensity for mental-time travel (Cheke and Clayton, 2010) and anticipatory behaviours (Mulcahy and Call, 2006; Osvath and Karvonen, 2012), but McGrew and Baehren (2016) argue that we lack evidence that this extends to the social domain. They also suggest there could also be differences in the costs and benefits of leave-taking across species: in cohesive groups in which the separation is never longer than a

number of hours versus species that exhibit more definite fission events (e.g. chimpanzees) this could affect any information that is exchanged about how long they will be apart. This constrained temporal factor could result in less frequent and conspicuous leave-taking behaviour compared to greeting.

It seems likely that non-human species have no elaborate leave-taking, unlike humans who engage in leave-taking "ceremonies" (van der Hart and Goossens, 1987), sometimes involving elaborate behavioural sequences. But "evolutionary components" may exist in the non-human animal repertoire which reflect the ancestral state of the behaviour, or its possible function(s). Furthermore, when considering the proposed levels of leave-taking (Figure 1.5), subtle changes in frequency or timing of behaviours during the day-to-day separations, could easily be missed unless they are the focus of specific study. Commentaries on this so far (McGrew and Baehren, 2016; Scheumann and Zimmerman, 2017) consider only obvious medium-level partings at fission-fusion. Focusing on interaction level separations and subtle changes that may indicate leave-taking may be more fruitful in non-human species. Investigation of these subtle but frequent leave-takings in daily partings of non-human species need to be undertaken (Table 1.2).

1.5 A new framework for leave-taking

Future efforts to address limitations in the study of leave-taking should fall broadly into two categories: its framework and empirical predictions. A dual focus on these areas will help to simultaneously strengthen the methods used to collect data and advance the evolutionary nature of hypotheses tested.

The lack of a robust framework links to the lack of empirical studies on leave-taking. Here, I have proposed an operational definition of leave-taking summarised as: behaviours occurring before intended cessation and separation from a social interaction of two or more individuals. I have advocated using levels of separation (Figure 1.5) as a way to navigate the gradient of leave-taking seen across different types of separation and reveal potentially interesting behaviours across species. Taking advantage of technological advances, video recording and behavioural coding software (Cristani et al., 2013; Friard and Gamba, 2016) can help address methodological issues and allow more effective study.

A comparative method should be part of this framework, to place leave-taking in an evolutionary perspective and identify candidate behaviours comparable across species. Variation across species could suggest different selection pressures of social system, environment, and context, and provide further opportunity of empirically testing. The apparent universality of this behaviour in humans suggests a deep evolutionary history in the hominin clade, but it remains unclear whether elements of leave-taking behaviour were present in our Last Common Ancestor with the genus *Pan*, or even with the Order Primates as a whole.

Table 1.2: Solutions to address current problems with the study of leave-taking.

	Problem	**Solution**
Theoretical	Lack of consistent definition	Define generally as "behaviours habitually occurring before intended separation from social interaction", from which to determine specific relevant measures within each study
	Lack of focus on level	Introduce levels of separation (Figure 1.5)

Methodological	Lack of empirical study	Apply the definition and framework across populations, including non-human species
	Data collection doesn't capture leave-taking	Take advantage of video technology to record behaviour and use video data coding software
	Appropriate candidate behaviours	Pilot study leave-taking data collection across populations and species, with a focus on non-verbal behaviours and including behaviours suggested in the literature, e.g. scratching, weight shift, eye gaze and body orientation
	Lack of control variables	Use non-social condition to test leave-taking as a social behaviour, and control other influential variables such as length of interaction, context, individual difference

In most, if not all, human populations leave-taking is seen prominent and important, and as such deserves careful attention from those interested in behaviour. The discrepancy between the literatures in greeting and leave-taking is stark. In part, this contrast is due to difficulties in studying leave-taking, but also due to a fragmented and underdeveloped theoretical framework. I argue that our understanding of leave-taking would benefit from greater consideration in the disciplines concerned with behavioural evolution, and that cross-species methods should now take advantage of technological advances to do so. Confirming some of our proposed predictions on leave-taking could inform us on critical aspects of its evolutionary origin, variation, and function.

Chapter 2: Theoretical position of the thesis

2.1 History of leave-taking literature

Across many topics of research, topics of publication wax and wane as interests change and methods advance. Burghardt advises that "if you want new ideas, read old books", and this statement certainly seems true of leave-taking. Little is to be found in current literature on the topic but delving into historical publications provides a wealth of information, covering theoretical ideas of the behaviour (e.g. Goffman, Albert and Kessler, Firth) and suggested or preliminarily tested hypotheses (e.g. Lockard, 1980; Whittaker et al., 1994).

Burghardt summarises the value of historical literature when he says that it does not just represent "dusty scholarship", and that these past efforts are critical in facilitating further study. The three main reasons he gives are so we do not spend efforts arriving at concepts already formulated, so we can build on promising leads of the past, and so we avoid dead ends. Although many ignore these footprints of our scientific forebearers, as old-fashioned and out-dated, these footprints could be as useful as evidence as the footprints of dinosaurs themselves, giving us clues into ideas which may be extremely valuable. We should not ignore the often surprisingly sophisticated conceptualizations of different eras that could enrich our toolkit of ideas in areas where improved theory is urgently needed (Fagen, 1981).

In the sparse leave-taking literature from the 21st century, it is rare to consider these historical perspectives, and instead mentions of leave-taking are fleeting and uncontextualized. As such, publications of leave-taking seem incredibly "unconnected" to other literature on the topic (Figure 2.1). For example, Scheumann et al.'s (2017) study on the grey mouse lemur has little reference to previous leave-taking literature, despite attempting to place their results in

evolutionary context of this behaviour. This is the case for many of the more recent publications on leave-taking, where there is either a sense of “reinventing the wheel” each time leave-taking is mentioned, or is mentioned “in passing”, not as the main topic of enquiry. This seems particularly odd given past interest in the topic, that it has not “accumulated” in the literature.

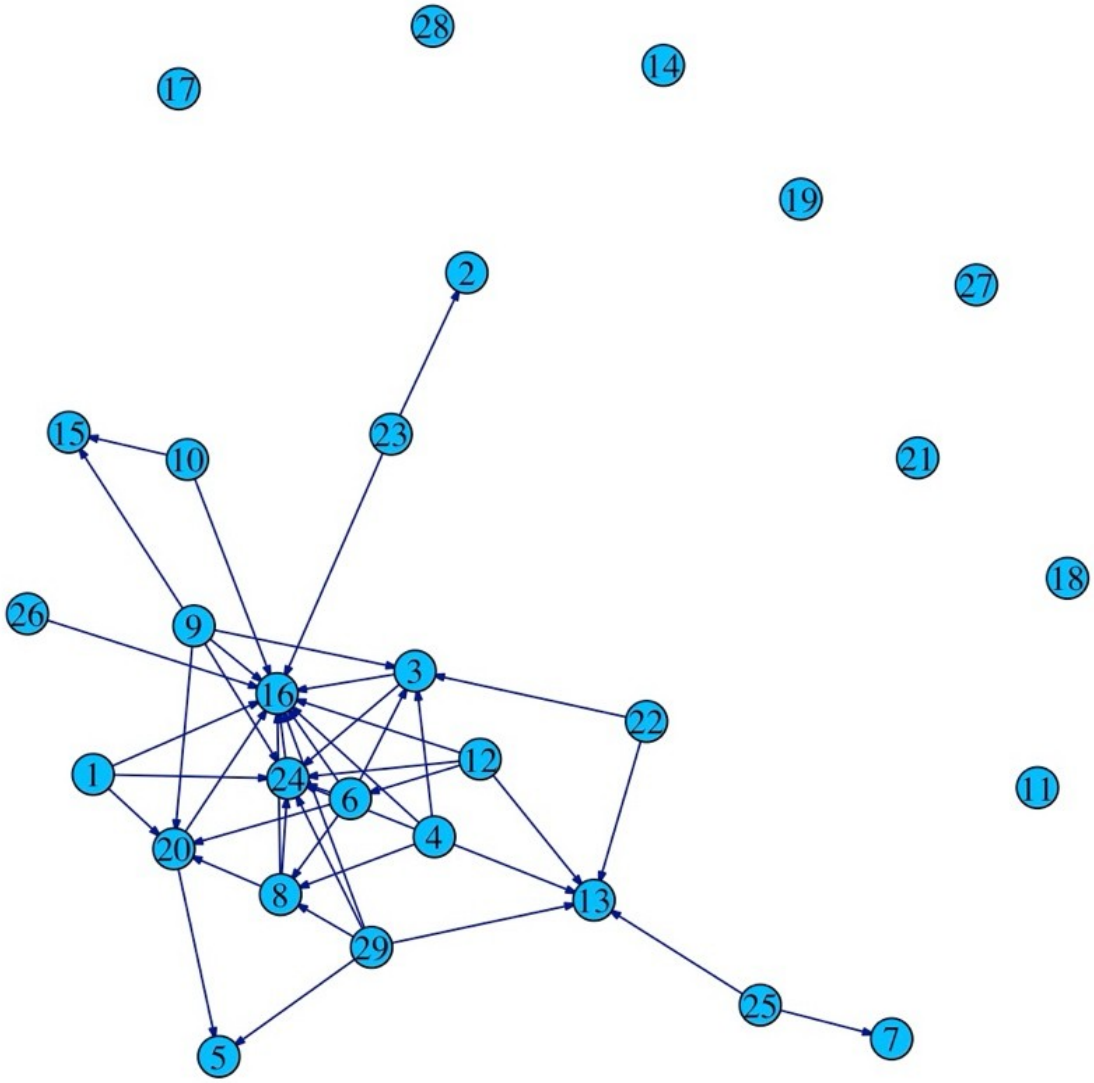


Figure 2.1: Citation network of the 29 key publications reviewed in Chapter 1.1 providing novel definitions 1. Adato, 1975, 2. Akindele, 2007, 3. Albert and Kessler, 1978, 4. Ameka, 1999, 5. Berne, 1968, 6. Betholia, 2009, 7. Blurton Jones and Leach, 1972, 8. Clark, 1981, 9. Clark and French, 1981, 10. Corsaro, 1979, 11. De Waal, 2007, 12. DuFon, 2010, 13. Firth, 1972, 14. Fitch, 1990, 15. Gleason and Weintraub, 1976, 16. Goffman, 1971, 17. Gräfenhain et al., 2009, 18.

Hassall, 2006, 19. Hong, 1985, 20. Knapp et al., 1973, 21. Lockard et al., 1978, 22. McGrew and Baehren 2016, 23. Rababah and Malkawi, 2012, 24. Schegloff and Sacks, 1973, 25. Scheumann and Zimmermann 2017, 26. Sukwiwat and Fieg, 1987, 27. Van der Hart and Goossens, 1987, 28. Whittaker et al., 1994, 29. Wang, 2005.

Citation networks are a useful way to understand the connectedness of literature. They can provide a method of understanding scientific development, where the visualisation represents publications and the relationships between others that reference them. This method became popular after the Second World War, when the pace of scientific research was rapidly accelerated (page 6, Ch 2, Garfield, 1987). Although it can be argued that the literary model is a gross oversimplification of the scientific process, where developments come in forms other than publications, the view it gives is both accurate and useful (Garfield, 1987: page 81). As in other areas of science, they can be used as a concise and easily understood way of illustrating the dynamics of a research development over time.

In Figure 2.1 the nodes represent publications, and the arrows represent a reference, where the arrow points towards the referenced paper. Each node is numbered and identified with the key above. This graph was created using the R package igraph (Csardi and Nepusz, 2019) where a matrix was created of references and each connection, allowing the direction of connections to be visualised and the unconnected references to be included as outliers. This figure represents only the 29 publications identified in Chapter 1 (Baehren, 2022) as having novel definitions of leave-taking, considered the most important contributions to the literature. Although it is usually possible, in recent literature, to automatically text mine references across papers in order to collect reference data, this was not possible in this sample due to the old nature of many of the texts (e.g. books, scanned articles, etc) meaning they could not be converted to .txt

format. Instead, the reference lists of each 29 publications were manually cross-checked for each other.

Although not exhaustive for the reasons described above, this is insightful. To test judgement of the relative importance of different contributions, node weight can be calculated: the number of reference links to other nodes in the network. Goffman's 1971 publication on leave-taking had the greatest weight, meaning it was by far the most cited (13 times), and Schegloff and Sacks (1973) also had several (8) references.

However, though these are comparatively the most referenced of the key publications, they still seem relatively under-referenced compared to what we might expect for a cohesive literature. For example, 8 publications do not reference any other publications in the list of 29, suggesting multiple novel origins of the study of leave-taking. Overall, the literature seems extremely disconnected, illustrating the disparate nature of knowledge of the topic. A network with low connectedness suggests that there is little cohesion and cross-referencing, where existing works have little impact on future work. In this sense, it seems that the risks Burghardt provides may be realised.

2.2 Revisiting the historical literature of leave-taking

The discussion that follows is an extension of the review of leave-taking in Chapter 1, here focusing on the value of historical perspectives when studying behaviour, in particular, leave-taking.

Using his chosen topic of play behaviour, Burghardt also discusses how the emphasis on studying play from a largely adaptive perspective had "baleful consequences", where the function was viewed as the most important feature, at the expense of other insights. Without

other, useful focus on the topic, mathematical modelling was premature as there was little foundational knowledge from which to generate hypotheses. He urges us to go beyond current fashions and to recognise that "what is new is often recycled, and what is novel is often a matter of emphasis" (Burghardt, 2005: page 41).

In leave-taking literature, as highlighted by the review (Baehren, 2022) and Figure 2.1, there is a huge disconnect between the historical, theoretical discussions of leave-taking, and more recent, tentative attempts to empirically study the behaviour. The gap between these two contributions, and indeed across the literature more broadly, has not been bridged. We can consider Goffman as one such contributor to the field, in particular noting the lack of animal studies, and the lack of literature more generally. He also suggests the broader form compared to leave-taking, as well as the variation shaped by relationship and context of the behaviour. Albert and Kessler also make an argument as to the importance of leave-taking and are one of the few researchers to suggest why there may be such paucity in leave-taking research. Knapp has also provided some theoretical background to the topic in discussions of human behaviour. These figures have arguably had the most theoretical contribution to the literature, though remain woefully uncited in more recent literature. We need to take both into account, studies should be couched in their theory otherwise the fears of Burghardt become realised: we reinvent the wheel and fail to account for things that have already been warned of. In addition to the historical perspective, it is also somewhat a foray into other disciplines, e.g. cultural and social studies, often dismissed by animal scientists, that may prove most valuable in generating testable hypotheses and theoretical frameworks.

These attitudes somewhat reflect the popularity and value assigned to different disciplines, for example, we seem to care less about the wider contribution a primate study may give, in terms

of the evolutionary history, the theoretical position on a topic, or the historical "narrative" that this contributes to. It also seems to reflect the politics of academia (so called, publish or perish), where sometimes the theoretical value is diminished at the expense of publishing lots, and quickly. Students and researchers have less time and are under extreme pressure to publish novel contributions, which could contribute to the diminishing focus on previous literature (Lemberger et al., 2022). It also does not acknowledge the work of those who live in primate home range countries e.g. so called "local people" and fieldworkers. These voices are often ignored when claims of a new "discovery" are made, usually by western educated people, who usually know less of the long-term behavioural observation (Turner et al., 2000).

2.3 Situating the research

As gleaned from the review in Chapter 1, the leave-taking literature is disparate and spans several disciplines. Though this highlights the interest in the topic across fields, it makes the frameworks for understanding leave-taking incongruent. To situate this research project, we need to understand the relationship between current frameworks relevant to leave-taking. "The power of any integrative approach is measured by the success by which it can accommodate the valid points of conflicting theories" (Burghardt, 2005: page 23), which is the aim of our overview of leave-taking; to simultaneously allow for the various perspectives of study, allowing us to identify lacunae and address them.

We will broadly consider four stages that set the scene for leave-taking: social interaction, leave-taking, interaction ending and separation. Across the literature, these stages are variable, with some descriptions dividing into several pre-leave-taking stages (e.g. Albert and Kessler, 1978; Schegloff and Sacks, 1973), but for the purpose of this chapter we will consider them as these broad categories. The four stages outlined here seem consistent across the literature and

so form the main categories for which to discuss frameworks. As discussed earlier, social interaction is a necessary condition to consider behaviour as leave-taking, and leave-taking must precede the interaction ending. The interaction ending is followed by separation, another necessary condition. These four stages represent the key "moments" in leave-taking, and each are understood differently depending on the perspective of the literature which aims to explain it.

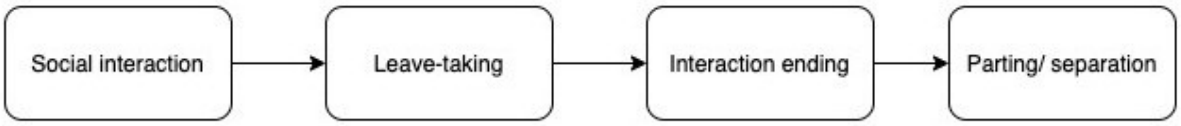


Figure 2.2: The process of leave-taking.

Tinbergen famously classified aims to study behaviour into four questions: 1) control/ causation, 2) development/ ontogeny, 3) adaptive function, 4) evolution/ phylogeny (Tinbergen, 1963). These questions can be easily applied to leave-taking: 1) How does leave-taking work? 2) How does leave-taking develop throughout an organism's lifetime? 3) What is the adaptive value of leave-taking? 4) How did leave-taking evolve in the species? The first two questions can be considered proximate (e.g. mechanistic, short-term reasons something occurs) and the latter two, ultimate (e.g. the adaptive, evolutionary reason), (Nesse, 2019). In our review of leave-taking, it was apparent that in current paradigms of leave-taking there has been a much greater focus on the proximate causes, compared to ultimate explanations, which are harder to understand and test. Nonetheless, we can draw on several ideas to bring together frameworks from other topics that might give insight into leave-taking and use these to highlight the neglected area that this research project will focus on.

c) INSUFFICIENT CONDITIONS
B) ULTIMATE CAUSES
A) PROXIMATE CAUSES
Leave-taking should not occur without social interaction
Type of leave-taking behaviour itself can be insufficient
Timing of leave-taking can be inappropriate, and will not drive leave-taking if interaction ending is not intentional
Lack of separation is insufficient for leave-taking
Social interactions are well understood to be adaptive in social species e.g. increasing bonding, access to mates etc.
Leave-taking may serve a social function e.g. increasing social bonding or reducing aggression
Interactions can end for a number of reasons e.g. maximising interaction with individuals
Separation can be beneficial to balance competition with socialising and varies in cohesive and fission-fusion species
Social interaction can be driven by a number of factors e.g. relationship, dominance, kin, environmental context
Driven by the interaction ending but also influenced by cultural, hierarchical, relationship, species and individual differences
Can be caused by replacement of individuals, natural end of activity or e.g. in foraging resource exhaustion
Allows individuals to socialise with other individuals, avoid aggression and pursue other activities such as foraging
1. Social interaction
2. Leave-taking
3. Interaction ending
4. Parting/ Separation

Figure 2.3: Framework of perspectives concerning leave-taking, with the main areas of research for this project in orange outlined boxes.

2.4 Proximate explanations of leave-taking

Proximate causes explain what immediately drives each stage of interaction and how behaviour is expressed. It can help us understand the mechanism and triggers for driving a behaviour. Social interaction (1a) is well studied across many disciplines, and due to its importance in defining leave-taking, is relevant to shaping it. For example, interactions can be affected by factors internal to the interaction such as social relationship and dominance, or external in the environment such as competition for scarce resources, or an individual's experience through their development. These factors indirectly influence leave-taking because of the social interaction which sets the scene for the other stages of interaction, for example a positive social encounter may affect leave-taking in that it will focus more on the continuation of positive affiliation and the future reunion (Albert and Kessler, 1978). Certain developmental factors may affect social interactions later in life (Carpendale and Lewis, 2004), for example children with siblings may demonstrate false belief understanding earlier than only children (Perner et al., 1994) and parenting style may affect social-cognitive development (Vinden, 2001). Many studies concern themselves with how early interaction period shapes social and cognitive development (Bakeman and Brown, 1980), with specific patterns such as rejection exacerbating antisocial behaviour throughout development (Dodge et al., 2003).

Leave-taking (2a) itself may be proximately driven by the ending of the interaction and shaped by factors independent to the social and environmental context, for example by individual, developmental, cultural or species level differences such as the propensity for fission-fusion (Aureli et al., 2008). A significant part of the leave-taking consists of leave-taking from a

developmental psychology perspective e.g. at what age leave-taking develops and how the verbal and non-verbal behaviours emerge (Gleason and Weintraub, 1976), and what context drive leave-taking at different stages of development (Grafenhein et al., 2009).

Interaction endings (3a) are proximately shaped by features of the interaction itself e.g. social replacement, topic termination, or externally from exhausting physical resources. This area seems of particular interest to psychologists, where it is argued to complement the study of leave-taking. For example, the reasons why interactions end could help explain the type of leave-taking, e.g. Albert and Kessler (1976) motivation for ending encounter and dissonance (Festinger, 1957) or imbalance (Heider, 1958).

Separation (4a) is proximately driven by the need to socialise with many individuals in a social group, and to experience other activities necessary for survival e.g. foraging, resting, escaping predation. This is influential in leave-taking, as it is suggested that separation may shape leave-taking in terms of length of separation, and even that leave-taking reflects the risk of separation (Firth, 1972). Most of the explanatory literature that covers leave-taking focuses on these proximate solutions, immediate causes, and their development, and helps us understand some of the ways in which the behaviour is shaped within populations.

2.5 Ultimate explanations of leave-taking

Ultimate explanations help us to understand what might be evolutionarily driving each stage of interaction and how behaviours are adaptive, as well as the big picture phylogenetic history of behaviour. They can help us understand the causes of behaviour and if they function for a particular purpose. Ultimate causes can drive proximate mechanisms, and so we consider the

adaptive function of each stage of interaction, in relating to leave-taking. Many of these vary based on social system and structure which will also be discussed. Social interaction (1b) is highly beneficial for social life, for example for improving social bonding, competing to increase dominance rank, to transfer important information (McGrew and Baehren, 2016). Ultimately, as with all evolutionarily advantageous behaviours, this maximises chance of survival and reproductive success. Broadly speaking, social interaction is shaped by the phylogenetic pattern of species, for example most primates are social species and live-in social groups.

Ultimate explanations of leave-taking (2b) are the biggest gap in terms of evolutionary significance; to our knowledge has never been empirically tested and may well vary between social systems. As discussed in the review of Chapter 1.1, leave-taking may have several adaptive purposes including announcing interaction end and providing useful information to remaining individuals, managing separation through social bonding, and reducing aggression. It could be likely that leave-taking is a result of phylogenetic patterns, like greeting behaviour, which is present across all primate species (Scheumann and Zimmerman, 2017).

Interaction endings (3b) ultimately occur to maximise interactions with different individuals which can improve bonding in the group and reduce aggression within group (Aureli and Schaffner, 2007). This also has adaptive benefits in that individuals can manage their time to balance socialising, resource acquisition and self-maintenance/ protection.

Relatedly, separation (4b) helps balances the social benefits of interactions with exploiting resources, genetic dispersal, reduce competition for food etc Separation can occur on different

levels e.g. individual, subgroup, community and this degree often relates to degree of fission-fusion (Aureli et al., 2008).

2.6 Insufficient conditions for leave-taking

Beyond the explanations, proximate and ultimate, for the stages involved in leave-taking, there are examples at each stage of conditions that do not suffice for driving leave-taking. A number of these come from the work of Goffman, who termed them false leave-takings, i.e., they shouldn't occur and if they do it is "wrong". For example, without social interaction (1c) leave-taking should not occur. This is demonstrated in Grafenhain et al's., (2009) study showing children are more likely to show leave-taking when they have been engaged in social interaction, not solo activity near others. Similarly, Goffman (1971) highlights how a young child waving as they exit the bus seems amusing; this is a false leave-taking as it has not been preceded by social interaction to all those on the bus. Behaviours themselves can be insufficient to be deemed leave-taking (2c), for example using culturally inappropriate behaviours, timings, or contexts (Carroll, 1987). This is discussed particularly in studies of language acquisition, e.g. Hassall, 2006; Cook, 1985; Sukwiwat and Fieg, 1987, Scarcella and Brunak, 1981. Similarly, a lack of leave-taking when it is expected is obviously insufficient. This was experimentally tested by Knapp (1973) who found when one individual is instructed to give no termination cues, the other attempts to adopt leave-taking structures, e.g. buffering, in order to terminate the interaction.

Goffman does not speak about failed leave-takings relating to the next interaction stage that we have identified, interaction ending (3c). Evidence suggests that non-intentional ending e.g. interruption or intercept, sudden death is not sufficient for leave-taking (Albert and Kessler,

1976), in that one must predict the interaction will terminate imminently. Finally, Betholia (2009) shows that in societies with little separation (4c) there is little leave-taking, thus it is imperative in driving leave-taking. Separation can be insufficient in driving leave-taking e.g. parting too soon, going in same direction, or returning too early (Goffman, 1971; Lockard, 1978). Similarly, separation that never ends for example at death or permanent departure could elicit similar behaviours to leave-taking but is insufficient in the sense that it does not fit into the cycle of meetings and partings and is not a "social interaction" between living individuals.

2.7 The Thesis

As demonstrated in Chapter 1 and the current chapter, the current literature does not involve evolutionary perspectives on leave-taking, particularly regarding non-human species. There is also a lack of cohesion in the literature and a disconnect to some of the earlier contributions of our knowledge on this topic, which the current research aims to rectify by drawing on knowledge from the historical literature. As described in Chapter 1, definitions of leave-taking are incongruent, and often not operational, seen as a behaviour assumed to be instantly recognised. Similarly, to how Burghardt writes on play behaviour, we may actually fail to recognise the behaviour or may misclassify presumed “obvious” behaviours, without considered definitions. Thus, “the challenge is in finding a definition that aids research, without being so vague that nothing is eliminated, or so rigid that relevant phenomena are excluded” (Burghard, 2005: page 49), which has been established already in the thesis.

While greeting and leave-taking are assumed to be human universals, no systematic comparative research has ever been undertaken on this topic. Thus, my study will fill an important gap in our knowledge of communication, ritual, and sociality. More specifically, this study will begin to address the incongruence in our knowledge of greeting vs leave-taking, as

the first extensive non-human study of leave-taking. This study will also provide a methodological framework for encouraging systematic cross-species study to test further hypotheses of behavioural evolution, and test this to ensure it is useful. Methodological challenges often limit our ability to conduct cross-species comparisons but by creating the operational definition of leave-taking and using video footage we will be able to develop a robust comparative framework for highlighting the similarities and differences, or absence, of leave-taking across species. Given that we understand how interactions open and progress, and that humans' sociality is seen as an anomaly, research on interaction endings is significantly lacking. This research will answer some of the broad questions about the presence, communicative nature, and function of leave-taking, and help us to understand why and how it may have evolved. Thus, to return to the framework of our current understanding on leave-taking research, this thesis will address some of the proximate drivers of the behaviour (mechanistic), as well as investigate ultimate explanations of leave-taking (adaptive function and phylogenetic history).

Biological anthropologists continue to be fascinated by what makes us "uniquely human", and how and when these traits evolved. Leave-taking is a possible candidate for such a uniquely human trait, is a common everyday behaviour and yet remains almost entirely unstudied evolutionarily speaking. As such, leave-taking is long overdue for serious consideration. The results of this study will be wide-reaching, laying foundations for future interdisciplinary work on this fundamental, possibly unique, aspect of human behaviour.

This research will focus on answering the following questions:

Chapter 4- How can we measure leave-taking in non-human primates?

Although there has been some attention in the literature to human leave-taking, in non-human primates the phenomenon has been almost entirely ignored. This is presumably in part because of the difficulty of studying the behaviour, both in terms of the definition and the *a priori* nature of the event. Despite this, non-human primates could give us valuable insight into both the function of the behaviour and its evolutionary origins. Because the definition of leave-taking has been linked to human interaction in current studies, it is difficult to know how best to measure this in other species. Thus, this study will test different measures of parting and leave-taking for the first time in a non-human species (chacma baboons) in order to determine whether leave-taking is an intrinsically social behaviour. This will in part address the Tinbergen's first question, the mechanistic structure of the behaviour, but also add to question four, the phylogenetic history of the trait by confirming the presence or absence in related non-human species, and thus whether it has a deep evolutionary origin in *Cercopithecidae*.

Chapter 5- Does leave-taking show evidence of intentional communication?

If leave-taking occurs mostly during partings of a social nature, it suggests that it could be an intrinsically social behaviour. However, this is not sufficient to tell us whether leave-taking provides referential information to conspecifics in an intentional communicative way. We will infer whether the leave-taking behaviours are communicative across species using three criteria for communication: receiver response, repetition of behaviour to gain attention, audience attention. This will help us to understand whether leave-taking could be used to impact others' knowledge state about impending separation.

Chapter 6- What are the proximate drivers of leave-taking?

Although leave-taking has been mostly considered from a proximate perspective, there has been no empirical tests of this in non-human interaction endings. We will investigate factors of the interaction that prompt leave-taking, using the framework from Albert and Kessler (1976) which outlines internal and external "motivations to leave". We compare this to what is assumed of human leave-taking to understand whether there are similarities in these proximate drivers of leave-taking and thus, make inference about the origins of this behaviour.

Chapter 7- What are the function/s of leave-taking?

Using our previous studies on the variation in non-human leave-taking, we can begin to investigate some of the driving factors behind these behaviours. We compare possible causal reasons behind leave-taking by constructing three hypotheses of social function of leave-taking: social regulation, separation indication, and risk management. These are three non-competing and non-exclusive models that we will test to rank how well they each fit the data, providing the relative importance of each. This will be the main addressing of Tinbergen's third question, the ultimate, adaptive function of leave-taking.

Chapter 3: General Methods

3.1 Introduction to methods

Designing methodology for this project was challenging. Not only did it require trying to investigate a behaviour that has never been empirically tested in non-captive, naturalistic settings, but the methods used must hold for species beyond humans and work comparatively. The scope of ethology, primatology and animal behaviour in general is changing; data is more readily available and easier to process, and technological advances mean that audio and video recordings are of higher quality and volume than previously possible (e.g. Leong et al., 2003; Cristani et al., 2013). Such media, and tools that can extract data from them, allow higher resolution data than would ever be possible in live observer recording, and have the benefit of being able to digitally calculate inter-observer comparisons and improve external reliability (Friard and Gamba, 2016). Much of this software is inaccessible to researchers because of expense and operating system requirements (e.g. Spitzen et al., 2013). Therefore, free software for the quantitative analysis of behaviour is important to compare behavioural sequences prior to parting to investigate leave-taking.

This study has three main methodological aims:

1) To appropriately define the terminology and include adequate controls for leave-taking to allow for robust validity of measures
2) To apply such frameworks to validated research methods for leave-taking and allow testing of further hypotheses about its evolution
3) To use software to speed up and standardise observational data, allowing for increased data collection and reliability testing

This chapter outlines the general methods that are applicable to all empirical chapters (Chapter 4, Chapter 5, Chapter 6, and Chapter 7). In each empirical chapter there is additional methodology described pertaining to the detail of each study.

3.2 Primate models for human evolution: a methodological compromise?

Although using phylogenetic closeness to model can be biased towards *homology* (shared ancestry), it can also be useful because it gives a similar ground for comparison. For example, primate species share a similar body plan, habitat, and way of experiencing the world (Jolly, 2001). Using multiple species in a cross-species comparison is a particularly powerful approach because we can test predictions using *analogy* (converged purpose) that can be more useful for determining function: if species have converged in some behaviour because of parallel environmental pressures then this can give insight into the functional purpose that phylogenetic closeness alone cannot offer (Strum and Mitchell, 1987). Using multiple species to test predictions is common in zoological studies (e.g. (Ember and Ember, 1979; Garland, 1999)) but less common in anthropology; an unhelpful idea left over from the assumption that humans are somehow special compared to other species. This thesis presents a method that is suitable for application across species and can be used to comparatively investigate leave-taking.

Studying human behavioural evolution is intrinsically difficult; unlike physical evolution there is no fossil record that is left behind. Processes that shape an organism or its behaviour are assumed to be uniform over time (Gifford-Gonzalez, 1991) and therefore we can infer through time the processes that shape it today. As we know that there are established relationships between ecological and behavioural variables, we can characterise these interactions and extrapolate them into the past (Williamson, 1997): no extant primate is analogous to an early

hominin, but they are subject to the same selection pressures and their responses would be consistent with trends found today (Rose and Marshall, 1996).

Thus, it is common to look to our closest living relatives in the primate order to try and reconstruct the behaviour of hominin species (DeVore and Tooby, 1987). The use of primates as models for human evolutionary processes is powerful; they share genetic, physical, and social traits with humans (Muller et al*.,* 2017), including aspects of communication (Seyfarth et al*.,* 2018). As direct observation is impossible for reconstructing behavioural evolution, model making is essential. Broadly speaking these models are categorised as referential or strategic. In reality there is no strict dichotomy between these types of models, after all when using a referential model, we are not assuming our ancestor *was* a chimpanzee. Equally, when constructing a hypothetical model, we rely on using data from *living species* and so the two are intrinsically linked. It is likely more productive to see each as contributing to our understanding through a cyclical process of refinement (Moore, 1996). However, positives and pitfalls of these non-distinct approaches are still important and are discussed below.

Referential models aim to identify similarities and differences between humans and other extant primates, attributing shared behaviours as retained by both species conserved from their common ancestor. Following this logic, behaviours that are present in two closely related species, were likely to have evolved only once in their most recent common ancestor (Suddendorf, 2004). The most popular referential model is the chimpanzee (*Pan troglodytes*), forming an integral part of comparative human evolutionary studies (Muller et al., 2017). Chimpanzees also have a long historical record of study that provides a wealth of data from which to draw predictions (de Waal, 2009).

However, as chimpanzees are historically studied more than other primate species this introduces a bias into research. To illustrate this, we are genetically equally related to the bonobo (*Pan paniscus*) as the chimpanzee, however as it has a much smaller population and distribution and did not achieve species recognition until recently, we have much less data on the species and our resulting ideas of hominin evolution are skewed in reflection of this (de Waal, 2009). Thus, reconstructions of human behaviour run the risk of becoming "chimpocentric" (Beck, 1982). Other species models have become popular, aiming to reduce this bias in comparative evolutionary study and model features of hominin evolution better attributed to other primates e.g. baboons (*Papio*), which have been used as useful models of ecology and sociality (Strum and Mitchell, 1987). They inhabit mosaic environments common to early hominins, are large bodied, terrestrial, highly social, and behaviourally flexible, making them exceptionally useful analogues for human behavioural evolution (Swedell and Plummer, 2012). Recent examples include the use of baboons to model fitness benefits of social bonds (MacFarland et al., 2017), energetic trade-offs (King et al., 2017) and the function of copulation calls (Bouquet et al., 2018). Studies of collective movement have also used baboons because of their multi-male, multi-female groups, social structure, and value in studying social bonds (King et al., 2011; Strandburg-Peshkin et al., 2015; Sueur et al., 2011). Many researchers believe that the "chimpocentrism" is warranted given that we share so much with chimpanzees genetically, behaviourally, and cognitively (e.g. Muller, 2017). Some of the most important recent insights into our evolution have come from chimpanzees, such as adaptations to savannah environments (Pruetz and Bertolani, 2009) or of ephemeral tool use that would otherwise be invisible in the archaeological record (Almeida-Warren et al., 2017). In summary, referential models can be extremely useful, but should be chosen carefully based on what we aim to model.

Many researchers strongly believe that we cannot use a single referential model; because by default in reconstructing a last common ancestor, they themselves are unique (e.g. Stanford, 2012; DeVore and Tooby, 1987). Because of this no living primate accurately predicts an extinct species, and we cannot project attributes from some single other species. Nobody disputes the special place that chimpanzees hold in human evolutionary study (de Waal, 2001) but instead by using strategic modelling we can make hypotheses focused particularly on an aspect of behaviour or ecology, instead of generalising the extant species to represent an extinct ancestor (e.g. Carvalho and McGrew, 2012). In referential models the similarities of the living species and humans are often emphasised at the expense of the differences (DeVore and Tooby, 1987), and the differences become difficult to explain. Ultimately, they cannot answer the question "if we share so many similarities, then why did we evolve as humans and not as chimpanzees?" (Boesch, 2007)

When using a chimpanzee, or a baboon model, we are not assuming that the chimpanzee or baboon is a representative of hominins, but rather sets of theories are defined and operationalized, relating new phenomena in meaningful ways. A good model can organise and interpret an expanding body of data, allowing new evidence to be perceived (DeVore and Tooby, 1987). To devise conceptual, strategic models we must devise solid theory, which makes empirical predictions about extant species, integrating the paleontological and archaeological record. For this, the comparative method is crucial (DeVore and Tooby, 1987), to use living species data to derive questions and definitions, as well as test them. Furthermore, the choice of chimpanzees as a model for a last common ancestor is not necessarily referential (Pilbeam and Lieberman, 2017), but rather is used to help construct similarities between extant African apes in their phylogenetic context. Further, unique traits in early hominins are not ignored: a chimpanzee-like ancestor reconstruction can help explore hypotheses (Muller, 2017)

using broad comparative datasets e.g. meat eating in humans (Wood and Gilby, 2017), human social organisation (Chapais, 2017) and warfare (Wilson and Glowacki, 2017).

More recently, comparative studies have looked beyond primate species to test strategic predictions using analogy, including land mammals, cetaceans, reptiles, birds, and even some non-vertebrates such as insects and octopi (reviewed in Fitch et al., 2010). This is a paradigm shift away from a 'scala naturae' school of thought that species increase in complexity with increasing relatedness to humans (Striedter, 2006). Instead, we now understand that all species have evolved for their various niches, and we can expect convergent evolution in species with similar adaptive problems (Fitch et al., 2010). Strategic models have been used with great success in recent years to understand the evolution of several phenomena including multi-level social systems (Sutcliffe et al., 2016), sex ratios (Kappeler, 2017), and play behaviour (Pellis et al., 2015). Although we must be careful not to over-estimate the similarity of intra-species variation between populations, identifying normative species-specific behaviour allows controlled, phylogenetic, inter-species comparison (Strier, 2017).

From a single referent model, we are limited in the conclusions we can draw, for example a common ancestor may have shared some behaviour but with little variation from which to test predictions about function. When we use a single species, we rely on homology, but in many ways behaviour that is shared because of *analogy* is more powerful for answering functional questions (Strum and Mitchell, 1987). This is because we can test poignant *convergence* of behaviour that can answer *why* a trait evolved as opposed to assuming it is homologous and shared in a last common ancestor, allowing control of the non-independence of related species (Blomberg et al*.,* 2002). This having been said, some phylogenetic closeness is useful because it gives a similar ground plan (Jolly, 2001) (e.g. four limbs, similar skeletal arrangement),

habitat (e.g. African savannahs and woodlands) and way of experiencing the world (e.g. primates are visual animals and therefore experience the world in a way similar to humans) and allows for convergent behaviours to present themselves similarly. But, if species have converged in some behaviour because of environmental pressures then this can give more insight into the functional purpose than phylogenetic closeness can ever offer (Strum and Mitchell, 1987). When species are 'too closely' related to humans it is hard to distinguish which features are converged and which are more primitive, but useful analogies from closely related species often means we bias our research in this way (Jolly, 2001). It also reveals apomorphies (derived traits), which can help distinguish between the respective factors that could be driving behaviour.

In this sense the best approach of modelling human behavioural evolution is to collect data on multiple species with varying positions of phylogenetic relatedness, to incorporate both homology and analogous convergence of behaviour (Garland and Adolph, 1994) and test how a trait (e.g. leave-taking) varies with variation in social and ecological factors (e.g. as has been used to test gregariousness in larvae, Terbot *et al.,* 2017). This avoids the single referent assumption that an extinct species could not have been different to a modern analogue. *Does this run the risk of becoming just a series of referential models?* Instead of individually comparing each primate species to our hypothesised predictions, we can create testable hypotheses that compare *multiple* species at once, allowing variation to be captured both between humans and the non-human primate, but also between the non-human primates themselves. Looking simply at each species could restrict traits to those shared by all modern species (Andrews and Aiello, 1984), but if we look for patterns of behaviour across the phylogenetic tree, we can identify rules that govern development of different traits (Foley and Lee, 1989). Here we can make assumptions about how changes occur in a way we cannot with

single referent models (Rendell and Di Fiore, 1995). This approach of multiple cross-species comparison is widely used in zoology, e.g. bonding behaviour in mammals and birds (Ember and Ember, 1979); locomotion behaviour in reptiles (Garland, 1999), gregariousness in larvae (Terbot et al., 2017), but has not yet been full embraced by evolutionary anthropology (Rendell and Di Fiore, 1995): presumably a relic of the idea that humans hold some special place in the animal kingdom and are exempt from the logic of true analogy. As a main criticism of comparative primatology from zoologists and paleoanthropologists, this approach marks a shift in the way we think about evolutionary scenarios, making them more testable and more believable. Making predictions based on multiple species varying sociality, morphology, ecology, and distinct evolutionary trajectories provides a more powerful approach than a simple comparison. No single primate species is a good analogue on its own for any other primate species, never mind a hominin, so instead we should identify the patterns and evolutionary pathways to create wider models.

Specifically, in looking at social behaviour, the comparative method offers a powerful tool to look at the overall relationship between behaviour and other changes over time. To do so we must devise ways to make comparisons between species as systematic as possible, for example McComb and Semple (2005) finding that the size of the primate vocal repertoire is associated with time spent grooming and increased group size. Using the primate order as a frame to test from, we have enough similarities as a four limbed, large brain, social mammal, and yet enough differences that when analogous forces modify behaviour in parallel, it is recognised and not just assumed to be homology (Jolly, 2001).

This thesis takes chacma baboons as the first species to holistically investigate the form and function of leave-taking; but presents methods that can be applied across a wide range of

human and non-human populations. Although the ideal scenario would be to present results across multiple species, this thesis aims to design and test the methods which can be built upon in future research.

3.3 Chacma baboons as models

Baboons are part of the Cercopithecidae family and share a common ancestor with humans around 36 million years ago (Boyd and Silk, 2014). Broadly speaking, several baboon species are grouped together because of similar ecology and social organisation are described as savannah baboons (Smuts et al., 2008). These species include yellow baboons (*Papio cynocephalus*), chacma baboons (*Papio ursinus*) and olive baboons (*Papio anubis*). Savannah baboons live in large, cohesive, multi-male multi-female, female bonded groups where the males tend to disperse out of their natal group and the females are philopatric (Grueter et al., 2012).

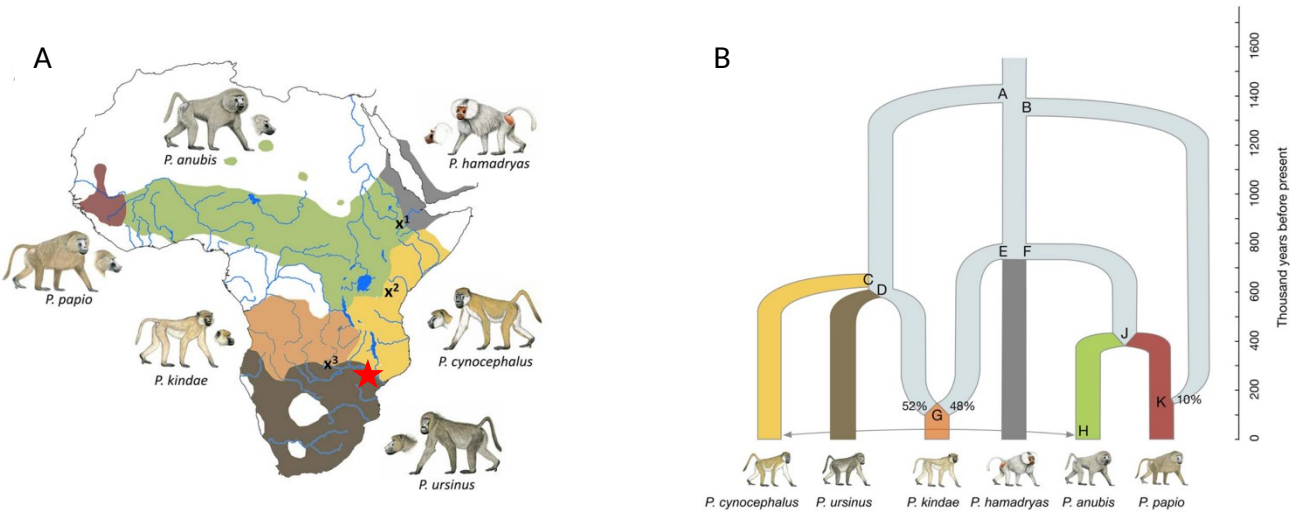


Figure 3.1 A: Distribution of the six *Papio* species across Africa with GNP marked with a red star at the border between *P. ursinus* and *P. cynocephalus*. B: Cladogram of the relationship between the six *Papio* species and the evolutionary scale of split between them. Images reproduced with permission from Rogers *et al*., (2019).

Baboons have historically held an important place in the study of human behaviour, and are often used as a model species for hominin evolution for two main reasons (Strum and Mitchell, 1987). First, many baboons including *Papio cynocephalus,* inhabit mosaic savannah and woodland environments like the Pleistocene environments where our genus emerged (Jolly, 2001) as well as Pliocene environments where early hominins ranged (Bobé et al., 2020). Baboons are also terrestrial, living mostly on the ground (Washburn and DeVore, 1961; Hammond et al., 2022) and are also argued to have an early-human-like social structure, with sexual dimorphism leading to aggression between males and resulting male dominance (Grueter, 2014). Baboon troop sizes correspond well with estimates of australopithecine group size, as well as population density; the compact troops of baboons may be like early groups of human hunting groups (Washburn and DeVore, 1961), where members of the group rarely leave one another and are closely related (van Horn *et al.,* 2007)

When looking at behavioural evolution, and specifically communication, baboons prove a fruitful model relevant to the evolution of language, as reviewed by Seyfarth *et al.,* (2005). Their communication is representative; carries discrete values e.g. age, sex, rank (Worden, 1998); is hierarchically structured; rule governed e.g. follows norms of directionality (Seyfarth and Cheney, 2003); independent of modality e.g. visually, and vocally (Kummer, 1968) and finally are propositional e.g. have an agent, an action, and a recipient (Seyfarth and Cheney,

2005). In this way, baboons are useful for thinking about the selective pressures that sociality has placed on our communication and helps us understand that before the emergence of language, hominins could have assigned meaning to other individuals' calls and extracted information from them (Seyfarth et al., 2005). They also help us understand the role of behavioural flexibility in communication: although vocalisations may be highly conserved across baboon species, behavioural plasticity allows for differences in social use across these groups (Hammerschmidt and Fischer, 2019).

Chacma baboon greeting is interesting, as this varies when compared to greeting of other baboon species. More specifically, chacma baboon greeting in males is brief and unelaborate, contrasting species such as Guinea baboons who have affiliative, friendly greetings, and the submissive, appeasing greeting in yellow and olive baboons (Dal Pesco and Fischer, 2020). This variation is thought to reflect variation in social system and the resultant patterns of interaction and social behaviour. The multi-level, male philopatric Guinea baboons have high tolerance and affiliation between males, who are often in closer proximity than males of other baboon species, and as such have more elaborate greeting rituals to test relationship quality (Dal Pesco and Fisher, 2018). Chacma and yellow baboons, together with kinda and olive baboons, have female philopatric groups, where male competition is therefore higher, and males spend less time in proximity with one another (Kalbitzer et al., 2015). Despite this similarity, tolerance levels vary, for example chacma male baboons tend to avoid one another, whereas yellow and olive baboon males demonstrate greater male-male coalition and reduced competition (Noë and Sluijter, 1990). This could explain the chacma baboon male's minimal greeting, and the yellow and olive baboons' appeasement, submissive greeting behaviour. However, greeting across baboons has historically been biased towards male-male interactions, and could benefit from expansion across females and the remaining dyad types (Muschinski et

al., 2023). These insights have profound implications for the study of leave-taking, which has been considered a bookend of interaction, together with greeting (Eibl-Eibesfeldt, 1971), and could be subject to similar socioecological pressures. From our limited data on males, we may expect more elaborate leave-taking in spatially tolerant species such as Guinea baboons, where it could act to regulate social relationships between close contact individuals. On the other hand, we could expect less elaborate leave-taking between male chacma baboons, who tend to avoid male-male interactions, and more submissive leave-taking in yellow baboons, to signal submissive status and avoid future hostile interactions. If chacma baboon leave-taking does exist, we may expect it to be associated with avoidance, rather than being affiliative or submissive as we may expect for Guinea and yellow/olive baboons, respectively. As we provide methods to investigate leave-taking, studies on greeting in female baboons would be extremely valuable in helping put together the missing puzzle pieces.

3.4 Study site

The Park itself covers 4067m2 across central Mozambique (Figure 3.2), where the base camp, i.e., Chitengo, is the home range to two troops. One of these troops, comprising of 39 individuals, is the focus of this study. Within this troop, 17 juveniles were excluded leading to a sample of 22 adult individuals in the present study. Infants were also excluded due to a lack of comparable separation with the adult counterparts. Importantly, baboons of Gorongosa National Park, Central Mozambique, experience a mosaic of habitats including closed canopy savannah, rainforest, montane grasslands, rivers, and caves (Martinez et al., 2019, Bobe et al.,2020, Santander et al., 2022). Modern environments similar to the ones inhabited in the past by Australopithecines 4.2 – to 2.3 million years ago “certainly included present day Gorongosa National Park” (Wilson, 2014: 28; Bobe, Martinez and Carvalho, 2020).

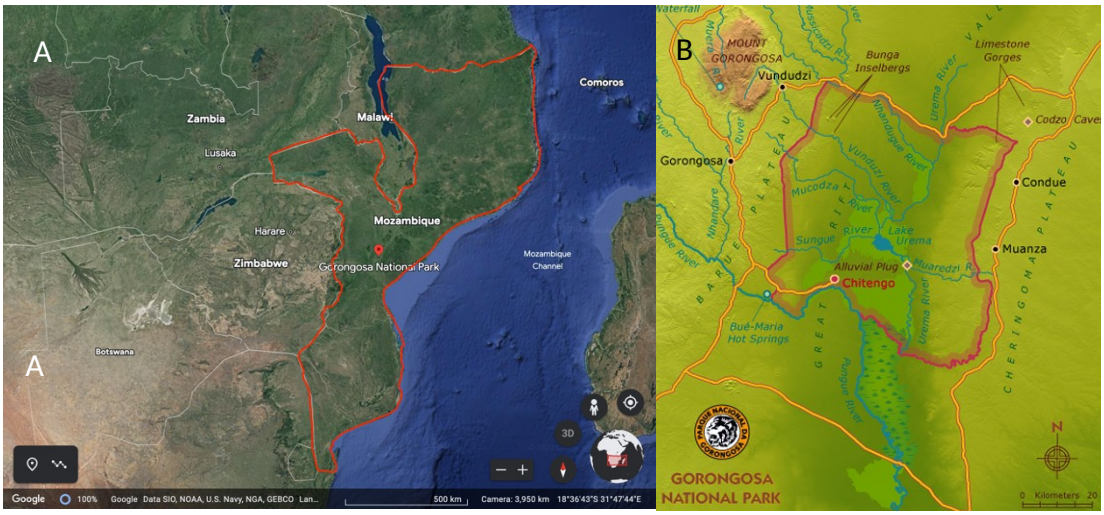


Figure 3.2 A: Location of Gorongosa National Park within Mozambique (adapted from Google Earth), B: Positioning of Chitengo camp within Gorongosa National Park (https://eowilsonfoundation.org).

The camp occupies around 0.157 km2 with a perimeter of around 2.13km. It is a tourist camp with cabins, campsite, restaurant, and safaris and thus the populations are very well habituated and can be observed well at close range and are largely unaffected by observer presence. On the other hand, this means that the behaviour of these animals is contextualised in an anthropogenic environment, which could lead to some idiosyncrasies that are not necessarily representative of the species. Despite this, **the opportunistic nature of baboons means that the Chitengo troop is not unique in this regard,** and the open terrain and well habituated troop make this setting and population ideal for recording every- day interactions of baboons.

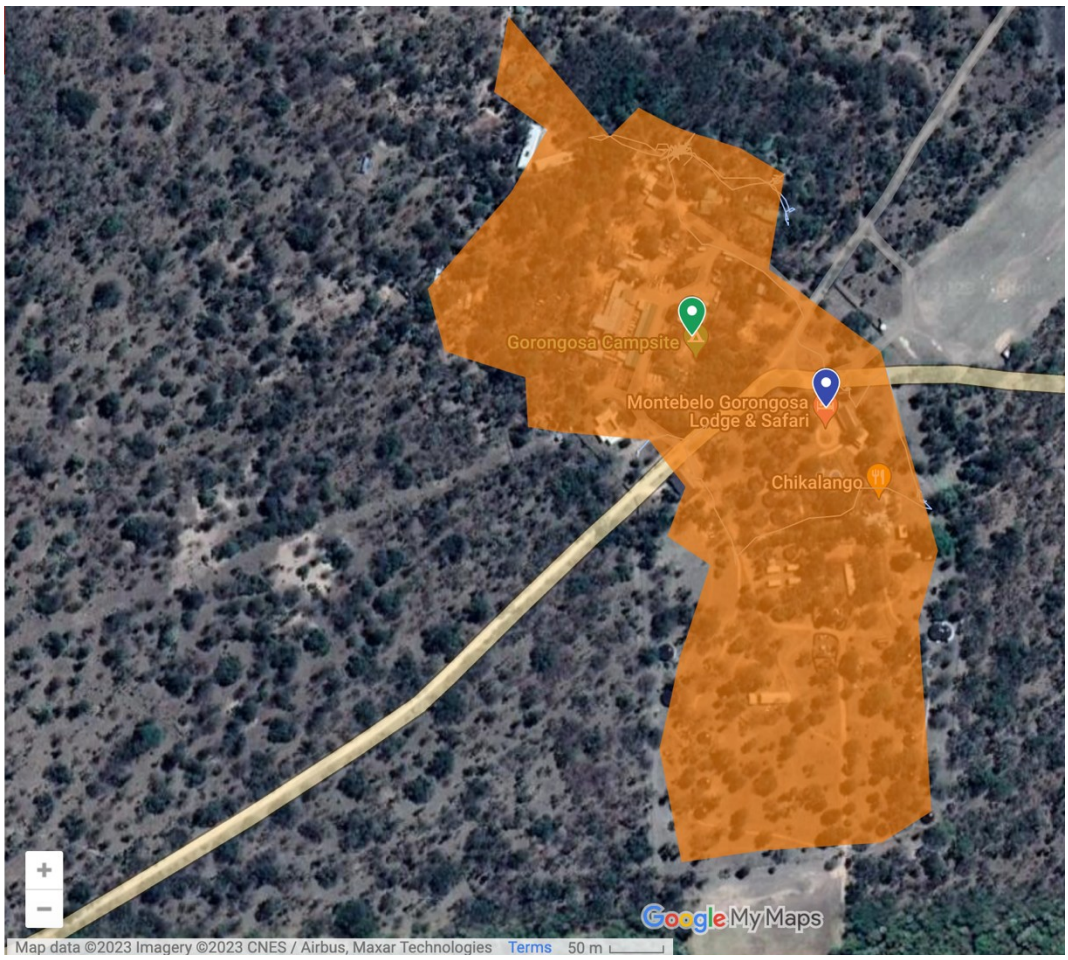


Figure 3.3: Map of Chitengo camp (adapted from Google Maps), highlighting the study area of the troop in orange. Campsite marked with green pin and Lodge marked with blue pin.

Table 3.1: Summary of population demographics

Adult Males	**Adult Females**	**Juveniles**	**Troop Total**
10	12	15	37

3.5 Data collection protocol

Videos were taken for this study across three months of field work (August, October and November of 2018) in Chitengo camp, Gorongosa National Park. The first month was to test

recording protocols and collect ***ad libitum*** data (Martin and Bateson, 2021). Following this, daily follows of the baboons were done and videos taken during the latter two months, totalling over 65 hours of footage. This was done opportunistically (albeit trying to randomize across sub-groups) during the follows to capture as many interactions as possible, rather than filming individual focal dyads. This method allowed as many spontaneous interactions as possible to be captured, as opposed to using scan sampling, and allowed the video database to be curated even before individuals were identified.

Video footage taken during the daily follows was done on a Nikon P900 83X Optical Zoom mounted on a tripod. This was done in an opportunistic way from when at least one individual was visible until all the group had moved out of the shot, thus including spontaneous interaction, solo behaviours, and parting events. Footage was then uploaded in behavioural coding software BORIS (Friard and Gamba, 2016) and the video played repeatedly to capture fleeting movements, as well as allow for easier and more accurate inter-coder reliability. This method is particularly important for behaviours that happen retrospectively, i.e., before the parting event, and allowed recording the parting events and then rewind to code the behaviours which precede them.

BORIS was used to collect behavioural data from digitally imported videos. This gave the advantage of rewinding from separation to record prior behaviour; something that is almost impossible to collect in-person. The unit of measurement for this study was “observations”, which is defined as being from the start of an activity (solo or joint) to the moment where the departure (solo or joint) occurs. Dyads were chosen opportunistically and exhaustively throughout the video footage, and the parting individual within that refers to the individual who

first leaves the dyad (or the only individual if it is a solo activity). For each observation the unique video ID it is from was recorded, and the observations numbered.

Table 3.2: Parting types and definitions.

	Solo departure	**Interaction end**	**Proximity departure**
Individuals present	Solo individual (no individuals within 1m)	Dyad (within 1m)	Dyad (within 1m)
Activity end	End solo activity e.g. rest, forage, self-groom	End joint activity e.g. groom, play, copulate	End solo activity (at least one of dyad) e.g. rest, forage, self-groom
Movement	Moves away from current spot (>1m)	Move away from one another (>1m)	Move away from one another (>1m)

Figure 3.4: screenshot of BORIS software used for data collection.

BORIS is an open-access event-logging software that can be used to collect behavioural data from digitally imported videos (Friard and Gamba, 2016). It is highly flexible: ethograms can be created or imported and set according to keys on the keyboard, which can then be used to code for behaviours or events in the programme, with an unlimited number of behaviours or states. It is also possible to code for independent variables that remain the same throughout

each observation. The advantage of using such software is that it speeds up data collection compared to manually recording the behaviours, as well as allowing easier complete inter-observer reliability, which can be done within the software. In addition to this BORIS has several useful features for analysing the fine details of behaviour, e.g. the videos can be paused and slowed down or sped up to easily improve the resolution of data coding. All the behaviours and states that are recorded are done so with an individual and time stamp, and modifiers can be used e.g. “scratch” and then “body”.

Variable	Definition
ID	Identity of the individual
Activity duration	Length of time (mm:ss) that activity lasts from start of behaviour to departure (move 1m radius away)
Leave-taking (presence of orientation shifting)	Move weight from one side to the other in a shuffling motion, can include change in orientation of body. Presence or absence.
Interruption	Individual or dyad are forced to move away (>1m) or joined by another individual

Table 3.3: Definitions of main variables used across the empirical chapter.

A)



B)



C)



Figure 3.5: A): An activity is occurring between a dyad. B): The pre-parting window two minutes before departure; individuals often stop the activity and may perform "leave-taking" behaviours. C): An individual departs, moving away from the other individual in the dyad by > 1m.

Behaviours were recorded using all-encounter sampling in the three-minute window prior to departure in all three parting type conditions, including each time one of the three behaviours started and stopped (Altmann, 1974). This means that each observation had a record of the number of occurrences of the two leave-taking behaviours. Following this, new variables were coded: whether each of the two behaviours occurred in the three-minute window (yes/ no). As outlined below, individual ID for both the receiver and signaller, parting type and activity duration were also recorded for each observation. (Table 4.3).

Over 500 dyad observations were initially identified from the 65 hours video footage. This number is relatively low due to only using adult dyads in this study; additionally, low visibility impacted the ability to include all pre-identified observations. Those including behaviours that could not be fully coded had to be excluded, including observations in which foliage or other individuals obscured view. Furthermore, some observations had no clear separation, for example if the camera cut out or vision became impaired by another individual. Observations in which the ending was caused by the joining of the third individual (or a second, in the case of solo observations) were also excluded, as well as those ending in interruption or immediately

followed by a follow, as they did not meet the criteria for intentional separation. Finally, those observations in which individuals could not be identified could not be used beyond descriptive statistics. Thus, the total number of observations to be included in the analyses totalled 371, and for the analyses involving just social interactions, totalled 216. Although this sample is small, we were able to control for inter-individual variation using R package "irr" (Gamer et al., 2012) and test the presence of candidate leave-taking behaviours in social interaction ends.

The context of observations is somewhat limited given the setting of video recording. Most of the video footage covered contexts of rest, foraging and grooming. However, as the context correlated so strongly with the type of observation (e.g. social interactions were almost entirely in grooming context), the context variable was not included in the present analysis.

There was also variation in the number of observations per individual, likely due to the variation in how habituated different individuals were and how many observable social interactions they were involved in. In the final sample of social interaction observations (n=216) only 24 individuals were identified, of the possible 37, due to the number of individuals that are not currently identified. Furthermore, adult males Quasimodo (n=4) and Pequeno (n=2) were observed much less frequently due to being peripheral, and less central to the group and less likely to be involved in observable social interactions. Others, such as adult females Maizey (n= 52) and Molly (n=58), are over-represented in the sample due to being high-ranking, central to the troop and participating in many social interactions. Individual ID for both signaller and receiver is controlled for in the models to account for this.

3.6 Methodological limitations

We cannot say "A interacts more frequently than B" because we cannot possibly hope to film all interactions of A and B and the videos we do have are on an *ad libitum* basis. Furthermore, some individuals may be more "observable' in the group e.g. subordinate male baboons seem to hang back and not be with the main group of baboons that are likely to be filmed. Instead, we can say "from x number of recorded interactions A showed self-scratching before parting significantly more than B". Behaviours are also possibly biased in this way because some are more visible that others, especially in certain contexts e.g. eye gaze in tall grass may be hard to see. We will not be able to make generalised conclusions about "how often" things happen, because as described we can never film everything that happened, and the scans are limited to the visible individuals. All the videos will have varying bias in sampling, individuals, and location but these factors can be acknowledged and included into the analysis e.g. individual ID. All the videos will still yield the necessary variation in context, interactions and individuals that will make this cross-comparison possible. Because none of the videos can record everything that every individual did all the time we cannot analyse data in terms of activity budgets, or absolute frequency. However, although these are important measures for many primatology studies, this project concerns itself more with the specific behaviours that occur before parting events, and we will not ask questions such as "how many partings are there in a day?" but rather "before partings, are there predictable patterns of behaviour?". As the observations in the footage will be random, and individual differences will be accounted for, we will be able to ask the kinds of questions we set up to answer in this research.

3.7 Data availability

R analysis scripts and dataset of the published empirical chapter are uploaded to the following GitHub repository: https://gitfront.io/r/user-7608054/4NFaXFUC9w14/gorongosa-baboon-95

leavetaking/ The scripts and datasets of unpublished chapters will be made openly accessible following publication. This will allow methods to be replicated and extended to other study populations.

3.8 Ethics

This work was carried out with ethical clearance from the Ministry of Tourism and the Gorongosa Restoration Project in Mozambique (permit number: PNG/Dsci/C110/2018). All data collection was observational in the troops' natural habitat and researchers did not come into contact with the animals.

Chapter 4: Yet Another Non-unique Human Behaviour: Leave-taking in Wild Chacma Baboons (*Papio ursinus*)

This chapter is an adapted and extended version of the manuscript "Yet Another Non-unique Human Behaviour: Leave-taking in Wild Chacma Baboons (Papio ursinus)"

(Published version available as Appendix 2).

4.1 Abstract

Leave taking is a common, possibly universal, feature of human social behaviour that has undergone very little empirical research. Although the importance remains unknown, it has been suggested to play an important role in managing separations, mitigating the risk, and increasing social bonding beyond the interaction itself. In nonhuman species, the literature is virtually absent, but identifying leave taking beyond humans may provide unique insights into the evolutionary history of this behaviour and shed light onto its proximate and ultimate function(s). Methods to study leave taking are not well-established, and the variation in definitions, measures, and control variables presented in past studies poses additional challenges. Baboons are a valuable model for investigating human behavioural evolution: as a flexible, highly adaptable, and social primate whose radiation is, similarly to humans, associated with the emergence of the African savannah biome. Using the framework and definition proposed by Baehren, we investigated the presence of leave taking in a wild, generalist primate and tested a range of candidate behaviours on prerecorded video footage: 1) self-scratching, 2) eye gaze, and 3) orientation in the direction of parting. Using multivariate analysis, controlling for interaction duration and individual variation, our results show that orientation in the direction of parting occurs predominantly before social separation

events. These results indicate evidence of leave taking in a wild nonhuman population and contrast with previous ideas that this is a uniquely human behaviour. The presence of leave taking in baboons suggests a deep evolutionary history of this behaviour, warranting further investigation into its function and presence across other nonhuman primate species.

4.2 Introduction

4.2.1 Lack of Leave-taking Study

Compared to the study of greeting, the ways in which interactions end are much less well-studied. This difference is exacerbated when looking at nonhuman species (Baehren, 2022). Nonhuman primates provide useful models for understanding how behaviour has evolved in humans, or how adaptive behaviours have converged (Jolly, 2001). For example, studies of greeting in chimpanzees suggest that these behaviours function to reduce tension and increase social bonding upon meeting (Nishida et al., 1999). The presence of greeting in nonhuman species suggests that this behaviour has an ancient origin that precedes the emergence of *Homo sapiens*, or in fact, the entire primate Order (Scheumann and Zimmerman, 2017). Indeed, Jane Goodall claimed that some of the most convincing similarities between animal and human studies are shown in greeting behaviour (Goodall, 1986). In contrast to this, studies of leave taking in nonhuman species are largely absent, and the origins in our lineage remain unknown.

The reason for this discrepancy in nonhumans remains unclear, as the behaviours have typically been considered together in humans. A handful of suggestions have been made as to why leave taking has not 'taken off' in the same way as greeting: it is hard to measure in animals, requiring more advanced technology to capture retrospective behaviours (Albert and

Kessler, 1978) or it may simply not exist (McGrew and Baehren, 2016). However, other sources suggest that there may be some evidence of nonhuman leave taking, even if it is does not parallel human leave taking as greetings often do (Van Lawick-Goodall, 1968). There are anecdotal reports of primate species showing possible leave-taking behaviours (e.g. De Waal, 2007), although these reports have never been subject to empirical study.

Furthermore, although the studies on human leave taking are greater in number, they mostly concern the linguistic structure of conversational endings (Baehren, 2022). Although these methods are appropriate for answering questions of conversation and language, they are less useful for tackling questions of evolution, especially across species. A potentially more useful avenue is to consider nonverbal correlates of parting, across cultures and species. This is useful in two ways: 1) behaviours independent from articulated language may show continuity across species and cultures, and thus inform us of similarities and differences (Duranti et al., 1997); and 2) may reflect basal aspects of shared communication across primates, as with greeting behaviours (Van Lawick-Goodall, 1968). It has been suggested that leave taking should be studied in nonhuman species, for example, where postural signals may serve an analogous function (Lockard et al., 1978), or when considering studies of group movement (Kummer, 1968). Ethological studies of leave taking are lacking, and those that do exist (e.g. Lockard et al., 1978; Whittaker et al., 1994) are not robust in providing replicable methods. Below, we consider and address possible ways to overcome these limitations.

4.2.2 Addressing Previous Limitations

In the review from Baehren (2022), there is a thorough discussion of the ways in which definitions of leave taking vary. This is a significant methodological issue, in part because it makes studies impossible to compare or reproduce, as the phenomenon of leave taking varies.

Almost all definitions relate leave taking to breaking contact, and many seem to also include breaking "social" contact, i.e., that moving apart is not enough; rather, it involves the ending of interaction. In short, significant variation in leave-taking definitions exists, with many studies omitting an operational definition entirely, making it difficult to compare studies. Additionally, Baehren (2022) also discusses the need to define the level of study, i.e., what conceptualisation of separation is used. This varies considerably across the existing studies and makes it hard to ensure similar phenomena are being compared. Can we include the everyday comings and goings and ends of conversations, even when individuals remain in the same place (e.g. Whittaker et al., 1994)? Can we only include departures which mark a complete removal from sight and contact (e.g. Scheumann and Zimmerman, 2017)? We argue that these levels of separation should be considered and acknowledged, including the everyday separations in nonhuman species. One reason for the shortage of previous studies could be the lack of appropriate data collection methods for leave taking: a necessarily difficult phenomenon to study due to the retrospective nature of it, i.e., the behaviour occurs before the visible separation. This point is raised by Albert and Kessler (1978), who claim that the properties of leave taking make it difficult to study, in part due to the shortness and high-speed nature of the behaviour. Their suggestion that leave taking could only be properly studied once technology allowed a permanent record to be created and retrospectively examined seems to have now been realised. Several studies attempt this in humans (e.g. Whittaker et al., 1994; Wang, 2005; Gräfenhain et al., 2009) but there is only one example of this being applied to nonhuman species, in the grey mouse lemur (Scheumann and Zimmerman, 2017). As suggested by Baehren (2022), these advances of both video technology and video-coding software could provide promising solutions to increase the availability of data on leave taking. Whittaker et al., (1994) measured human verbal cues and

orientating signs in closing sequences, described as “turning away”. We thus include nonvocal, orientating behaviours that may be relevant to interaction endings. To ensure that behaviours measured are unique to social interaction endings, we compare to nonsocial endings. In a study by Grafenhain et al., 2009, children were found to show leave taking more frequently in the context of joint activity, as opposed to leaving a solo activity in close proximity to another individual. This suggests that the social nature of the interaction is, at least in part, driving the leave taking. Besides the need to control for social interaction, many studies neglect controlling for the length of interaction. Lockard (1978) includes length of interaction as a variable, which failed to reach significance, concluding that restlessness or boredom alone is not sufficient in explaining these behaviours; however, this possibility is still important to account for.

4.2.3 Baboon Models for Leave taking

Baboons share a common ancestor with humans from between 21 and 25 million years ago (Steiper et al., 2006; Langergraber et al., 2017). Broadly speaking, several baboon species are grouped together because of similar ecology and social organisation and are described as savannah baboons (Smuts et al., 2008). These species include yellow baboons (*Papio cynocephalus*), chacma baboons (*Papio ursinus*), and olive baboons (*Papio anubis*). Savannah baboons live in large, cohesive, multimale, multifemale, and female-bonded groups where the males tend to disperse out of their natal group and the females are philopatric (Grueter, 2014). Savannah baboons inhabit mosaic savannah and woodland environments like the Pleistocene environments where our genus emerged (Jolly, 2001). Marked interspecies variation in baboon social organisation is particularly interesting and, as such, they are one of the most studied primate species (Patzelt et al., 2014). Although baboon social systems have

historically been thought to be a dichotomy, between the multilevel hamadryas and the cohesive savannah baboons, many argue that we must allow for greater variability in our understanding. This variation would also allow greater understanding of the typically cohesive species, which are usually stable, but do split up on occasion, e.g. when foraging in habitats with scarcer resources or greater predation pressure.

In several ways, savannah baboons are useful for thinking about the selective pressures that sociality has placed on social structure and the resultant interactions. For example, bonds between females, particularly kin, are thought to be especially important in savannah baboons, who form strong, equitable, enduring bonds with specific female partners (Silk et al., 2010). These bonds are adaptive and have a direct effect on fitness, as shown by the positive association with infant survival (Silk et al., 2003) as well as adult female lifespan (Silk et al., 2010). When interacting with other nonrelated individuals, they demonstrate a form of "emotional bookkeeping", influenced by previous affiliative interactions and forming the strongest bonds with those with whom they have the most balanced and reciprocal grooming interactions (Cheney and Seyfarth, 2018). So called "friendships" between male and females, beyond mating, are particularly well-modelled in baboons (Buchan et al., 2003). Male mammals are expected to care for offspring only when it is directed towards their related young, but in cercopithecines, this seems to be the case even with low paternity certainty (Huchard et al., 2010). This is thought to play a role as a counter strategy to infanticide in chacma baboons, but in more tolerant species where infanticide is rare, it may provide protection against nonlethal forms of aggression (Lemasson et al., 2008). Similarly, in yellow baboons, mothers are found to benefit directly from these friendships, gaining more protection from harassment, usually from genetic fathers (Nguyen et al., 2009). Furthermore, baboons have been touted as a valuable model for the evolution of human language due to

their domain-general cognitive functions and gestural production (Fagot et al., 2019). In contrast to traditional ideas that human language arose due to uniquely human changes (e.g. Chomsky and Keyser, 1988), new perspectives suggest that language evolved from a combination of components which can be investigated in other living primate species, of which baboons provide a relevant example due to the diversity of research available (Fagot et al., 2019). Within their communicative behaviour, baboons are known to coordinate group movement (Stueckle and Zinner, 2008; Strandburg-Peshkin et al., 2015) and display ritualized greeting when they come together (Smuts et al., 2018). Furthermore, evolutionary continuity between baboons and great apes, as well as similar neural specialization, suggests that such gestural communication could have an ancient Catarrhine origin 25–40 million years ago (Meguerditchian, 2022). In short, savannah baboons provide promising close-knit social groups to investigate short-term departures within cohesive groups and are a good model for investigating the origins of potential leave-taking behaviours. The presence of such behaviour in baboons would be significant, implying a deeper evolutionary history of the behaviour or convergent evolution to meet a similar socioecological need.

In this study, we present a new framework for studying leave taking in nonhuman primates, using chacma baboons (*Papio ursinus)* as an example. We first test the definition and framework for leave taking presented in Baehren's work (2022). Additionally, we determine which behaviours are useful as candidate leave-taking behaviours. We then employ the use of new data collection methods to collect and control for behavioural patterns, determining whether this framework can highlight the importance of social interaction in leave taking, and allow more nonhuman species to be studied. We predict that, based on the social definition (Baehren, 2022), leave taking is significantly more likely in social separation compared to

proximity or solo departure. Finally, we discuss the results in an evolutionary context, highlighting the advantages of applying our approach to further studies of nonhuman primates.

4.3 Methods

The full methods relevant to this chapter can be found in Chapter 3, in particular, pertaining to the field site, population, and data collection protocol.

4.3.1 Addressing Methodological Issues

1. Using a Considered Definition

Here, we used the definition "behaviours occurring before separation from social interaction" to refer to leave taking, as outlined by Baehren (2022). To this end, we focused on the sociality of interaction as a necessary precursor to leave taking, which allowed us to differentiate between behaviours that just occur before movement versus the socially charged ending of an encounter.

2. Defining the Level of Study

In Baehren's review (2022), the level of study is discussed as being an area of particular confusion across studies of leave taking. In the daily following of free-ranging wild populations, it is often not possible to see great numbers of long-term separations, e.g. group departure, transfer, etc. These events are relatively infrequent and would not yield high amounts of data to investigate the associated behaviours. However, in cohesive groups, it should be possible to look at the endings of daily interactions that happen frequently between

individuals of the same social group. Although these interactions may not have the "finality" of longer separations, the frequency of their occurrence and their potential function in the ongoing social relationships within the group might mean that they are in fact particularly important for our understanding of leave taking. In this study, we looked at the low-level leave takings, endings of social interactions within a cohesive group of chacma baboons (Figure 3.1a-c). This allowed the practical benefit of an increased sample size of separation events, but also the detailed investigation of these "every day" social separations from dyad interactions.

3. Data Collection Methods

As described in Chapter 3, video recordings were carried out in an opportunistic way from when at least one individual was visible until all the group had moved out of the shot, thus maximising footage of spontaneous interaction, solo behaviours, and parting events. The videos were played repeatedly to capture fleeting movements, as well as allowing for easier and more accurate intercoder reliability. This method is particularly important for behaviours that happen retrospectively, i.e., to rewind from parting events allowing the coding of behaviours which precede them.

4. Determining Candidate Behaviours

Pilot observations of baboon self-scratching prior to parting prompted the selection of this behaviour in the present study. Such behaviour is also referenced in published work, within the broader category of "self-directed behaviours". For example, "explosive hand contact" is

a leave-taking behaviour in humans defined as “a rapid striking movement in which the hand(s) came in contact with either another part of the body (usually the thighs) or a foreign object (e.g. schoolbooks)- usually a slapping or striking motion” (Knapp et al., 1973). As a common behaviour in baboons, self-scratching is not unique to separation or anxiety contexts. However, investigating an increased likelihood before separation could suggest similarity with human self-directed leave takings. In this case, self-scratching could reflect anxiety around separation or the decision to separate, although testing such causation is beyond the scope of the present study.

Further to this, previous leave-taking studies suggest the importance of changing orientation (e.g. Lockard et al., 1978) which Knapp et al., (1973) includes as part of the behaviour of “major trunk movement” and “positioning”. Visual orientation in the direction of parting, such as “breaking eye contact” to look away, is also a potential parallel across species. Orientating behaviours could be important in leave taking as they may represent a subtler intention to depart than simply moving away, as a gradual shift to the departure (Lockard et al., 1978). This contrasts with orientation towards each other which usually occurs during interaction (Kendon, 1990), signalling the opening and closing of the dyad. In infants, turning away has been argued to represent the threat of breaking off contact (Murray, 1980) suggesting that it can be used intentionally to manage the ends of interactions.

Similarly, breaking eye contact or gazing away from the conspecific could act as an intermediary state where the dyad is no longer completely engaged but before final departure (Albert and Kessler, 1978). Similar to the example above, maintaining eye contact represents an ongoing social interaction as the channels for communication are open, whereas “turning

the shoulder or refusing to make visual contact" (Eibl-Eibesfeldt, 1970) is an aggression-blocking behaviour, threatening to break off contact.

Specific, measurable, and varied candidate behaviours must be carefully chosen and justified in order to address the methodological issue of ensuring relevant behaviours are captured.

5. Control Conditions

Combining the efforts of previous studies, we included length of interaction as a control variable. We did so by including the number of seconds from the start of the social behaviour (or activity in the case of solo condition), until the move away, as a factor in the models. This allowed us to control for the fact that restlessness could lead to some behaviours disproportionately occurring in long interactions (Lockard et al., 1978). We also included the parting type as a key variable in the model: whether the individual was parting from a social activity, leaving a solo activity, or leaving a solo activity in close proximity to another individual (see Table 4.1). We categorised these conditions based on whether activities were a social activity (grooming, playing, copulating) and whether they were in close proximity (estimated 1m) to another individual. This is important in our new framework because it helps us understand whether behaviour is happening significantly more at the endings of social interactions than asocial activity endings, i.e., whether such behaviour is really socially charged. Full details of the parting types are outlined in Chapter 3.

4.3.2 Analyses

All analyses were conducted in R version 3.6.3 (R Core Team, Vienna, Austria). Analyses were conducted at the observation level, where each observation contributed one data point. Each observation had all independent variables associated with it (parting type, individuals in dyad, and duration of interaction). The dependent variables for each observation were measured in the three-minute pre-parting window and included the presence or absence and the frequency of each candidate behaviour. We predicted, based on the social definition of leave taking (Baehren, 2022), that leave taking would be significantly more likely in social separation, compared to proximity separation or solo departure.

A multilevel approach was applied to account for the fact that repeated individuals are used across observations in order to avoid pseudoreplication, i.e., each individual contributes to more than one observation and, therefore, more than one data point. This approach is ideal for a situation of repeated individuals and multiple levels, avoiding the atomistic and ecological fallacies (Subramanian et al., 2009) by modelling individuals and their contexts simultaneously. It also allows for missing data and the imbalance of the model, while accounting for individual differences (Deeming and Jones, 2015). Ultimately, this allowed an understanding of whether the current framework for measuring leave taking is both appropriate and useful.

The analysis took a multivariate approach. As leave taking had never previously been studied in this context, we began with a descriptive investigation of what behaviours occur in the preparting window. Although these behaviours are defined and measured as distinct occurrences, it is possible that there is correlation between occurrences of different

behaviours, e.g. individuals that exhibit self-scratching might also be more likely to show other behaviours such as directional eye gaze or weight shift. In this sense, we cannot treat these independent variables as truly independent of one another, and, therefore, we must use a multivariate approach. These outcomes were nested within each observation, and the structure of the model allowed both the relationship of the independent variables to be assessed, as well as the effects of other factors on these variables.

"Choice" of behaviour can be modelled in two ways: multinomial and multivariate. Multinomial models assume the independence of irrelevant alternatives, i.e., the choices are mutually exclusive. Behavioural choices, such as those in the current study, are not mutually exclusive and may relate to more than one correlated behaviour at once. For example, in each observation, self-scratch and weight shift are not mutually exclusive; both are possible to co-occur. Therefore, we used a multivariate model, allowing for possible contemporaneous correlation in the three candidate leave-taking behaviours.

This study took two approaches: binary leave-taking presence/absence and frequency count of the behaviour in the preparting window. Thus, we needed a model that could account for multivariate binary and count outcomes. There were two types of correlation that we needed to be aware of: correlation within individuals and correlation between possible outcomes. The General Linear Mixed Models (GLMMs) generally work well for the clustered or multilevel aspect of data analysis but can also be extended to allow for multivariate comparisons. This is performed by creating multiple GLMMs for each response variable and combining the responses in a single model by imposing a joint multivariate normal distribution for the variable-specific random effects. A multivariate probit model estimates several correlated binary outcomes jointly, and the Poisson version of this model can do the same for count

(frequency) data. The package McGLM (Bonat, 2018) provides a general statistical modelling framework for normal and non-normal multivariate data analysis, designed to handle multivariate response variables. Thus, the predictions were that the candidate leave-taking behaviours would be significantly more likely to be present (binary model) and greater in frequency (frequency model) in the social condition, than the proximity or solo conditions.

4.4 Results

These observations fall across the three categories outlined above: solo, proximity, and social. The numbers of observations in each category can be seen below in Table 4.3. The variation in number between the three types of separation is controlled for in the analysis.

Table 4.1. Number of observations by parting type.

Parting Type	**Number of Observations**
Solo	100
Proximity	43
Social	61
TOTAL	204

The context of observations was limited; the majority included contexts of rest, foraging, and grooming. However, as context correlated so strongly with parting type (see Figure 4.3), only parting type was used in the present analysis, due to the focus on the social driver of leave taking.

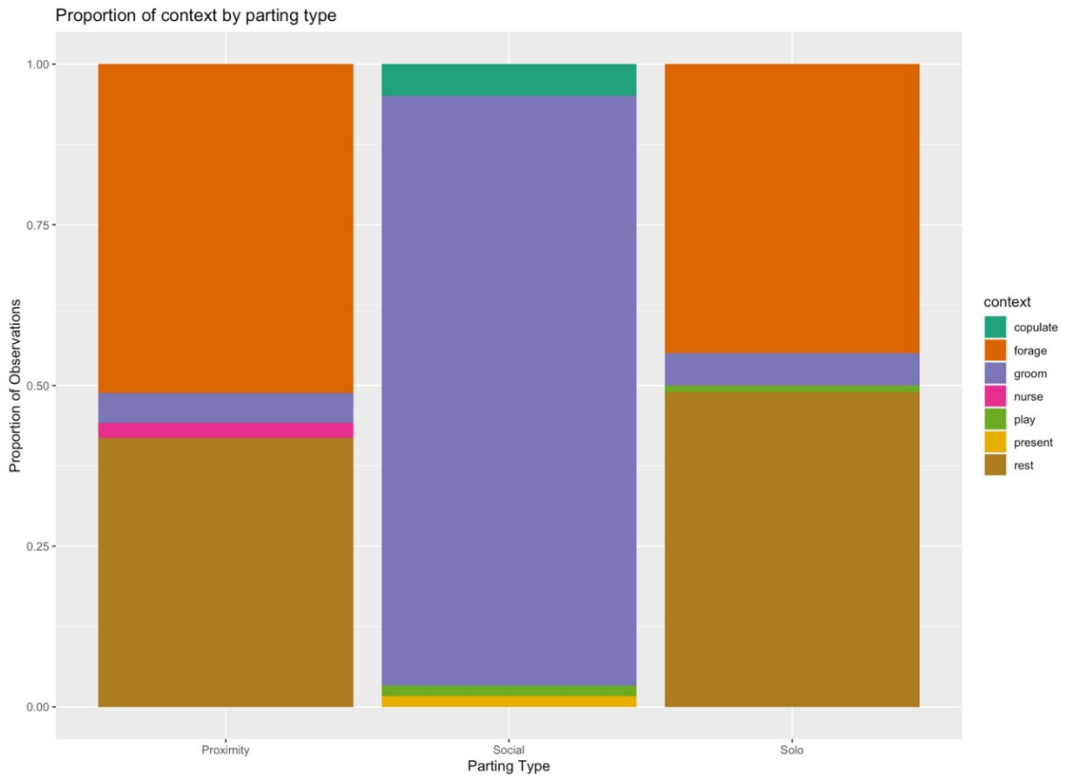
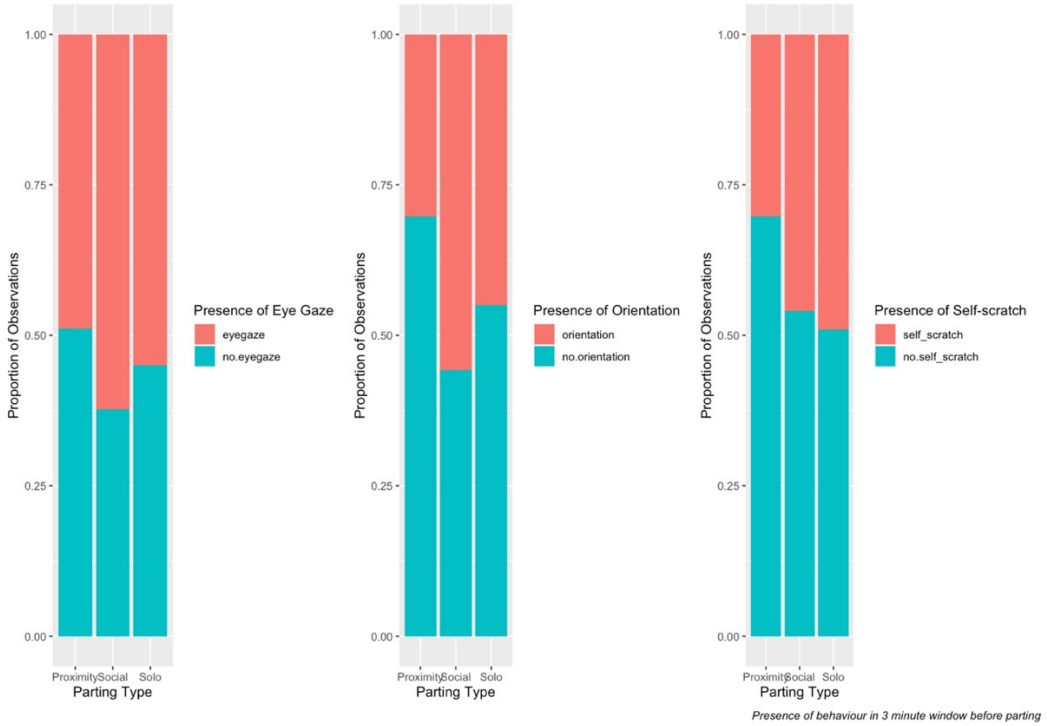


Figure 4.1. Proportion of context by parting type**.**

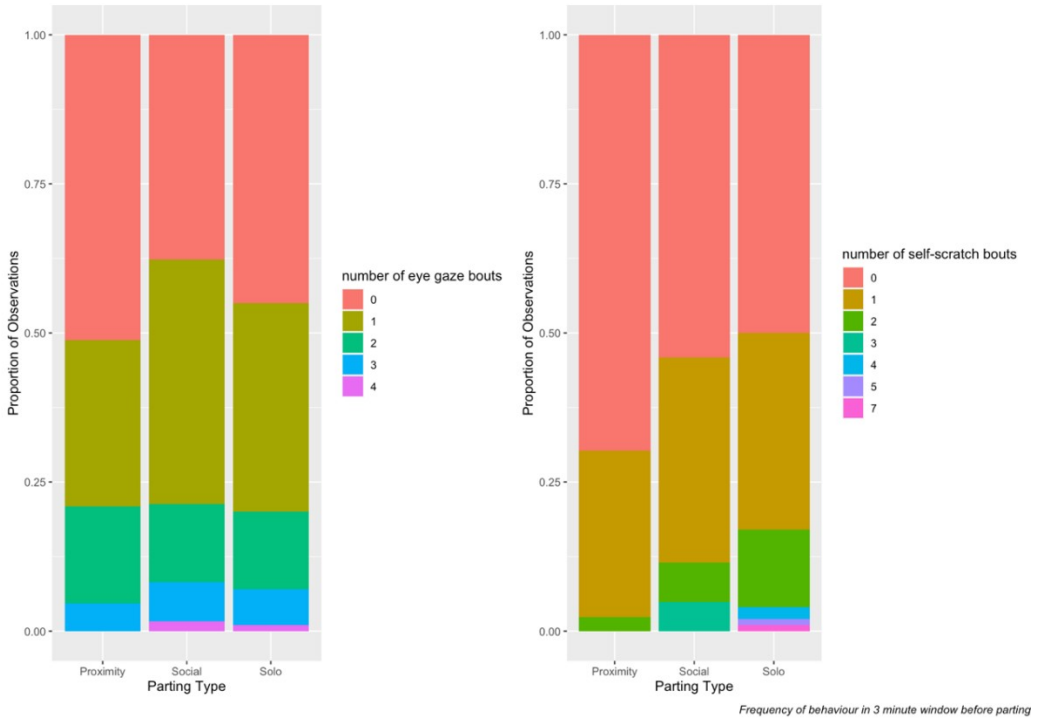
There was also variation in the number of observations per individual, likely due to the variation in habituation. In the final sample of observations, only 22 individuals were identified out of the possible 37 due to the exclusion of juveniles. Furthermore, adult females Zoe (n = 3) and Maddie (n = 3) were observed much less frequently. Others, such as adult male Arrow (n = 16), were over-represented in the sample. Individual ID was included in the models to account for this.

Figures 4.4a and 4.4b illustrate the exploratory analysis of the data. Figure 4.4a shows the proportion of total observations (n = 204) where each of the three candidate behaviours was present and absent. Similarly, Figure 4.4b shows the frequency of each candidate behaviour

across total observations (n = 204). These two outputs (presence/absence and frequency) reflect the basis for the two strands of investigation.



(a)



(b)

Figure 4.2. (a): Proportion of observations where candidate behaviours were present/absent. (b): Proportion of observations with each count of candidate behaviours**.**

4.4.1 IO Reliability

We assessed interobserver reliability with a second person who was naïve to the hypotheses coding over 10% of the observations. The observations used in interobserver reliability were taken at regular intervals throughout the full dataset to ensure a true cross-section of the data was compared. We considered our data to be reliably collected if the proportions of agreement between two observers using Cohen's kappa (Cohen, 1977) were significantly different from those expected by chance. Cohen's kappa values (CK) are considered fair if ranging from 0.4 to 0.6 and good if between 0.6 and 0.8 (Watkins and Pachego, 2000). Interobserver reliability was deemed good; all measures produced similarity that was significantly more than would be expected by chance (presence of self-scratch, CK = 0.741, $p \leq 0.000$; frequency of self-scratch, CK = 0.652, $p \leq 0.000$; presence of gaze, CK = 0.502, $p = 0.004$; frequency of gaze, CK = 0.551, $p \leq 0.000$; and orientation, CK = 0.584, $p = 0.001$).

4.4.2 Statistical Analysis

We used focal sampling to record the possible leave taking of chacma baboons, investigating which of the candidate behaviours occurred, and how often, in the three minutes before parting. We analysed 205 observations in 22 individuals across solo, proximity, and social endings. We predicted, based on the social definition of leave taking (Baehren, 2022), that behaviours would be significantly more likely in social separation compared to proximity separation or solo departure.

Self-scratching was produced in 90 observations, eye gaze in the direction of parting in 114 observations, and orientation towards parting direction in 92 observations. Observations had a mean duration of 163.66 seconds and a range of 5.05–913.86 seconds.

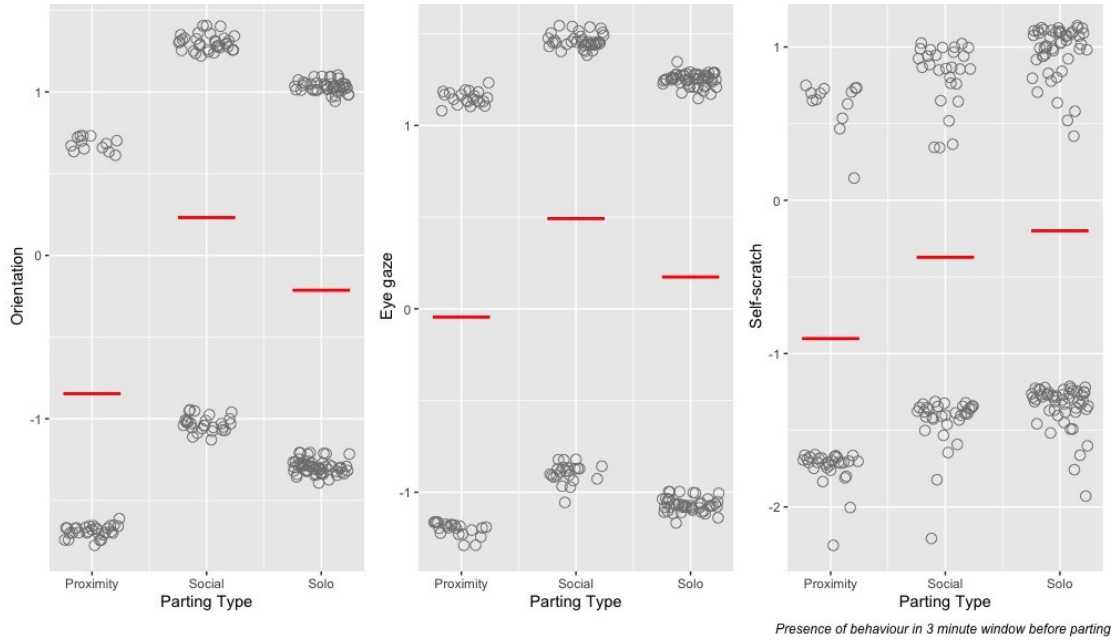
We calculated Cook's distances to look for influential observations that could affect the models (Nieuwenhuis et al., 2012). We identified around six potentially influential observations for self-scratch, four for eye gaze, and six for orientation that could be considered outliers; however, we decided not to remove them as this variation could reflect true differences in the frequency of behaviour. Thus, we decided to run and interpret all observations to obtain first insights into leave-taking behaviour that is, as of yet, unstudied in its own right in wild nonhuman species.

Multivariate response variable regression models allow multiple response variables to be included within one model (while holding them constant) instead of conducting several models separately, and they estimate the correlation between each response variable (Bonat, 2018). The models included the duration of interaction and parting type as covariates. Duration was a continuous predictor covariate and parting type had categories of social, proximity, and solo context. We included individual ID for the leaving and remaining individual as random effects to account for the repeated measures and avoid pseudoreplication. We ran two multivariate models. The first had the three response variables measured as binary outcomes (0 = behaviour absent, 1 = behaviour present, in the three-minute window prior to parting) for self-scratch, eye gaze in the direction of parting, and orientation in the direction of parting, and are referred to hereafter as the “binary” models. The second had eye gaze in the direction of parting and self-scratch measured as counts, i.e.,

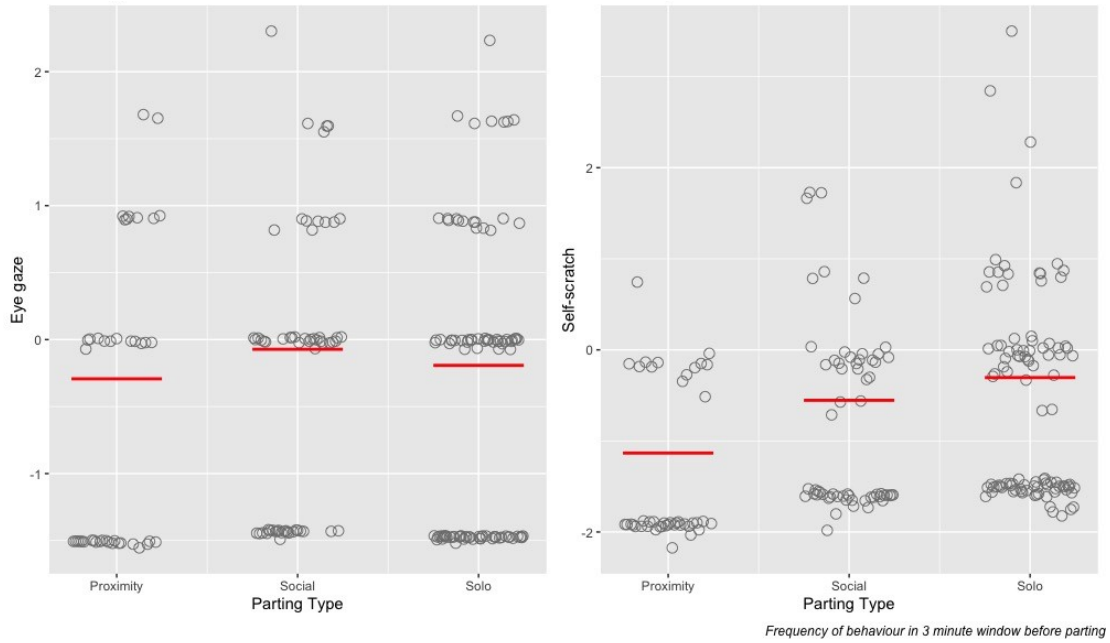
frequency of occurrences in the three-minute window prior to parting, together with the original binary measure for orientation, and are referred to hereafter as the "frequency" models.

A combination of logit and gamma-log error distributions was used in the models depending on the residual normality of each response variable. We used pseudo-Akaike's information criterion (pAIC) values calculated in 'mcglm' to determine model selection (Bonat, 2018). The pAIC is similar to Akaike's information criterion (AIC) used in model selection but contains penalty terms to account for multiple response variables in the model.

Figures 4.3a and 4.5b were created using the package "visreg" (Breheny et al., 2020) and illustrate the conditional relationship between the candidate behaviour and parting type. They take account of the other factors of interest, specifically, duration of interaction and individual ID. The fitted model was used to predict values of the response variable (depicted as grey circles), across the range of the chosen explanatory variable (x axis), along with the regression line. The other variables were set to their median value (for numeric variables) or most frequent category (for categorical variables). Thus, for Figure 4.3a, we can see that controlling for ID and duration, there were differences in the presence of candidate behaviours across the parting types. Similarly, for Figure 4.3b, we can see that there was some difference in frequency of self-scratch across parting type, controlling for ID and duration, whereas there was little difference in the frequency of eye gaze in the direction of parting when controlling for the same factors. The following models in the next section will investigate whether these apparent differences are statistically significant.



(a)



(b)

Figure 4.3. A: Relationship between candidate behaviour presence and B: frequency of parting type, controlling for interaction length and duration**.**

After residual analysis and diagnosis (see Table S1, Table S2, and Figures S1–4), the interpretations of the models are presented. We predicted, based on the social definition of leave taking (Baehren, 2022), that behaviour is significantly more likely in social separation, compared to proximity separation or solo departure. Tables 4a–5b present the estimates of the regression parameters by the models, where 4 relates to the binary model (*a* for orientation, *b* for eye gaze and *c* for self-scratch) and 5 the frequency model (a for eye gaze and b for self-scratch). The tables show the regression parameter estimates, standard errors (SE), odds ratio (OR) with 95% CI, and z-statistics and *p* values. Table 4 illustrates that social parting type is significantly associated with orientation. Table 5 illustrates that presence of orientation is associated with social parting type, and frequency of self-scratch is associated with solo parting type.

Table 4.2. – Regression parameter estimates for joint binary model. ***** Denotes statistically significant values (*p*-value < 0.05).

	Effects	**Estimate**	**SE**	**z-statistics**	***p*-value**
Eye gaze	Intercept	−0.0649759376	0.3287922059	−0.1976201	0.8433423
	Duration	0.0002494702	0.0008174598	0.3051774	0.7602310
	Parting type (social)	0.5343620581	0.4121778865	1.2964355	0.1948255
	Parting type (solo)	0.2090787868	0.3727807890	0.5608626	0.5748912
Self-scratch	Intercept	−1.106534038	0.3591822027	−3.080704	0.002065119
	Duration	0.002242691	0.0008856267	2.532321	0.011331019
	Parting type (social)	0.526836372	0.4339131629	1.214152	0.224689829
	Parting type (solo)	0.697408563	0.3983954436	1.750544	0.080024571
Orientation	Intercept	0.8690858410	0.3574207691	−2.4315482	0.01503445

Duration	0.0002375434	0.0008119219	0.2925692	0.76985144
Parting type (social)	1.0857820340	0.4292195876	2.5296656	**0.01141713***
Parting type (solo)	0.6328640846	0.3964570247	1.5962993	0.11042198

Table 4.3- Standard errors (SE), odds ratio (OR) with 95% CI, and z-statistics and p values for joint binary model**.**

	OR	**2.5%**	**97.5%**	***p*-value**
Solo	1.000	0.999	1.002	0.760
Proximity	1.706	0.761	3.828	0.195
Social	1.233	0.594	2.559	0.575

Table 4.4– Regression parameter estimates for joint frequency model**. *** Denotes statistically significant values (*p*-value < 0.05).

	Effects	**Estimate**	**SE**	**z-statistics**	***p*-value**
Eye gaze	Intercept	2.87 x 10^{-4}	0.1913975773	−1.50156733	0.1332089
	Duration	1.345058e-05	0.0004388482	0.03064973	0.9755489
	Parting type (social)	2.116943e-01	0.2297794091	0.92129348	0.3568972
	Parting type (solo)	8.942667e-02	0.2161082851	0.41380489	0.6790170
Self-scratch	Intercept	−1.2261484383	0.3109283951	−3.943507	0.0000802985
	Duration	0.0008138371	0.0004770604	1.705942	0.0880189587
	Parting type (social)	0.5824369726	0.3587461767	1.623535	0.1044750885

	Parting type (solo)	0.8417835343	0.3312493396	2.541238	**0.0110460580***
Orientation	Intercept	0.8690858410	−0.3574207691	−2.4315482	0.01503445
	Duration	0.0002375434	0.0008119219	0.2925692	0.76985144
	Parting type (social)	1.0857820340	0.4292195876	2.5296656	**0.01141713***
	Parting type (solo)	0.6328640846	0.3964570247	1.5962993	0.11042198

Table 4.5- Standard errors (SE), odds ratio (OR) with 95% CI, and z-statistics and *p* values for joint frequency model**.**

	OR	**2.5%**	**97.5%**	***p*-value**
Solo	1.000	0.999	1.001	0.976
Proximity	1.236	0.788	1.939	0.357
Social	1.094	0.716	1.670	0.679

4.5 Discussion

4.5.1 Evolutionary Context

This was the first time that control conditions were used to investigate the presence of leave-taking in a wild nonhuman primate: here, the chacma baboon (*Papio ursinus)*. We showed that, through controlling for leaving close proximity and solo activities, it is possible to measure leave taking in the wild. This is the first indication of leave taking, as a measure of ending social behaviours (Baehren, 2022), existing beyond humans.

Our results support the significance of shifting orientation to the direction of parting in the three-minute window before social separation. Increased frequency of self-scratch was associated more strongly with the solo condition, which could be due to increased anxiety of staying with the group, moving away alone, or beginning a social interaction.

This provides preliminary evidence that social separation in baboons drives behaviour, specifically orientating in the direction of parting, and opens a number of research hypotheses about the function of leave taking across species, such as managing separation (Lockard et al., 1978), increasing the affiliative nature of interactions (DuFon, 2010), or mitigating risky ends to interactions (Aureli and Schaffner, 2007). The results also extend Lorenz's idea of "intention movements" (Lorenz, 1937: p. 256), where initiating behaviours are understood by conspecifics. The current study distinguishes itself from Lorenz's framework by eliminating instances where the behaviour is "imitated" or "contagious", i.e., where the conspecific would also leave. The current study is concerned only with those instances where separation of dyads occurs, not "synchronised, collective cohesion" (Baehren, 2022: p 10).

The presence of leave taking in baboons could suggest a deep evolutionary history of the behaviour, present since the last common ancestors of humans and baboons. Further investigation would be needed to determine the presence of leave taking in other baboon species and in more closely related species to humans such as chimpanzees or other great apes. Compared to a lack of association with orientation in the direction of parting in solo and proximity separations, this suggests that the behaviour plays a uniquely social role that could have evolved for a social function. This paves the way for understanding how leave taking

functions in natural, spontaneous interactions; for example, it may assist in strengthening social bonds (DuFon, 2010) or in minimising aggression (Okamoto et al., 2001).

4.5.2 Towards a New Framework for Leave taking

1. Definition

This study provides evidence that a social definition (Baehren, 2022) is a useful way of determining leave taking, and that separation from close proximity is not enough to drive leave-taking behaviours. This echoes earlier assertions that leave taking is a uniquely social behaviour (e.g. Albert and Kessler, 1978; Corsaro, 1979; Betholia, 2009) and parallels assumptions about human leave taking occurring solely to manage social interaction and expectations (e.g. Albert and Kessler, 1978; Goffman, 1971). This builds upon Lockard's previous work (1978) claiming that "focused interaction is a necessary pre-condition", from using a control of moving away together in the same direction.

2. Control Conditions

Thus, by extension, this study supports the use of definitional controls, such as separation from close proximity and solo departure, to infer the presence of leave taking before social separation. Similarly, using the length of interaction prevented behaviours that could be due to restlessness being attributed to leave taking. Such a paradigm could, and should, be applied across species and populations to further investigate the evolution of leave taking in nonhumans.

3. Levels of Separation

This also strengthens the idea of levels of separation, including the idea that leave taking could exist even in cohesive groups because of the need to successfully end social interactions (Baehren, 2022). These results represent the low level of separation outlined in Figure 1.5 of Chapter 1, where dyads separate for short periods of time within the cohesive group. This framework suggests that we need to include enquiry on different levels of separation, e.g. daily recurrent separations, and not just group-level separations such as fission or permanent separations such as group transfer. Thus, the presence of leave taking in a species such as baboons, that is typically considered cohesive (Anderson and McGrew, 1984), parallels what we see in the literature on human leave taking where both short-term, low-level separations (e.g. Lockard et al., 1978; Whittaker et al., 1994; Schegloff and Sacks, 1973) and long-term, high-level separations exist and are of interest (Van der Hart and Gooseens, 1987).

4. Data Collection Methods

This study pertains to the comment from Albert and Kessler (1978) on the methodologies of leave-taking study, where they hypothesise that good research will only be possible once technology improves sufficiently to capture the fleeting nature of leave taking. This is exactly what our method achieves, both through the use of recorded high-quality video footage and the video-coding software, allowing behaviours to be retrospectively coded in minute detail at greater speed and accuracy. It means that videos can be rewound, rewatched, and slowed down to improve data validity, especially cross-observer validity. Furthermore, video archives are more accessible as they can be studied remotely now and in the future. The data collection software with a predetermined ethogram means that the same method can be applied across species and populations.

5. Candidate Behaviours

Unlike most of the literature on human leave taking, this study focused only on nonvocal behaviours. Pilot observations prior to this study and indications from existing literature were able to help us identify orientation behaviour that appears to be significant prior to parting. Compared to studies such as that by Knapp et al., (1973), a narrower range of candidate behaviours were used due to the application to nonhuman primates. However, it seems that there is some overlap in leave-taking behaviours across species. For example, body orientation is found in both baboons and humans, where greeting involves orienting to face one another (Betholia, 2009: p. 74), and leave taking involves visual-orienting signs such as turning away (Whittaker et al., 1994). This is suggested in humans to signal readiness to depart, rather than simply moving away (Lockard et al., 1978). In humans, these behaviours are thought to be used to buffer verbal cues, although there is no evidence that this is the case in chacma baboons. Interestingly, conversation analysis has recently been extended to baboon behaviour with regard to orientation in greeting sequences (Mondada et al., 2022). Such studies provide support for our findings of shifting orientation as a way to break social contact and offer an exciting method to extend baboon leave-taking research.

In summary, this study provides a definition with controls, a method, and novel candidate behaviours, which together facilitate cross-species research on leave taking. Together, this gives a clear advantage over previous definitions, not least because it can be applied across species, but also because it strengthens support for the presence of such behaviours. This allows us to further investigate the evolutionary origins of leave taking, to understand how and when it has evolved as a universal behaviour in humans.

4.5.3 Limitations

There are several limiting factors of this study, most notably that this method has thus far only been tested on a single population. It remains to be seen whether it will provide evidence for leave taking in others. Despite the sample population providing a good basis for close-range video footage and behavioural-data collection, our archive gave a limited context of behaviours, possibly affected by the anthropogenic environment. The sample size was also regrettably limited by external factors which did not allow all individuals to be identified or endings to be coded. More data collection was impossible to achieve due to the constraints posed by the COVID 19 pandemic. Automated video identification and behavioural recognition software would speed up the data collection process and account for less human error than manual coding (Schofield et al., 2019).

We cannot assume that these leave-taking behaviours have been produced intentionally. Support for the social definition suggests that shifting orientation occurs significantly before ending social interactions. However, we do not yet know enough to determine whether this behaviour could constitute an intentionally produced signal of departure. One alternative explanation could be that this behaviour is more likely at the end of social interactions because of increased anxiety, in the same way predator calls were once understood (Macedonia and Evans, 2003). Nonetheless, we cannot rule out the possibility that this is an intentionally produced gesture. Further research will test this hypothesis using previously established methods to deduce intentionality.

It must also be considered that video footage may not always be possible: although cheaper and more accessible that in previous decades, access to video cameras and storage of archives could pose a problem for some researchers with limited funds. Additionally, high quality video footage of behaviour may not be possible on populations which are not well habituated. This may limit the range of populations we can use to understand leave-taking, and other methods such as camera traps could be considered to circumvent this problem.

4.5.4 Conclusions

One of the most interesting aspects of these results is that orientation in the direction of parting is more likely when leaving the social condition, as compared to the close-proximity condition, suggesting this behaviour is dependent on social interaction itself and not just the presence of other individuals. Ongoing research will look in greater detail at the dyad to determine whether this is an intentional signal of departure and whether there is a social function. Context is also important, as our results suggest that baboon leave taking is variable and not a social constraint upon leaving as in humans (Betholia, 2009).

Interestingly, self-scratching prior to parting was significant in the solo condition. This also warrants exploration, particularly with regard to anxiety of separation from the group. Although not significant in the social condition, self-scratching did occur in many social partings, deserving further investigation as to whether there is a particular social context for its occurrence. The signal precursor route hypothesis suggests that social signals can arise from unintentionally produced asocial behaviours (Lockard et al., 1978) and become specialised over time to convey information more effectively (Laidre and Johnstone, 2013). Self-directed behaviours, e.g. head scratching and beard stroking, are reported in humans as

relating to uncertainty or anxiety (Laidre and Johnstone, 2013), similar to their counterpart behaviours in nonhuman primates, e.g. scratching or fumbling (Maestripieri, 1993). Despite this, there is little relating these behaviours to separation specifically. Features of human cognition such as theory of mind and empathy could explain why human leave taking has become more elaborated, although potentially rooted in similar emotional, anxiety-related responses. This should be further investigated in relation to self-scratch behaviours to determine their role in solo departures.

These results also open up the possibility of repeating the study across baboon subspecies, increasing our understanding of the cultural and ecological variation that may exist in leave taking, as it does for greeting (Dal Pesco and Fischer, 2020). Differences in aggressive behaviour, social cohesion, and female-bondedness may affect this propensity to leave take, and baboons would offer an ideal model species to investigate this given the radiation of related species across Africa (Washburn and DeVore, 1961). The lack of risk in Gorongosa National Park could also impact these results: baboons there spend more time on the ground compared to other populations (Hammond et al., 2022) and this could increase opportunities for such short-term, recurrent social interactions. Such opportunities increase visual proximity, and as such, leave taking may be a necessary adaptation to social life on the ground. Expanding this framework across other predominantly terrestrial species, such as chimpanzees, would help to begin exploring this idea.

The results of this study demonstrate that leave taking may not, after all, be a result of "unique and terribly human interpersonal forces", as claimed by Knapp et al., (1973: p. 182). Instead, as Goffman stated, animal versions of goodbye are much harder to establish than

human versions (1974), but the improvements in animal behaviour research and technology have indeed made this feat possible, as predicted by Albert and Kessler (1978). Our results expand previous work on non-human leave-taking (Rodrigues et al., 2018; Heesen et al., 2021) to provide a replicable framework to compare across species. The benefits of a measurable definition, control conditions, levels of separation, digital methods, and choice of candidate behaviours demonstrate the value of this new framework for studying leave taking beyond humans. The conclusions of this study provide the first evidence of leave-taking behaviour—orientation in the direction of parting—in a wild nonhuman population. The study offers insights into the evolutionary origins of leave taking, which could have a much deeper ancestral history than previously thought (McGrew and Baehren, 2016). The function of this behaviour and presence in other primate species will be important in determining how it has evolved to become so prominent in modern humans.

Chapter 5: Leave-taking in chacma baboons (*Papio ursinus*): an intentional social signal?

5.1 Abstract

Leave-taking, defined as behaviours occurring at the ends of social interactions, has been largely ignored by empirical research across both humans and non-humans. Recent evidence in wild chacma baboons suggests that orientation shifting of the body towards the direction of parting occurs at the ends of social activities but is largely absent when leaving asocial activities. This suggests that individuals could use this behaviour as a social signal to indicate intention to depart. However, further markers of intentionality remain to be tested. To test this hypothesis, we used four criteria to measure intentionality in baboon orientation shifting behaviour at the end of social interactions: i) audience composition, ii) audience attention, iii) audience checking, and iv) consistent receiver response. There is no consensus as to how many of these criteria must be met to qualify a behaviour as intentional, though it is acknowledged that the greater the number of criteria fulfilled, the greater the likelihood of intentionality. Using GLMMs with binomial error structure, our results suggest that the orientation shifting behaviour of baboons fulfils one of these criteria of intentional communication: a consistent audience response, being significantly more likely in those interactions ends that are not succeeded by following behaviour. We conclude that although there is not yet enough evidence supporting chacma baboon leave-taking as an intentional behaviour, it plays an important role in coordinating separation behaviour at social interaction ends. We suggest that intentionality frameworks should be further developed for application to non-ape species, and for behaviours where eye gaze may be confounded by other factors.

5.2 Introduction

Leave-taking refers to behaviours occurring at the end of social interaction (Baehren, 2022) and is historically and currently understudied in both humans and non-human species. A recent review of the topic by Baehren (2022) outlines possible reasons for this lacunae, identifying difficulties in studying the behaviour in animals and suggesting that a comparison of contexts of social and asocial separations could be key to identify the presence and function of such leave-taking behaviours. Previous work (Baehren and Carvalho, 2022) presents data on leave-taking in chacma baboons, where orientation in the direction of parting was found to occur significantly before social interaction separation, contrary to asocial separations. This is consistent with behavioural intentionality and fulfils the criteria of exclusive use in social contexts. However, social use alone has been criticised as insufficient evidence of intentionality since behaviours can be triggered by other, less complex, mechanisms such as arousal and anxiety (Liebal et al., 2014). As a suggested human universal (Goffman, 1971), an understanding of whether this behaviour is used intentionally, and of the evolutionarily implications of such finding are long overdue.

Intentionality has long been considered one of the hallmarks of human language, and as such, an understanding of when it evolved remains central to various strands of evolutionary research. These investigations form an important part of our understanding of how and when language evolved to intentionally direct recipients' attention to external events and can be investigated using a comparative approach with closely related species. This area of cognitive and linguistic study is important, as it shapes our understanding of communicative interpretations. For example, in understanding that closely related species to humans direct their communication to elicit specific responses from conspecifics, we assume that this

behaviour has a more ancient evolutionary origin and could have been present in shared common ancestors. These nuances of behaviour are impossible to discern from the fossil record alone, but such comparative methods enlighten us on the complexities of behaviour that are so integral to our modern-day communication.

The definition of intentionality itself is controversial; one school of thought uses the term to refer simply to predicting subsequent behaviour (Smith, 1979), whereas another definition, derived originally from philosophy, uses the term to denote a hierarchy of increasingly complex mental states underlying the behaviour (Whiten and Byrne, 1988). Hauser and Nelson (1991) suggest using "predictive signalling" to refer to the former, and "intentional signalling" to refer to the latter. Here we focus on intentional signalling and define this as a way of understanding the mechanisms underpinning the expression of communicative behaviours (Graham et al., 2020).

Dennett's levels of intentionality illustrate how the process can vary, and indeed, how lower levels of intentionality may provide cognitive "building blocks" for more sophisticated communication (Dennett, 1983). Zero order intentionality assumes no understanding of the other individual, and behaviours are reflexive and automatic. In contrast, first order intentionality refers to behaviour driven by beliefs and desires to modify the behaviour of others. Although the signaller might understand the effects, there is no need to understand the minds of others. Second order intentionality requires the individual to understand both their own and others mental states, with intention to modify not only behaviour, but also the mental state of others. Some argue that true communication requires second order intentionality (e.g. Grice, 1957) in that it requires understanding of their own and others mental states e.g. an animal would produce a signal to warn a conspecific of an alarm call, thus modifying their knowledge state *and* their behaviour to escape from the predator. Human

language is second-order intentional communication; we intend to alter the mental state of other individuals (Scott-Phillips, 2014). Graham et al., (2020) give a hypothetical non-human example where zero-order intentional communication would elicit a call upon approaching a food patch due to increased arousal by the discovery of food. For first-order intentional communication the call would be to notify other individuals of the food patch and recruit them to join. Second-order intentional communication would consider the mental states of other individuals, informing ignorant members of the food patch and altering their mental state from ignorant to knowledgeable. Although we use second-order intentional communication, the extent to which it exists in the animal kingdom is yet unknown.

Few studies tested whether primates produce signals with second-order intentionality, thus modifying the mental states of conspecifics, but the ones that tried are focused on Great Apes. There is some evidence that chimpanzees can modify their calls depending on the ignorance state of others (Crockford et al., 2012). There has been criticism directed towards these studies though (e.g. Schel et al., 2013) with the argument that receiver knowledge confounded signaller knowledge, thus there is an alternate explanation that cannot be ruled out. For example, Crockford et al., (2012) provide evidence that chimpanzees produce more alert calls towards a predator model depending on the knowledge of the receivers, though Schel et al., (2013) argue that because the signallers were also ignorant when the receivers were, the call rate could have simply reflected fear. If this were the case, this would only qualify for zero-order intentionality e.g. a response to the stimulus which does not consider the other individual, and is an automatic, inflexible signal.

Although evidence of second-order intentionality is more difficult to establish in non-human species, first-order intentionality has been operationalised and supported across many species using the framework from Townsend et al., (2017), which draws on markers used to study

intentionality in pre-linguistic infants as well as non-human animals. Mocha and Burkart (2021) advocate for a layered approach, in which "first-order intentional signalling is a necessary, but not sufficient, building block for higher-order intentional communication". They therefore define second-order intentional signalling as "first-order + the signaller believes her signalling affects the intentional state of the recipient". Crucially, the first-order criteria could be explained by zero-order intentional processes (Graham et al., 2020), and even evidence of several such criteria could be explained by a combination of mechanistic processes (Schnell et al., 2021). This issue highlights the difficulty with studying intentionality in non-human species and has led researchers to argue that we should look for converging evidence that makes intentionality a more plausible explanation than a mechanistic, reflexive one (Liebal et al., 2014). Altogether, this means looking for support across multiple markers of intentionality, leading to a greater probability that the signal is facilitated by intentionality, rather than a series of non-intentional mechanisms (Mocha and Burkart, 2021).

Townsend et al.'s (2017) framework operationalises these criteria for use in non-human primate research. First, to test whether the signal is goal-directed, it should be repeated until the goal is met, i.e., the signaller should persist until the recipient responds. Intentional behaviours are expected to fulfil certain social criteria, most simply, that the behaviour should occur in the presence of a social audience. Building on this, the signal should be sensitive to the composition of said audience, for example occurring more in the presence of kin (Cheney and Seyfarth, 1985) or high-ranking individuals (Laporte and Zuberbühler, 2010). Together, these social criteria demonstrate the ability to selectively produce signals to be received by an audience, and the ability to target these to specific conspecifics. Following this, audience checking criteria should also be established, in which the signaller should be sensitive to the attentional state of the receiver. In doing so, the signaller should only produce

the signal when the receiver is paying attention and should continue to monitor the receiver for a response. Finally, the recipient should show a consistent behavioural response following the signal, which should occur more frequently than at other times to show that the response is connected to the signal (Graham et al., 2020).

Definition (Dennett, 1983)	Example (Graham et al., 2020)
Behaviours are reflexive and automatic. There is no need to understand the mind of others, or the effect of the behaviour	Elicit a call upon approaching a food patch due to increased arousal by the discovery of food
Behaviours are driven by beliefs and desires to modify the behaviour of others. May understand the effect of their behaviour, but without understanding the mind of others	Elicit a call to notify other individuals of the food patch and recruit them to join.
Behaviours are driven by intention to modify not only behaviour, but also the mental state of others. Should understand the mental state of others and the effect of the behaviour on it.	Elicit a call to inform ignorant members of the food patch and to alter their mental state from ignorant to knowledgeable

Level of intentionality	Zero order	First order	Second order

Table 5.1: Summary of levels of intentionality, combining Dennett's levels of intentionality (1983), with examples in non-human species from Graham et al., (2020).

There is no consensus about how many of these criteria should be met to determine intentionality, though Dennett (1983) suggests that one from each broader category would suffice and allows the framework to be flexible enough to be applied across species.

Leave-taking could offer a communicative strategy to warn of intent to imminently depart. As such, it could potentially function to increase social bonding in separated individuals, as a social strategy to manage ecologically dispersing groups, or to manage the risks associated with interaction ends (Baehren, 2022). From the sparse literature, it is thought that leave-taking is a communicative strategy in humans, with specific language and gestural patterns used to ease the transition from social to asocial state (Lockard, 1980), and careful adjustment of leave-taking behaviour based on the receiver context, for example using greater vocal leave-takings when the receiver is not in view (Tang, 2007). However, an investigation into how this intentional behaviour evolved in humans is missing from the literature, and it is unclear whether non-human employ similarly intentional strategies to navigate the ends of their social interactions. Failing this, it could be that non-human leave-taking is a reflexive, zero order

intentional behaviour, which occurs because of anxiety or other emotional reaction to separation.

Compared to Great Ape gestures, the communication of other non-human primates has had limited attention with regards to intentionality. It is well understood that non-human primate species communicate with gestures, and research has largely focused on the function of these gestures. However, it is less well understood as to whether they are done with the intent to modify the receivers' attention, behaviour, or knowledge (Gomez, 2007). From what we do know, non-Great Ape predator calls fulfil some criteria of first-order intentionality. Research on Thomas Langurs (*Presbytis thomasi*) showed that they continued eliciting predator calls until all group members had responded (Wich and de Vries, 2006), and similarly, in Diana monkeys (*Cercopithecus diana*), predator calls were continued until a response was given (Stephan and Zuberbühler, 2016). Bourjade et al., (2015) expand the question of intentionality beyond predator signals in Olive baboons using a food-requesting paradigm, finding that baboons tailor signals as a function of human's visual attention, accompanied by gaze alteration and elaborating the signals when there was a communication breakdown. Crucially, the criteria themselves are designed with human subjects in mind, and thus, may be applicable to Great Apes in ways that are not suited to other species. Differences between baboons and chimpanzees, for example, could drive some of the differences in behaviour. The greater cohesion of baboon social groups could result in less need to intentionally modify behaviour, in the way that fission-fusion chimpanzee groups do. With this in mind, applying intentionality criteria to non-Ape species could highlight important differences in how these species structure their communication to understand and modify others' behaviour.

This study focuses on a non-vocal behaviour produced by wild chacma baboons (*Papio ursinus griseipes*) in the three-minute window before social departure from conspecifics. We

already know that baboons shift their body orientation in the direction of parting at the end of social interactions (Baehren and Carvalho, 2022), which is consistent with intentionality. If chacma baboons produce leave-taking intentionally as recipient-directed signals, we would expect to find that the behaviours were sensitive to who was present and thus mediated by the audience composition. Extending to criteria of audience checking, we also expect the signaller to monitor individuals visually and produce the behaviour when they have checked the audience, and when they have audience attention. Finally, we expect leave-taking to elicit a consistent audience response, reflecting the behaviour as a referential signal. In this case, we expect shifting orientation to be consistently associated with a lack of follow from the receiver, since the behaviour is expected to pertain to separation.

Table 5.2: Intentionality criteria adapted from Townsend (2017) included in the present study.

Category	**Criteria**	**Inclusion / exclusion in present study**
Goal directed	Behaviour repeated until goal achieved	No obvious goal to achieve, nature of the behaviour means it isn't usually repeated
Socially directed	Audience presence	Tested in Baehren and Carvalho, 2022
	Audience composition	Included
Audience checking	Audience attention	Included
	Audience checking	Included
Audience response	Audience shows consistent behavioural response	Included

5.3 Methods

General methods are outlined in Chapter 3. 65 hours of video footage of a troop of 37 chacma baboons were recorded in Chitengo camp, Gorongosa, Mozambique from Oct-Dec 2018, capturing opportunistic spontaneous interactions. 216 independent observations of social interactions were identified within the footage, and behaviours were recorded/coded for each in a three-minute window prior to departure. We used focal sampling to describe the possible intentionality of orientation before separation in chacma baboons, that is, which of the 4 intentionality criteria were supported. Additional measures of intentionality were also recorded in association with each observation (see Table 5.3).

Table 5.3: Intentionality criteria operationalised.

Intentionality criteria	**Variable**	**Description**
Audience composition	Dyad type	Sex pairing of the dyad interacting where the first sex is the focal individual who is first to leave. Male-male (1), male-female (2), female-male (3), and female-female (4).
Audience attention	Gaze of the receiver	Gaze of receiver is towards signaller for at least 2 seconds.
Audience checking	Gaze of the signaller	Gaze of signaller is towards receiver for at least 2 seconds.
Audience response	Follow	An individual moves away (> 1m) in the same direction as the first individual to depart, within 30 seconds of

their departure

All analyses were conducted in R version 3.6.3. Analyses are conducted at the observation level, where each observation contributes one data point. Generalised Linear Mixed effects Models (GLMMs) with binomial error structure were used to investigate the influence of explanatory variables (each of the intentionality measures) on a binary response variable (shifting orientation in the direction of parting, or not) for each observation. We also added observation duration as a continuous fixed effect to account for possible effect of interaction length on the production of orientation shifting behaviour or the receiver reaction to it. Due to the repeated sampling of individuals across observations we also included individual ID of both signaller and receiver as random factors, by adding random intercepts using the package lme4 (Bates et al., 2014). This approach can thus account for individual differences as well as variation driven by context, by modelling both simultaneously. It will also cope with the missing data and imbalance of the model, while looking at the within and between individual differences (Deeming and Jones, 2015).

As the models included multiple fixed explanatory variables, we excluded each explanatory variable individually to find the most parsimonious model with the lowest AIC value. Variables were considered to improve the fit of the model if their exclusion raised the AIC by at least two units. Here, the best-fit models were those with all predictor variables. Due to the repetition of GLMMs on the same outcome variable (orientation shift vs not), we applied Bonferroni corrections to the significance values of the predictor values, such that significance was considered to be below 0.0125.

We first calculated Cook's distances to look for influential observations that could affect the models (Nieuwenhuis et al., 2012). Looking at the association with orientation, we identified around two for audience composition, two for receiver attention, two for audience checking, and five for audience response that could be considered as outliers, however, we decided not to remove them, as this variation could reflect true differences in orientation behaviour. We then checked for collinearity between the variables (maximum VIF= 1.19) including all predictor variables. Since this assumption was satisfied, we deemed the models suitable for analysis and decided to run and interpret all observations to obtain first insights into intentionality of the behaviour.

5.4 Results

Previous work has demonstrated that baboon leave-taking behaviour, specifically, shifting orientation of the body in the direction of parting, is used significantly in social interaction endings, when compared to proximity or solo endings (Baehren and Carvalho, 2022). The following analysis will consider 216 social interaction endings across 21 visible individuals, 9 males and 12 females, to assess whether factors associated in previous studies with intentionality (Table 5.3) are associated with production of this leave-taking behaviour.

5.4.1 IO reliability

We assessed inter-observer reliability with a second coder naïve to the hypotheses coding over 10% of the observations. The observations used in inter-observer reliability were taken at regular intervals throughout the full dataset, to ensure a true cross-section of the data were compared. We considered our data to be collected reliably if the proportions of agreement observed between two observers using Cohen’s Kappa (Cohen, 1977) were significantly

different from those expected by chance. Cohen's kappa values are considered good if ranging from 0.4 to 0.6 and very good if between 0.6 and 0.8 (Watkins and Pacheco, 2000). Inter-observer reliability was deemed a minimum of good, all measures produced similarity that was significantly more than would be expected by chance (Appendix 5).

5.4.2 Statistical analysis

We predicted that if orientation was used as an intentional leave-taking signal, it would be significantly associated with audience composition, receiver attention, audience checking, and consistent receiver behavioural response. A likelihood ratio test revealed a significant difference between the full and null models ($\chi^2 = 17.006$, $P = 0.04863$), suggesting that our full model was more informative than the corresponding null model. We plotted the probability of shifting orientation as a function of all four variables using the R packages ggplot2 (Wickham, 2016) and sjPlot (Ludecke, 2021), as seen in Figure 5.4.

1) Audience composition

To assess if leave-taking behaviour was mediated by the sex composition of the dyad we coded for "dyad type" where combinations included: male leaving male, female leaving female, male leaving female, or female leaving male. A GLMM with binomial error structure was used, where presence of shifting orientation in the direction of parting (0/1) was the dependent variable. For independent variables, we used the dyad type and duration of the interaction. The GLMM revealed that the presence of orientation in the direction of parting was not significantly mediated by the dyad type, with all dyad types having similar likelihood of shifting orientation prior to social separation.

Table 5.4: Regression parameter estimates, standard errors (SE), odds ratio (OR) with 95% CI and z-statistics and p values for audience composition GLMM.

Effects	**Estimate**	**SE**	**z-statistic**	**p-value**
Intercept	-0.2137043	0.4266057	-0.501	0.616
Duration	0.0004332	0.0004856	0.892	0.372
Dyad	-0.0039970	0.1546914	-0.026	0.979

2) Audience attention

As a marker of behaviour being attended to by the audience, we examined whether receivers showed more frequent gaze towards the signalling individual in the leave-taking window, compared to when no signal was given. We predicted that, if behaviours were being paid attention to by the receiver, the receiver should look to the signaller more frequently during production of a leave-taking behaviour, compared to when no leave-taking behaviour was exhibited. We tested whether orientation shifting behaviour (vs no orientation shifting), was associated with the conspecific individual looking at the signaller more frequently within the 3 minutes prior to departure. A GLMM with binomial error structure was used, where the orientation in the direction of parting (0/1) was the dependent variable. For independent variables we included the duration of the interaction and receiver gaze to the signaller frequency as audience attention. We found that orientation in the direction of parting was not associated with attention of the audience.



Figure 5.1: The audience (remaining individual, on the right) is paying attention to the orientation shifting and leaving of the leaving individual (on the left).

Table 5.5: Regression parameter estimates, standard errors (SE), odds ratio (OR) with 95% CI and z-statistics and p values for audience checking GLMM.

Effects	**Estimate**	**SE**	**z-statistic**	**p-value**
Intercept	-0.2763156	0.1732889	-1.595	0.111
Duration	0.0004232	0.0004710	0.899	0.369
Audience attention	0.1777377	0.2483214	0.716	0.474

3) Audience checking

As a further marker of calls being directed at recipients and callers monitoring the behaviour of others, we examined whether the baboons preceded their leave-taking orientation shifting behaviour with more frequent gaze towards recipients. We predicted that, if behaviours were received by an audience, the intended recipient should look to the signaller more frequently when in conjunction with a leave-taking behaviour, compared to when no leave-taking behaviour was exhibited. A GLMM with binomial error structure was used, where the orientation in the direction of parting (0/1) was the dependent variable. For independent variables we included the duration of the interaction and frequency of signaller gaze towards

the receiver within the 3 minutes prior to departure. We found that orientation in the direction of parting was not associated with audience checking.



Figure 5.2: The leaving individual (in this case, the groomee, on the right) is orienting in the direction they will part and gazing towards the remaining individual (groomer, on the left).

Table 5.6: Regression parameter estimates, standard errors (SE), odds ratio (OR) with 95% CI and z-statistics and p values for audience checking GLMM.

Effects	**Estimate**	**SE**	**z-statistic**	**p-value**
Intercept	-0.212191	0.1678248	-1.378	0.168
Duration	0.0004308	0.0004829	0.892	0.372
Orientation	0.0286866	0.2272552	0.126	0.900

4) Audience response

As a final marker intentionality, we examined whether recipients had a consistent behavioural response in line with the expectation of the signal. We predicted that, if leave-taking is to be a

signal of separation, the receiver would not follow the signaller after their departure when there is shifting orientation. We coded whether, in the 30 s period following leave-taking behaviour, the receiving individual followed the signalling individual. A GLMM with binomial error structure was used, where orientation in the direction of parting (0/1) was the dependent variable. For independent variables we included the duration of the interaction and the receiver following signalling individual within 30s of their departure (0/1). We found that there was a significant association between audience response and orientation (Figure 5.4). In those social interactions endings that were preceded with an orientation shift, the receiver individual was significantly less likely to follow (Figure 4.2), adding support for this behaviour as a way to navigate separations, and not just the end of the interaction itself.



Figure 5.3: Example of A) follow and B) no follow.

Table 5.7: Regression parameter estimates, standard errors (SE), odds ratio (OR) with 95% CI and z-statistics and p values for gaze alteration GLMM. * Denotes statistically significant values (p-value < 0.0125).

Effects	**Estimate**	**SE**	**z-statistic**	**p-value**
Intercept	-0.0581038	0.1725567	-0.337	0.73633
Duration	0.0004706	0.0005443	0.864	0.38732
Follow	-1.0544653	0.3984045	-2.647	**0.00813***

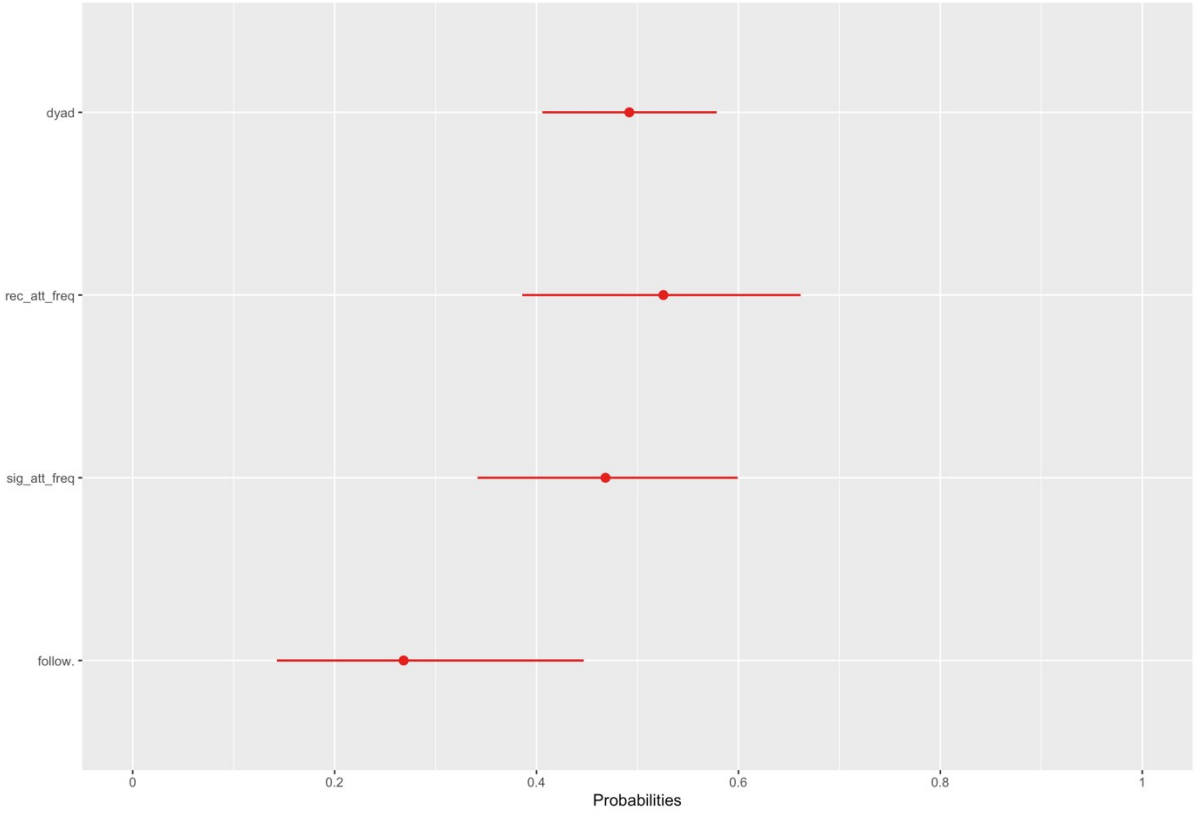


Figure 5.4: Probability of shifting body orientation for each intentionality criteria.

5.5 Discussion

Having combined the test of four intentionality criteria with the findings of Chapter 4, the results of this study suggest that the baboon leave-taking behaviour of shifting orientation towards the direction of parting fulfils only two of five criteria for intentional communication. More specifically, presence of an audience and consistent audience response significantly predict shifting orientation at the ends of social interactions.

Previous research has demonstrated that this behaviour is significantly associated with the ending of social interactions (Chapter 4, Baehren and Carvalho, 2022), but here we demonstrate that it is also associated with a consistent audience response, being significantly more likely in those interactions ends that are not succeeded by following behaviour. We argue that the results of this study fulfil some of the criteria for first-order intentionality, however, we do not yet have enough evidence to confidently support the intentionality of shifting orientation as a leave-taking behaviour. This behaviour could be explained by less cognitively demanding processes (Graham et al., 2020), and without combined support for multiple criteria we cannot suggest that the behaviour is used socially with the goal of communication. Communicative behaviours are thought to have evolved from simpler behaviours, such as touches and locomotion patterns, becoming increasingly stylised and distinctive signals (Zahavi, 1980). The results of this study could situate chacma baboon leave-taking as an interesting gradient between simple, functional behaviour, and the elaborate, ritualised leave-taking we see in humans.

The results pertaining to audience response highlight the association of shifting orientation with separation, and not to merely end the interaction and maintain cohesion, as distinguished by Baehren (2022). Instead, this complements research on mechanisms to maintain group

cohesion, which is well studied across the animal kingdom, for example in primates, birds, social insects, and fish (King and Cowlishaw, 2009). Baehren's (2022) levels of separation suggest that leave-taking at the dyad level allows the management of low-level separation between individuals, whilst maintaining cohesion at the wider group level. Furthermore, this provides additional support for orientation behaviour as a key part of social interactions themselves. It has been long established that orientation towards the interacting partner of a dyad is important in ongoing social interactions, both in humans (Kendon, 1990) and non-human species (Crockford et al., 2015), showing attention and engagement with the interaction. However, this is the first evidence that the opposite behaviour, shifting away, can elicit consistent behavioural responses in the receiver. Shifting away from the interacting partner towards the end of a social interaction discourages the interacting partner from following, and thus, inhibits the maintaining of contact. This supports existing ideas that leave-taking is normative, and departures can be "failed" (Goffman, 1971) if they do not meet certain criteria. That leave-taking occurs primarily in this chacma baboon troop when following does not occur suggests that similar norms may exist, and more research into the behavioural response if these norms are violated is warranted.

Although not significant in the model, the results pertaining to dyad type suggest variation which would be interesting to further explore. Leave-taking was seen to be more likely in female leaving interactions, as opposed to male ones. Specifically, it was higher in frequency in female-leaving-female and female-leaving-male dyads, compared with male-leaving-female dyads. Chacma baboons are female philopatric (Jolly, 2020) and benefit from strategies to maintain close social bonds, with both males and females in the troop (Palombit et al., 1997; Lemasson et al., 2008). Female-male bonds are thought to impact reproductive success; Palombit (2009) outlines how so called "friendships" could protect against

infanticide by encouraging females to form strong bonds with existing males, reducing the chance of their being supplanted by new, immigrating males. Such research has been supported by playback experiments, where male chacma baboons reacted strongly to the distress calls of their female "friends", contrasting their minimal response to non "friend" females. Furthermore, male-female bonds in baboons are thought to have survival advantages; Campos et al., (2020) find that hybrid baboon males with stronger bonds to females have longer lifespans. That leave-taking appears to be used more in female-leaving-male dyads could indicate that it acts to manage important social relationships, that are at risk of infiltration from an extraneous third party, potentially increasing fitness via reproductive success and survival. In addition to this, female-female bonding in chacma baboons, as with other savannah baboons, is central to the social organisation and follows lines of uterine kinship passed down matrilineally (Jolly, 2020). These bonds too are a key indicator of reproductive success (Palombit et al., 2008), and are maintained largely through reciprocal grooming. Greeting behaviour too is seen more frequently in female chacma baboons, compared with males of the same species (Faraut et al., 2019). This is thought to reflect the males' lack of tolerance, who tend to avoid proximity, especially with other males (Kalbitzer et al., 2015). As such, this research supports a trend towards similar sex patterns of greeting and leave-taking in chacma baboons, reinforcing the idea that both might be driven by similar socioecological factors. It would be important to further explore how such factors impact leave-taking behaviour across baboon species, and whether more tolerant and cooperative species, such as yellow or olive baboons, have more elaborated male leave-taking behaviour, as they do with greeting behaviour (Hausfater and Takacs, 1987).

We found no evidence of audience checking frequency being associated with orientation shifts, suggesting that the behaviour is not recipient focused. This does not support previous

research on captive baboon communication that gestures are socially directed (Bourjade et al., 2014). Receiver attention was also not supported by our data. We suggest that the lack of support for both of these criteria could be because gaze is a behaviour related to movement, due to its role in assessing where to travel, and it is thus hard to disentangle its association with intentionality when investigating leave-taking behaviour.

It would be important to establish if there are other criteria that could be used in leave-taking research to better indicate intentionality. One avenue to investigate this could be to measure responses to so called "false departures" (Goffman, 1971), as a way to gauge whether the behaviour is given, or received, with the intention of a certain outcome. For example, how does the departing individual respond if the remaining individual does follow them? Or, how does the remaining individual respond if the departing individual returns "too soon"? Measuring such responses to violated expectations of the behaviour may shed light on intention from the perspective of the intended outcome and avoid such difficulties with gaze related measures. It is also important to consider how the intentionality criteria can be applied outside of Great Ape species, where there could be more group cohesion and less signs of intentionality. Indeed, it could be that such species have less need for intentional behaviour, since they maintain close proximity and could have less need to modify others' behaviour. More work should be done on investigating measures for intentionality in non-Great Ape species.

In conclusion, baboon shifting orientation towards the direction of parting when ending social interactions meets only two key criteria of intentionality: audience presence and audience response. We demonstrate that these orientation shifts elicit specific behaviours in receivers i.e., not to follow the departing individual, and demonstrate that this behaviour occurs

indiscriminately across dyad types, however the typical criteria of intentionality involving attention in signaller and receiver are not supported. We suggest that frameworks for intentionality need to be adjusted to involve non-gaze related criteria, as this can be confounded by movement related gaze.

Chapter 6: Conceptual Archaeology of a Temporal Place: Albert and Kessler (1976) applied to chacma baboons (*Papio ursinus*)

6.1 Abstract

Although leave-taking in non-human species has been preliminarily investigated in a few species, the mechanisms driving encounter ends remain unstudied. In 1976 Albert and Kessler published a landmark paper, outlining theories about what drives social encounter ends and providing a framework of internal and external motivations leading to separation. This framework has been underused in aiding our understanding of how proximate mechanisms for separation drive leave-taking and offers a valuable opportunity to better understand the relationship between separation and behaviour. Having previously identified leave-taking in wild chacma baboon (*Papio ursinus*), in the current paper, we apply this framework to their leave-taking to better understand how the motivations to leave impact leave-taking. Using GLMMs with binomial error structure, our results suggest that internal motivations to end interactions are better predictors of orientation shifting behaviour, when compared to external motivations. We argue that these results validate the use of Albert and Kessler's framework across species and suggest that leave-taking could have originated as a way to signal internal drivers of interaction ends, a behaviour which has become elaborated in human behaviour.

6.2 Introduction

6.2.1 Introduction to the temporal place

Just like human encounters, animal encounters must come to an end. There has been a recent increase in the interest surrounding non-human primate leave-taking, defined as behaviours occurring at the end of social separation (Baehren, 2022), with evidence that chimpanzees (Heesen et al., 2021) and baboons (Baehren and Carvalho, 2022) end social interactions with specific behaviours that are comparable to those of humans, such as gestural and postural changes. Such interaction endings represent temporary pauses of continuity within ongoing relationships, and Albert and Kessler's 1976 milestone paper outlines a variety of proximate mechanisms to understand these endings. Building on such theories of *why* interactions end could help us understand the proximate drivers of leave-taking. Despite several testable hypotheses being generated in their paper, the empirical analysis to support these remains lacking.

Albert and Kessler (1976) conceptualise interaction endings as the point where all forms of communication between two parties have ceased. They situate these endings as within ongoing social relationships, where the ending is a type of temporal boundary between two different categories of experiences: being alone and being with others. Whereas Albert and Kessler (1976) refer only to human populations throughout their paper, here we apply these theoretically to the social behaviour of non-human species, and empirically to chacma baboons (*Papio ursinus*), in order to understand the evolutionary origins of the proximate mechanisms to end interactions, and their relationship with leave-taking. Chacma baboons pose good models for the understanding of such endings, since they live in cohesive groups which experience regular short-term separations within interacting dyads. Previous research

has highlighted their propensity to show leave-taking in such scenarios (Baehren and Carvalho, 2022) and as such, they could provide good models for understanding how such separations and leave-taking are related to one another.

The framework from Albert and Kessler (1976) closely parallels research and conceptualisation of non-human leave-taking. Baehren (2022) outlines levels of separation that reflect differing extents and permanence of interaction ends. At the low level are short-term recurring separations, and at the high level are long-term separations. Such short-term separations have been investigated successfully in baboons (Baehren and Carvalho, 2022). Similarly, Albert and Kessler (1976, p. 147) refer specifically to "routine everyday events" as an important backdrop for understanding separations. In addition to this, Albert and Kessler (1976) make reference to the social unit at play in separations, with a focus on two-person social encounters, but the potential to consider separation at the groups or national level. Paralleling this in the non-human setting, Baehren's (2022) levels of separation present fission-fusion as a gradient that exists across all species to differing extents and have been applied to baboon dyads (Baehren and Carvalho, 2022). As such, the theories that Albert and Kessler present for proximate drivers of separation are well aligned with the frameworks already established for leave-taking research in non-humans.

6.2.2 Additional problems of causal attribution

Despite this alignment, there are some challenges with applying a theoretical framework designed for humans to the study of non-human species. Albert and Kessler (1976) outline problems of causal attribution of both the *real* and the *expressed* reason for terminating a social encounter; something which is an important consideration in human leave-taking. The expressed reason can be thought of as the justification one gives the other, or that they

mutually agree on, regarding the cause of the interaction's end. In addition, they introduce internal and external reasons for interaction termination, where internal reasons are those related to interaction itself (positive or negative) e.g. joint task has been brought to a satisfying conclusion, or because the interacting individuals become hopeless, bored, or conflicted. External reasons refer to those outside of the interaction, e.g. closing of a door, entrance of third party, departure of a plane, where environmental influences cause the interaction to cease. This forms a 2x2 matrix whereby interaction endings can be either internally or externally motivated and can be real or justified. For example, they describe a scenario (p. 152) where the real reason for termination is boredom, but the expressed reason is external, e.g. a fabricated appointment (Cell 2, Table 6.1). Humans give external justification for any termination, except when permanent ending is desired, or the positive internal reason is obvious. Furthermore, when the real reason is external and obvious it almost always serves as the justification. In cases where internal justification is necessary an attempt will be made to find a positive one.

Table 6.1: Replica of Table 1 from Albert and Kessler (p. 152: 1976): The source of the real reason and the provided justification for ending.

		Justification	
		Internal	External
Real reason	Internal	Cell 1	Cell 2
	External	Cell 3	Cell 4

However, in non-human species it is much more difficult to disentangle real and justified reasons for interaction termination. Although differences between actual knowledge and communicated knowledge has been investigated in non-human species (e.g. work on deception, see Johnson et al., 2005), the evidence is limited in terms of its widespread existence across species and even across individuals. As such, for the purpose of this research we treat real and justified reasons for terminating encounters as equal in non-human species, and thus only cells 1 and 4 are relevant (Table 6.2) when compared to human leave-taking (Table 6.1), and we will simply consider the internal and external reasons for leaving.

Table 6.2: Adaptation of Table 1 (Albert and Kessler, 1976): The source of the real reason and the provided justification for ending in non-human species.

		Justification	
		Internal	External
Real reason	Internal	Cell 1	N/A
	External	N/A	Cell 4

6.2.3 Internal and External Processes of Ending

Albert and Kessler (1976) deem the distinction between internal and external motivations to leave a fundamental one. It is thought necessary to describe the motivational forces of interaction ending to fully understand the ongoing social relationship of coming together and going apart again. In fact, they go as far as to state that "the full meaning of social interaction is known only when its end is known" (p. 150) and argue that the preliminary classification of ending processes into internal and external is less an expository convenience than a reflection

of the fundamental logical and phenomenological categories out of which endings are constructed. This remains unstudied empirically in all species, and thus, here we outline the internal and external processes of endings raised by the authors and discuss their applicability to non-human species.

a) Internal processes

The first internal ending process that Albert and Kessler (1976) refer to is the "summary process", whereby individuals give an abbreviated statement of the history of the social encounter. They are often symbolic in nature, expressing key themes of the encounter and enabling the interactants to remember the interaction, usually (though not always) positively. In doing so, this also places the interaction in the past, historicising it, often using past tense to mark this shift. Despite the clear importance of summary processes in navigating human interaction endings, Albert and Kessler (p. 158: 1976) pose that it is "largely a product of cognitive activity and relies heavily on language. At its core it is an exercise in the conceptualization of history." This is another aspect of behaviour that is difficult to see parallels in non-human species. Although mental time travel is documented in some primate species (e.g. chimpanzees Cheke and Clayton, 2010), the ability to communicate summative statements refer to past events is beyond the scope of current research (McGrew and Baehren, 2016).

The other internal ending process that Albert and Kessler (1976) discuss is that of resource exhaustion. They outline that this process locates a finite resource which is essential for the continuity of the encounter and whose depletion leads to termination. The resources relevant here include more obvious examples such as a limited food source that is the basis of an

interaction, as well as the limitation of more personal resources such as energy and time. It is well understood that non-human species must balance their time between activities to maximise their reproduction and survival (Fehlmann et al., 2017). Some primate species have even been shown to have vastly different social interactions when freed from the constraints of food availability (García et al., 2021). As such, measuring the impact of resource availability on leave-taking could easily be investigated in species beyond humans. In the present study we consider the main resource to be "time" and hence measure the duration of the interaction. In other non-human contexts, depletion of food stuffs could be a proxy for this measure.

Social psychology gives us many theories as to why social interactions come to an end. Consistency models, such as those on imbalance, describing a necessary harmonising of the interpersonal relationship (Heider, 1958), and on dissonance, where conflicting beliefs or behaviours leading to discomfort and alteration (Festinger, 1957) give one type of framework. Additionally, exchange theories (e.g., Kelley and Thibaut, 1985) argue that an ending will occur when the outcomes within a relationship fall below the comparison of an alternative relationship. We measure such parallels in the current study by measuring behaviours that could pose threat or stress, such as aggressive behaviour or infant grabbing.

In addition, social exchange theory takes a cost-benefit approach (Thibaut and Kelley, 2008) where individuals are assumed to maximise benefits and minimise costs of their interactions. We believe these theories are relevant to the discussion of internal ending processes as both relate to the dyad dynamics central to the ongoing relationship and can be applied to non-human relationships by investigating the behaviours during and following social separation.

As such, we will consider social exchange to be when one individual leaves the interaction to join another interaction immediately.

b) External processes

In addition to the processes that are within the social interaction itself, Albert and Kessler (1976) outline a number of external processes that motivate individuals to cease their interactions. The first of these external processes refers to the physical environment in which the interaction takes place. Environments have built in endings, e.g., a path that two people are walking along which then splits into two, prompting separation. The physical environment also provides distractions which can prompt an individual to terminate the current encounter in favour of such an alternative. These environment features map neatly onto those experienced by non-human species, where there are alternative activities for individuals to participate in, which may drive the decision to end a current interaction, and are thus measured in the current study.

Also external to the dyadic interaction, the wider social environment can motivate interaction ending, either by entrance of a third party or by imitation of others' separations. Entrance of a third party, causing the withdrawal of an original individual, is known in animal studies as displacement (Troisi, 2002) and will be measured in the current study. Albert and Kessler (1976) also describe contraction of social environment, whereby other departures in the wider social group facilitate a "general exodus" (p. 162). This too is directly relevant to non-human species, and indeed positions the research somewhere between the two separate (yet related) concepts of group movement and individual separation, as defined by Baehren (2022).

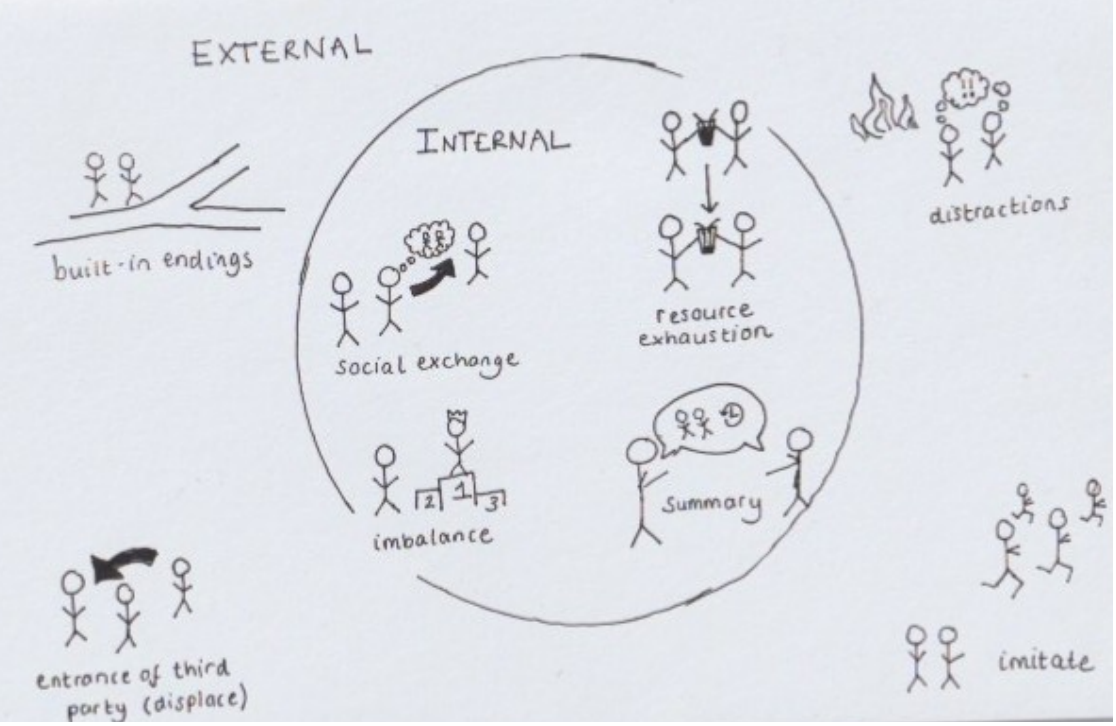


Figure 6.1: Conceptualisation of internal and external motivations to end.

6.2.4 Processes for ending social interactions in non-humans

This research aims to apply the above insights to the study of social interaction endings in wild chacma baboons (*Papio ursinus*). We first identify which of the processes outlined by Albert and Kessler (1976) can be tested on non-human species (Table 6.3) and group these into the respective internal and external categories.

Table 6.3: Internal and external processes and their applicability to non-humans.

	Process	**Applied to non-humans**
Internal	Summary	No- focused on linguistic summaries
	Social exchange	Yes
	Imbalance	Yes
	Resource exhaustion	Yes

External	Built-in endings	No- in theory possible but difficult to get a large sample size of interactions that involve such built-in endings
	Distractions	Yes
	Imitating others	Yes
	Entrance of third party	Yes

Following this, we hypothesise that ***leave-taking in social interactions is more likely with internally motivated endings than externally motivated endings.*** We expect chacma baboons to need to communicate such temporal shifts that may not be as intuitive as external processes such as distractions, imitations, or displacement by a third individual. These internal features of the interaction, such as social imbalance, exchange, or predicted exhaustion of a key resource, may not be as obviously apparent could warrant signal production. Although research on other primate signals is overwhelmingly in support of their use to reference real-world, referential objects, intrinsically social signals such as greeting are known to reflect intricacies of the social interaction itself. We might thus expect primate species to use leave-taking to extricate themselves from social interactions brought to a close by internal forces.

6.3 Methods

General methods are outlined in Chapter 3. 65 hours of video footage of a troop of 37 chacma baboons were taken in Chitengo camp, Gorongosa, Mozambique from Oct-Dec 2018, capturing opportunistic spontaneous interactions. 216 observations were identified within the

footage for social interactions, where behaviours were recorded in a three-minute window prior to departure. Measures of internal and external variables were also recorded in association with each observation (Table 6.4).

6.3.1 Analyses

All analyses were conducted in R version 3.6.3 and alpha values were set at 0.05. Analyses are conducted at the observation level, where each observation contributes one data point. Generalised Linear Mixed effects Models (GLMMs) with binomial error structure were used to investigate the influence of explanatory variables on a binary response variable (shifting orientation in the direction of parting, or not) for each observation. Due to the repeated sampling of individuals across observations we included individual ID of both signaller and receiver as random factors in the models, by adding random intercepts models using the package lme4.

Generalised Linear Mixed effects Models (GLMMs) with binomial error structure were used to investigate the influence of explanatory variables on a binary response variable (orientation in the direction of parting, or not). Due to the repeated sampling of individuals across observations we included individual ID of both signaller and receiver as random factors in the models, by adding random intercepts models using the package lme4 (Bates et al., 2014).

6.3.2 IO reliability

We assessed inter-observer reliability with a second person naïve to the hypotheses coding over 10% of the observations. The observations used in inter-observer reliability were taken at regular intervals throughout the full dataset, to ensure a true cross-section of the data were compared. We considered our data to be collected reliably if the proportions of agreement observed between two observers using Cohen's Kappa (Cohen, 1977) were significantly

different from those expected by chance. Cohen's kappa values are considered good if ranging from 0.4 to 0.6 and very good if between 0.6 and 0.8 (Watkins and Pacheco, 2000). Inter-observer reliability was deemed very good, all measures produced similarity that was significantly more than would be expected by chance.

Table 6.4: Variables associated with internal and external motivations to end interactions.

	Process	**Measure**
Internal	Social exchange	Does departing individual move to another social interaction immediately after focal interaction? (0/1)
	Imbalance	Is there infant grabbing? (0/1)
	Resource exhaustion	Is there copulation call (0/1)
		Duration of interaction (mm:ss)
External	Distractions	Does departing individual look towards something else before leaving? (0/1)
	Imitating others	Are other individuals visibly departing? (0/1)
	Entrance of third party	Does a third party join before departing individual leaves? (0/1)

We first calculated Cook's distances to look for influential observations that could affect the models (Nieuwenhuis, Grotenhuis and Pelzer, 2012). Looking at the association with orientation, we identified around four potentially influential observations for the external model and four for the internal model that could be considered as outliers, however, we

decided not to remove them, as this variation could reflect true differences in orientation behaviour. We then checked for collinearity between the variables (maximum VIF= 1.087). Since these assumptions were satisfied, we deemed the models suitable for analysis and decided to run and interpret all observations to obtain first insights into intentionality of the behaviour.

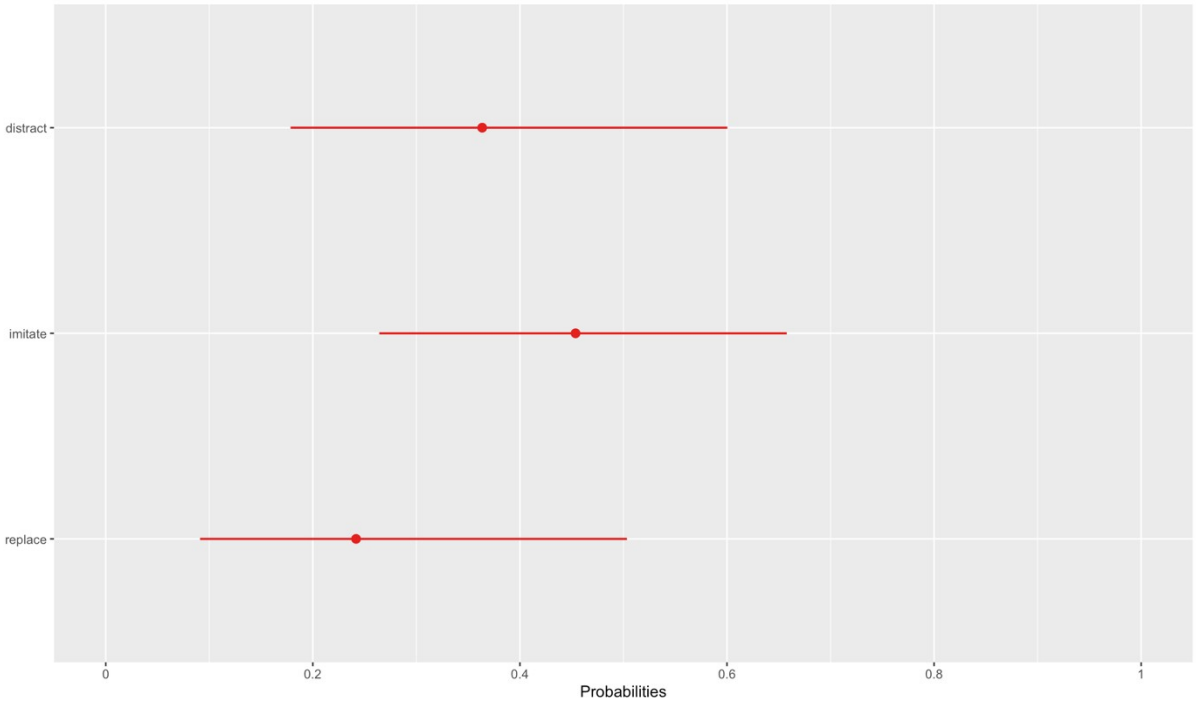
In addition to looking at whether each model significantly predicted leave-taking behaviour, we used Akaike's information criterion corrected for small sample size (AICc; Burnham et al., 2011) to compare our models according to how likely they were based on our data (Duboscq, Romano, Sueur & MacIntosh, 2016). We considered the model having the smallest AICc value as the one explaining best our observations.

6.4 Results

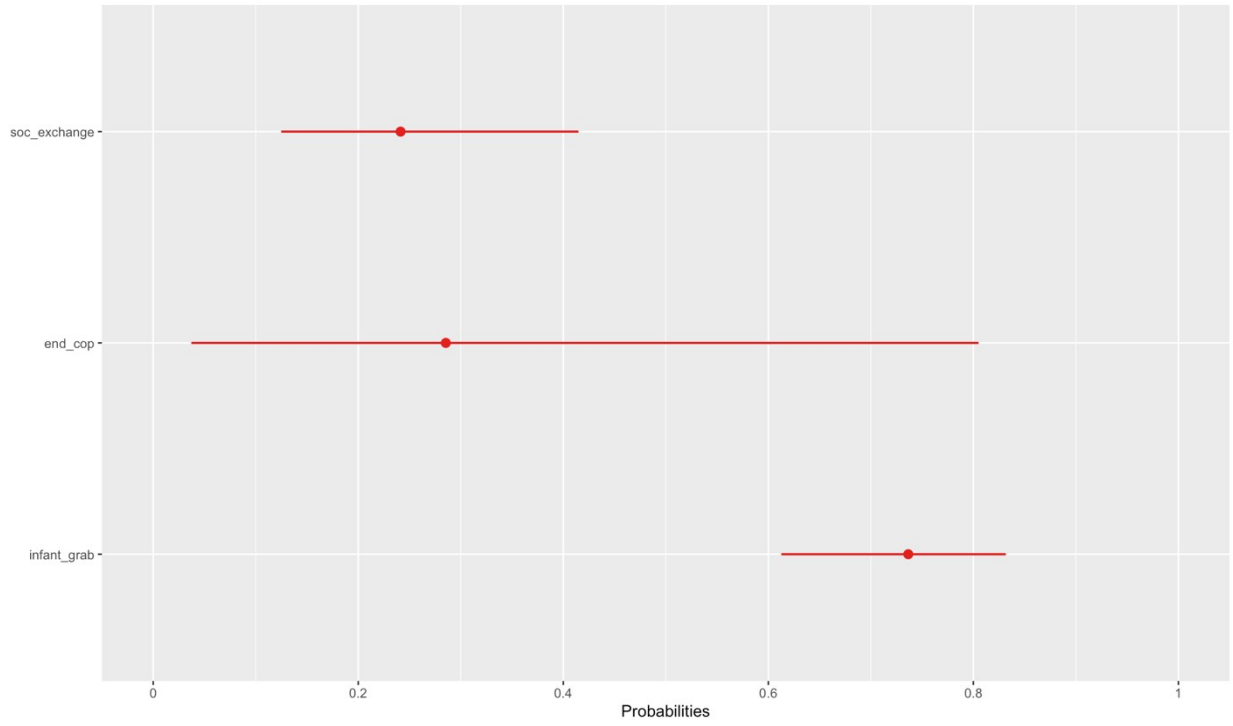
Previous work has demonstrated that baboon leave-taking behaviour, specifically, orientation of the body in the direction of parting, is used significantly in social interaction endings, when compared to proximity or solo endings (Baehren and Carvalho, 2022). Following this, we examine whether, within social separations, internal or external motivations for ending better predict leave-taking behaviour. We predict that internal motivations for ending social interactions will be better predictors of leave-taking than external motivations in wild chacma baboons.

We analysed 215 social interactions to examine the relationship between internal and external factors driving separation, with predetermined presence of leave-taking events. A likelihood ratio test revealed a difference between the full and null models ($\chi^2 = 21.468$, $P = 0.000667$),

suggesting that our full model was more informative than the corresponding null model. The comparison of the model weights between the two models provides greatest support for the internal, which had a 100% chance of explaining the data better than the external model. These results suggest that the internal motivators for leave-taking best predict orientation shifting in chacma baboons, when compared to external motivators. We plotted the probability of shifting orientation as a function of the external variables (A), and internal variables (B), using the R packages ggplot2 (Wickham, 2016) and sjPlot (Ludecke, 2021), as seen in Figure 6.2.



(A)



(B)

Figure 6.2: Relationship between Orientation shifting and the (A): External and (B): Internal predictors of separation.

Table 6.5: Results of the GLMM testing the internal model. * Denotes statistically significant values (p-value < 0.05).

	Estimate	**SE**	**Z**	**CI**	**P**
Intercept	-0.51	0.23	-2.23	-0.96 to -0.06	**0.03***
Social Exchange	-1.15	0.41	-2.80	-1.95 to -0.34	**0.01***
Duration	0.00	0.00	0.96	0.00 to 0.00	0.34
Copulation Call	-0.92	1.19	-0.77	-3.25 to 1.42	0.44

Infant grab	1.03	0.29	3.54	0.46 to 1.60	**0.00***

Table 6.6: Results of the GLMM testing the external model. **(*)** Denotes values approaching statistical significance (*p*-value < 0.05).

	Estimate	**SE**	**Z**	**CI**	**P**
Intercept	0.01	0.16	0.09	-0.29 to 0.32	0.93
Distract	-0.56	0.49	-1.13	1.53 to 0.41	0.26
Imitate	-0.19	0.43	-0.43	-1.02 to 0.65	0.66
Replace	-1.14	0.59	-1.94	-2.30 to 0.01	**0.05(*)**

The specific results of the models highlight some interesting results. For instance, infant grabbing was the predictor most likely to lead to orientation shifting behaviour. Lack of social exchange was negatively associated with orientation shifting behaviour, meaning that not moving to another social interaction was associated with lack of leave-taking. Replacement by a third individual also approached significance. In contrast, features of the "outside world" i.e., separate to the interaction, were not significantly associated, such as other individuals moving away or distraction by other non-interacting individuals. These findings suggest that features relating to the interaction itself are better drivers of leave-taking in chacma baboons than those relating to the outside world.

6.5 Discussion

This thesis previously applied a novel method to the behaviour of wild chacma baboons to elucidate the presence of leave-taking (Chapter 3), and then demonstrated that the resultant behaviour fulfilled key criteria of intentionality (Chapter 4). The results of this chapter suggest that orientation in the direction of parting, previously identified as leave-taking in chacma baboons, reflects internal motivation to end interactions rather than external drivers of the behaviour from the outside world.

When investigating motivators to leave social endings, orientation is significantly more likely when separation is driven by internal factors. This suggests that leave-taking behaviours may be prompted when the motivation to leave is from features intrinsic to the social interaction. One potential reason could be the "obviousness" of external motivations to leave; as Albert and Kessler (1976) argue, if a sudden fire causes an interaction to cease then it is unlikely that much time must be spent to make this clear. There was a significant association of orientation shifting and internal reasons to leave, suggesting that this behaviour is used differentially to manage expectations of internally motivated endings.

There is no available data to compare the results of this study directly to human separations, but Albert and Kessler (1976) suggest that human populations acknowledge both internal and external reasons to leave. They discuss internal motivations to end as a process requiring complex communication about factors outside the social interaction, where humans have

uniquely evolved the reflective, summarising features that give specific internal need to tie up the interaction. They state that "internal reasons are those related to the content and history of the interaction itself" (p. 152). That orientation shifting seems driven by such internal reasons to end interactions, raises the possibility that this mechanism of leave-taking could have a deeper evolutionary origin than previously thought. Further application of this framework on other species would help us to better understand the evolution of leave-taking in relation to its motivating factors, but our current findings suggest that internal motivations to end interactions could be the primitive, shared condition in primates that drives leave-taking, whereas external drivers could be derived in humans, or indeed Great Apes. This could reflect the suggestion made by Albert and Kessler (1976) that human language allows for specific reference to the real and justified reasons for ending. In non-human species, external reasons to end may be obvious and require no communication. Further, they likely do not have a system of leave-taking that can refer to "justified" reasons for ending, where internal reasons are often justified as external, and this could put less selective pressure on the communication of external reasons in general.

These results further raise the possibility that humans have further developed a process which originally functioned to signal the ending of internal factors to better differentiate between the two categories. Although in baboons some predictors of both internal and external motivation to end are meaningful in predicting orientation shifting, it seems that humans can refer more specifically to the reason for leaving. As outlined by Albert and Kessler (1976), human language can refer to features of the interaction itself e.g. summarising and well-wishing. Furthermore, human language can refer to things beyond the immediate interaction e.g. past, or future interactions. The concept of mental time travel in non-humans is controversial

(Cheke and Clayton, 2010), but even conceptualisation of present moments in time would require additional cognitive abilities to communicate this during a social interaction. In contrast, reference to more tangible features of the external environment is well documented in many non-human primate species (Fichtel, 2020). Our results are consistent with other findings that baboon leave-taking is intentional (Chapter 4), here showing that it is consistently associated with features of the interaction.

Albert and Kessler (1976) discuss at length the problem of causal attribution, whereby real and justified reasons for leaving are given in human leave-taking (Table 1.1). This is an interesting concept that has no obvious equivalent in non-human species (Table 1.2). For instance, the real reasons seem unable to be concealed or expressed in other species, if boredom is the motivation to leave then it is not justified using another more socially acceptable reason. Albert and Kessler suggest internal reasons for ending the interaction may be avoided as they could make the interaction less positive e.g. acknowledging boredom, upset, or even that the interaction is over. In a sense this is related to the *choice* that the interaction is to be terminated, or as framed by Albert and Kessler (1976), it is "related to the suspicion that… somehow something has gone wrong with the interaction" (p. 153). They propose that there is a socially learned disposition to provide an external justification for any termination, apart from when a positive internal reason is obviously available. Without the ability in non-human species to give a different "justified" reason rather than a "real" reason, this could help explain why external drives do not significantly predict orientation shifting. It is interesting that chacma baboons are significantly less likely to shift orientation in externally motivated endings; this could reflect a more sudden end for which leave-taking is

not able to be prepared for. We argue it is more likely a lack of the human disposition to prefer external justifications for endings.

To summarise, the association in chacma baboons of internal motivations to leave social interactions and eliciting leave-taking behaviour, could be explained by 1) the obviousness of some external reasons, which may not need to be communicated, 2) the apparent inability in non-humans to use techniques such as summarising and mental time travel to communicate features of the interaction which may reflect internal motivation to leave, and 3) a lack of social taboo around internal reasons to justify interaction ends. All three of these hypotheses should be further explored, although may prove difficult to test empirically.

Importantly, these findings do not suggest that external reasons to leave interactions are not related to driving separation. Indeed, social exchange, imbalance and resource exhaustion were found to be common reasons to leave social activities. Rather, the findings instead support the idea that these motivations to leave were not significant in predicted orientation leave-taking behaviour.

Many further questions are raised as a result of applying this framework to non-human species. For instance, expanding the investigation of motivations to end interactions in chimpanzee or spider monkey (*Ateles*) populations would give insights into how the construction of endings could differ in a fission-fusion species. Furthermore, we may expect the importance of internal motivations to end interactions to differ in such a species which are more closely related to humans, and in which mental time travel is better documented. Expanding this research to chimpanzees could help us understand the evolutionary changes in

leave-taking behaviour, for example, did leave-taking in internally driven interaction ends evolve before the *Homo-Pan* split?

The findings of this research are of great importance in leave-taking research, as they fill the gap in understanding how processes driving the separation itself could also be driving the leave-taking. Research in human populations documents well how the nature of leaving affects the presence and expression of leave-taking (Knapp et al., 1973; Duranti, 1997; Rababah and Malkawi, 2012), but this is the first evidence that the same could occur beyond humans. Although context has been considered previously, the subtleties of the endings of social interactions have been ignored. This paper extends our understanding of leave-taking beyond just the behaviour itself to consider a process which includes the motivation to end and the subsequent construction of such an ending. Albert and Kessler's 1976 milestone paper gives us important theory underpinning the conceptual archaeology of a temporal place, and indeed emphasises that "the full meaning of a social interaction in known only when the end is known" (p. 150).

Chapter 7: Why say "goodbye"? The function of leave-taking in wild chacma baboons (*Papio ursinus*)

7.1 Abstract

Although the function of greeting has been explored across primates, the function of its counterpart, leave-taking, remains unstudied. With evidence of orientation shifting towards the direction of parting in chacma baboons being an example of such behaviour to signal the end of social interaction, investigating its function seems the next natural step. Several functions of leave-taking have been suggested for humans, including increasing social bonding, providing information about separation, and managing conflict or competition. Here we test three hypotheses using wild chacma baboons: 1) social regulation, 2) signalling separation, and 3) risk management. We used an information theory approach to investigate these functional hypotheses of baboon leave-taking. We found less support for social regulation or separation indication as drivers of the behaviour, but results did support the use of body orientation in the direction of parting to manage risk, e.g. when there could be tension over valuable resources. We suggest that leave-taking in chacma baboons could have originated as a mechanism to decrease the risk of ending social interactions, especially to manage costly competition or mitigate conflict. Hence, the function of leave-taking could vary across primate species, depending on social systems, and levels of tolerance and competition.

7.2 Introduction

Despite much interest in the topic of greeting, its counterpart leave-taking has received little attention. Even in humans, which most of the literature relates to, the function of leave-taking has attracted little attention, where focus has been primarily on expression and proximate cause of the behaviour (Chapter 1.2). Historically this was thought to be because of difficulties in studying a behaviour which happens often unpredictably and at great speed (Albert and Kessler, 1978), though as predicted, technology has now improved so has our ability to capture the fleeting nuances of leave-taking. Recent interest has provided some of the groundwork for understanding leave-taking, including its definition as a behaviour occurring before separation from social interaction, and a framework for measuring it across species and populations (Baehren, 2022). It has also been studied recently in some non-human species such as wild baboons (Baehren and Carvalho, 2022) and captive chimpanzees (Heesen et al., 2021). Despite this, there is little to empirically investigate the function of leave-taking.

Some of the most interesting evolutionary questions surround questions of function. One way for groups of social animals to manage relationships is through social behaviour, specifically by performing ritualised behaviours during close encounters (Mercier et al., 2017), such as greeting. Greeting is widespread across species, though the exact function is variable, and in some cases, unknown. Five main functions are suggested in current literature to explain greeting: benign intent, conflict management, to signal submission, social coordination and testing social bonds (Mercier et al., 2017). Although greeting and leave-taking are often considered in conjunction with one another, it is argued that they could in fact have very different functions (McGrew and Baehren, 2016). In addition to this, the function of leave-

taking could be variable and multipurpose. This variation could reflect different social systems across species or reflect different propensities within species.

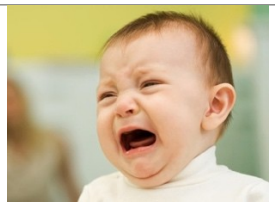
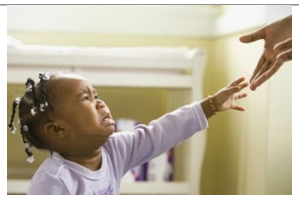
Leave-taking in chacma baboons (*Papio ursinus)* does not occur in all social endings however, it does occur significantly more in contexts of social separations compared to non-social (Baehren and Carvalho, 2022). One reason for this low leave-taking frequency could be that other, unstudied, or unknown, behaviours are used upon separating to manage the parting in other dyad types. These behaviours could be less conspicuous than shifting orientation and thus not be as easy to detect, especially from video footage. Alternatively, there could be more nuance in the context of chacma baboon leave-taking, i.e., occurring mostly in specific social situations and not indiscriminately at the end of all social interactions. Understanding the function of leave-taking could help us to determine if and why the behaviour may be more prevalent in certain contexts.

Similar to greeting behaviour, human leave-taking comes in a variety of modalities e.g. vocal, gestural or postural (Lockard, 1978). Previous studies have suggested that non-vocal behaviours are particularly prominent in non-human leave-taking e.g. body orientation shifts in chacma baboons (Baehren and Carvalho, 2022) and mutual gaze behaviour in chimpanzees (Heesen et al., 2021). In humans there are similar non-verbal behaviours that complement the linguistic literature such as gestures, posture, and breaking contact behaviours (e.g. Whittaker et al., 1994; Firth, 1970; Haddington, 2019). Functions of leave-taking have not undergone any systematic study, in humans or non-human species. As such, function has been inferred from some of the more descriptive literature and hypotheses subsequently

designed. As discussed in Chapter 1.2, much of the focus of leave-taking has been on proximate rather than ultimate causes of leave-taking and so little is discussed concerning the adaptive, functional value of the behaviour. From the literature we have pre-determined three, not mutually exclusive, possible hypotheses for the function of leave-taking.

The separation indication hypothesis posits that leave-taking acts to inform of imminent separation, a form of decreased access according to Goffman (1971). It is certainly a necessary aspect of the definition across studies (Baehren, 2022), and in a sense by the very nature of its definition must relate to separation. Some of the suggested reasons for this need to signal separation is that it could reduce the anxiety associated with separation, particularly in relation to self-scratching behaviour, which is often interpreted as anxiety behaviour across species, including humans (Troisi, 2002). Lack of separation is also highlighted by Goffman (1971), as a false-leave-taking, where leave-taking behaviours are demonstrated but no separation occurs, not fulfilling sufficient conditions for proper leave-taking. Furthermore, in longer separations there are more elaborate displays in humans (Whittaker et al., 1994), and with no separation at all there is no leave-taking (Betholia, 2009), suggesting that leave-taking function relates to this separation. It is suggested that separation could drive such behaviour from the instinct of children to stay close to mothers (Blurton-Jones, 1972), as a survival instinct. Parallels in infant distress at separation and expression of leave-taking (for example, crying, holding out arms, following, Bowlby, 1969) could suggest that leave-taking has a function to maintain contact as a result of innately present attachment, increasing survival chance.

Table 7.1: Parallels between infant distress at separation and normative leave-taking behaviours. Image sources from top to bottom and left to right: *desicomments.com, tvfanatic.com, sleepingshouldbeeasy.com, gettyimages.in, verywellimages.com, escape.com.au, verywellmind.com, ingles.com, gettymages.com.*

Behaviour	**Infant distress at separation**	**Parallel example of normative leave-taking behaviour**
Expression of sadness		
Maintaining contact		  
Reaching out		 

According to the social regulation hypothesis, leave-taking would act to strengthen the relationship between individuals, continuing social ties (Lockard, 1980). In the human literature there is much support for this hypothesis, e.g. that leave-taking reflects a positive

interaction and hopes to resume at some point in the future (Albert and Kessler, 1978). Across definitions of leave-taking, many refer to social interaction as a crucial component (Baehren, 2022). In this condition, leave-taking would occur more in activities that act to strengthen social bonds and is a way to manage the relationship, even continuing when individuals cannot be together, and would be less likely in tense or threatening interactions. DuFon (2010) suggests that a positive and successful leave-taking could send a relational message regarding feelings and attitudes that bolsters the relationship for the time apart and Firth (1972) goes as far as to say that it could even be adaptive in facilitating positive social relationships. An insight into joint commitment from Grafenhein et al., (2009) shows that young children are more likely to show leave-taking when they are engaged in social behaviour such as play, rather than independent solo behaviours. It seems assumed that leave-taking plays some crucial role in social behaviour, and even social bonding, though this hypothesis remains to be tested. It could be the case that leave-taking functions to bolster social relationships in species which have close spatial proximity and high tolerance, where the behaviour could be expected to help regulate relationships, e.g. Guinea baboons (Dal Pesco and Fisher, 2018). In contrast, this might not be expected of species such as chacma baboons who have lower tolerance, particularly between males, and where greeting behaviours are less elaborate and more tense (Dal Pesco and Fischer, 2020).

According to the risk management hypothesis, leave-taking could act to mitigate the social risks of interaction, and the associated separation. Across species, individuals acknowledge existing dominance relationships by advertising status (inferior, from subordinate) which increases tolerance (de Waal, 1986). This is seen in greeting in species such as wolves and dogs (Schenkel, 1967), macaques (de Waal and Luttrell, 1985) and hyenas (East et al., 1993).

Comparison of greeting rituals in baboons suggests that such behaviours promote tolerance and diffuse tension. In more tolerant baboon species, such as Guinea baboons, greeting rituals are more elaborate and reciprocal, whereas in more competitive species such as olive and chacma baboons, greetings are more tentative and tense (Dal Pesco and Fischer, 2020). As such, leave-taking could perform a similar function to greeting which varies based on social system and context. In humans, the "politeness" of leave-taking reflects the norm-bound social expectation (Rababah and Malkawi, 2012) and there is evidence in children that there is training by adults on these cultural norms and expectations (Corsaro, 1979). Under this hypothesis, leave-taking could function to avoid conflict and repair relationships after agonistic interactions, or when there is competition for valuable resources that could cause tension. There is much discussion of this occurring at fusion events (Aureli and Schaffner, 2007) but little on fission. Goffman (1971) argues that a lack of leave-taking seems improper and impolite, so perhaps this behaviour allows us to successfully end interactions without causing negative feelings towards the other individual, especially in tense or non-positive interactions. Crucially, we do not expect these hypotheses to be mutually exclusive, or consistent across contexts or populations.

Table 7.2: Summary of functional hypotheses.

Hypothesis	**Description**	**Sources**
Indicate imminent separation	Acknowledge separation and the imminent ending of social interaction	Lockard 1980; Whittaker et al., 1994; Betholia 2009

Social regulation	Associated more with affiliative interactions, increasing support from, and bolstering relationships with other individuals	DuFon 2010; Goffman; Grafenhain 2009; Firth 1972
Risk management	Mitigate agonistic interactions and repair social relationships after conflict or threat. Acknowledge existing dominance relationships, reduce aggression, and increase group stability	Aureli and Schaffner 2007

This research focuses on chacma baboons, which are often used as models for social and cognitive evolution (Fischer et al., 2019). They are extremely social animals, who live in multi-male multi-female groups and produce a range of communicative behaviours. Interest on their greeting behaviour has grown in recent years (Dal Pesco and Fischer, 2020) and, more recently, leave-taking has been studied in baboons (Baehren and Carvalho, 2022). Specifically, interest in how greeting varies across the different species of baboons has illuminated the importance of social system on determining the form and function of behaviour. In chacma baboons, greeting is minimal and tense, especially in males, reflecting their lower levels of tolerance and affiliation and a lack of proximity with other males (Kalbitzer et al., 2015). Although greeting behaviour in female chacma baboons is less well studied, evidence suggests that their behaviour on approach to other females is more closely driven by tension and dominance hierarchy, reflecting the riskier interactions when compared to other more tolerant baboon species (Faraut et al., 2019). In particular, the chacma baboons in Gorongosa National Park have been investigated in relation to the sex differences of approach behaviour, highlighting that ear-flattening with lip-smacking is seen across male

and female approaches (Muschinski et al., 2023). Previously, using a novel definition of leave-taking, orientation shifting towards the direction of parting has been highlighted as a leave-taking behaviour in chacma baboons (Baehren and Carvalho, 2022). This minimal leave-taking, more prominent in females than in males, is directly in line with what we see for chacma baboon greeting and reinforces the "bookended" relationship of the two behaviours. In this test of function, we therefore predict that risk management would be the most likely function of leave-taking behaviour in chacma baboons, paralleling the tension driven greeting behaviours seen in this species.

Here, we compare models of possible functions, using *a priori* determined predictors of each model. We have identified seven predictors to test the three hypotheses outlined above. Three of these pertain to features of the separation itself, that is, that leave-taking is not expected to occur in unexpected or sudden separations, when the receiver follows the signallers, or when separation is closely followed by another social interaction. Two predictors concern the behaviours in the interaction: leave-taking reflects "breaking contact behaviours" or occurs more often after threat. The final two predictors are contextual, i.e., that is, the type of dyad interacting, and whether the interaction involves or is near to valuable resources. All these predictors are defined in the following methods section.

We used an information theory approach, where these predictors are used to model the three non-competing, functional hypotheses. This allowed us to provide differential support for the hypotheses, ranking them in order of likelihood, to suggest the most probable function based on how well they fit the data, instead of using a falsification method based on p values. This

produces insights into the relative importance of each hypothesis, which are represented by combinations of relevant social predictors.

7.3 Methods

General methods are outlined in Chapter 3. 65 hours of video footage of a troop of 37 chacma baboons were taken in Chitengo camp, Gorongosa, Mozambique from Oct-Dec 2018, capturing opportunistic spontaneous interactions. 216 observations were identified within the footage of social interactions, where behaviours were recorded in a three-minute window prior to departure. Additional measures associated with the hypotheses were also recorded in association with each observation (Table 7.3).

7.3.1 Analyses

All analyses were conducted in R version 3.6.3 and alpha values were set at 0.05. Analyses are conducted at the observation level, where each observation contributes one data point. Generalised Linear Mixed effects Models (GLMMs) with binomial error structure were used to investigate the influence of explanatory variables on a binary response variable (shifting body orientation in the direction of parting, or not) for each observation. Due to the repeated sampling of individuals across observations we included individual ID of both signaller and receiver as random factors in the models, by adding random intercepts models using the package lme4 (Bates et al., 2014).

7.3.2 IO reliability

We assessed inter-observer reliability with a second coder naïve to the hypotheses coding over 10% of the observations. The observations used in inter-observer reliability were taken

at regular intervals throughout the full dataset, to ensure a true cross-section of the data were compared. We considered our data to be collected reliably if the proportions of agreement observed between two observers using Cohen's Kappa (Cohen, 1977) were significantly different from those expected by chance. Cohen's kappa values are considered good if ranging from 0.4 to 0.6 and very good if between 0.6 and 0.8 (Watkins and Pacheco, 2000). Inter-observer reliability was deemed at least good for all variables, all measures produced similarity that was significantly more than would be expected by chance.

Table 7.3: Description of the predictors across all hypotheses.

Hypothesis	**Predictors**	**Description**
Indicate imminent separation	Leave-taking does not occur in sudden endings	Interaction is terminated by interruption or disturbance such as another individual breaking up the interaction (human or baboon) by walking through the dyad, or a human driving through the dyad (Yes/No)
	Leave-taking does not occur when receiver follows signaller	Receiver moves away (> 1m) in the same direction as the signaller moved, within 30 seconds of signaller's departure (Yes/No)
	Leave-taking occurs alongside submissive or "breaking contact" behaviours	Behaviour before separation involves breaking contact: stopping contact (Yes/No), dropping eye contact (Yes/No), or presenting (Yes/No)
	Leave-taking does not occur when there is consecutive social interaction	The same individuals interact again within 2 minutes of separation (Yes/No)
Social regulation	Leave-taking occurs after positive social interaction	Social interaction is positive, grooming, copulating, or inspecting, and does not involve fighting, threat display, or

		threatening behaviour such as infant snatching (Yes/No)
	Leave-taking is associated with the dyad type	Sex pairing of the dyad interacting where the first sex is the focal individual who is first to leave/ potential signaller. (1) male-male, 2) male-female, 3) female-male and 4) female-female)
Risk management	Leave-taking occurs more often after aggressive or threat behaviour	Social interaction involves fighting, threat display, or threatening behaviour such as infant snatching (Yes/No)
	Leave-taking occurs more often around valuable resources	The social interaction involves human food items, infants, or swelling female (Yes/No)
	Leave-taking reflects submissive or "breaking contact" behaviours	Behaviour before separation involves breaking contact: stopping contact (Yes/No), dropping eye contact (Yes/No) or presenting (Yes/No)

For the separation indication hypothesis, we included leave-taking occurring outside of sudden, unexpected endings as a predictor. This is because in previous work (Baehren, 2022) it has been suggested that if leave-taking relates to the decision to separate, it should not occur when the separation is not planned. We also included leave-taking not occurring when the receiver follows the signaller, as in other work (Lockard, 1980; Baehren and Carvalho, 2022) it has been suggested that moving in the same direction after separation is not true leave-taking. This is also the case for the other predictor we included, that leave-taking should not occur when the same dyad has a consecutive social interaction. We then included leave-taking including submissive or breaking contact behaviours as a predictor, as previous work has suggested that infants' earliest ways of ending interactions involve signals that "break contact" with the caregiver, which emulate separating behaviours as they literally "break away" (Eibl-Eibesfeldt, 1970).

For the social regulation hypothesis, we included two predictors. We did not include whether the interaction involved affiliative behaviour such as grooming or playing, as behaviours known to increase social bonding (Cheney et al., 2010), since almost all our social interactions involved such behaviours. Instead, we included whether it also included some aggressive or threatening behaviour, in our sample, most frequently infant snatching, since this could reflect a breakdown of the affiliative nature of the interaction, and as a form of reproductive competition (Maestripieri, 1993). This assumption is supported by the fact that infant snatching is associated with distress and even injury of the infant (Silk et al., 1981), and by evidence that this occurs more often in pregnant or mothers who have recently given birth (Wasser and Barash, 1981). Ending the interaction in such instances could act to protect a mother's own infant, while maintaining the relationship with other adult females. We also included the dyad type, as the dyad sex dynamic could be a social influence that differentially affects affiliative behaviour, especially if relating to dominance or reproductive opportunities. Previous research on human leave-taking suggests that sex is an important factor in determining presence or type of leave-taking (Goffman, 1971).

For the risk management hypothesis, we included whether the interaction included aggressive or threat behaviours as a predictor. This hypothesis would expect that leave-taking could be a way to mitigate the risk of aggressive behaviours, or threat of them, and as such could appease relationships following such aggressive encounters. In addition to this we included the presence of valuable resources as a predictor, as previous research suggests that greeting behaviours could act in this context to minimise competition (Aureli et al., 2008) and leave-taking similarly could act to manage relationships in resource-risky environments. We also included the breaking contact behaviours, reflecting the "risk" (Firth, 1972) or "threat" (Murray, 1980) of separation.

We first calculated Cook's distances to look for influential observations that could affect the models (Nieuwenhuis, Grotenhuis and Pelzer, 2012). Looking at the association with orientation, we identified only one potentially influential observation, however we decided not to remove it as all assumptions were satisfied with its inclusion. We then checked for collinearity between the variables (maximum VIF= 1.2). Since these assumptions were satisfied, we deemed the models suitable for analysis and decided to run and interpret all observations to obtain first insights into the function of this important, yet understudied, behaviour.

Following the process used by Mercier et al., (2017), we used Akaike's information criterion corrected for small sample size (AICc; Burnham et al., 2011) to rank our models according to how likely they were based on our data (Duboscq, Romano, Sueur & MacIntosh, 2016). We considered the model having the smallest AICc value as the one that best explains our dataset, with all other models with increasing AICc score explaining our data less well. AICc values balance the better fit of more predictors in a model, with their increasing complexity by including a penalty term for more predictors in a model (Anderson, 2008). If two models have the same fit but one has less predictors, it would thus be the one with less predictors that would be ranked better and have a smaller AICc. the less complex model will be ranked better (Mercier et al., 2017). In the current method, the models are ranked relative to one another, and so as such, the best model is the best relative to the other models used.

For each model, we used generalised linear mixed models (GLMM; Baayen et al., 2008) fitted with a binomial structure and logit-link function. We used whether we observed leave-taking within a dyad as the response variable, but for ease of discussion, we refer to it as whether the leaving individual shifted orientation towards the direction of parting within the

three-minute window (Yes = 1/No = 0). We entered leaving and remaining identity as random intercepts to control for repeated measurements.

7.4 Results

We analysed 216 observations of dyadic social encounters to examine the general pattern of baboon leave-taking behaviour A likelihood ratio test revealed a significant difference between the full and null models (χ^2= 25.878, P = 0.0005296), suggesting that our full model was much more informative than the corresponding null model. This full model included all predictor variables used across our three non-competing hypotheses, and results are outlined in Table 7.4 below.

Table 7.4: Results of the GLMM testing predictors that may affect orientation at the end of social separation. ***** Denotes statistically significant values (*p*-value < 0.05).

	Estimate	**SE**	**Z**	**CI**	**P**
Intercept	-0.5883593	0.5346378	-1.100	-1.6362301260 to 0.459511429	0.271122
Follow	-1.0274390	0.4236211	-2.425	-1.8577211633 to -0.197156823	**0.015293***
Sudden ending	0.8190902	1.1926043	0.687	-1.5183712187 to 3.156551573	0.492204
Valuable resource	-0.4513785	0.3452477	-1.307	-1.1280514515 to 0.225294476	0.191075
Breaking contact	0.4976459	0.2983107	1.668	-0.0870324183 to 1.082324143	0.095273

Dyad type	0.0490086	0.1738220	-0.282	-0.3896935554 to 0.291676262	0.777984
Consecutive interaction	0.3959768	0.5145107	0.770	-0.6124456198 to 1.404399141	0.441526
Duration	0.0004527	0.0004531	0.999	-0.0004353816 to 0.001340851	0.317732
Threat behaviour	1.0910605	0.3146677	3.467	0.4743230385 to 1.707797934	**0.000526***

We then visually explored the dataset using the R package ggplot2 (Wickham, 2016), comparing body orientation presence to each of the predictor variables (Figure 7.1). This provided an overview of the relationship between our variables of interest.

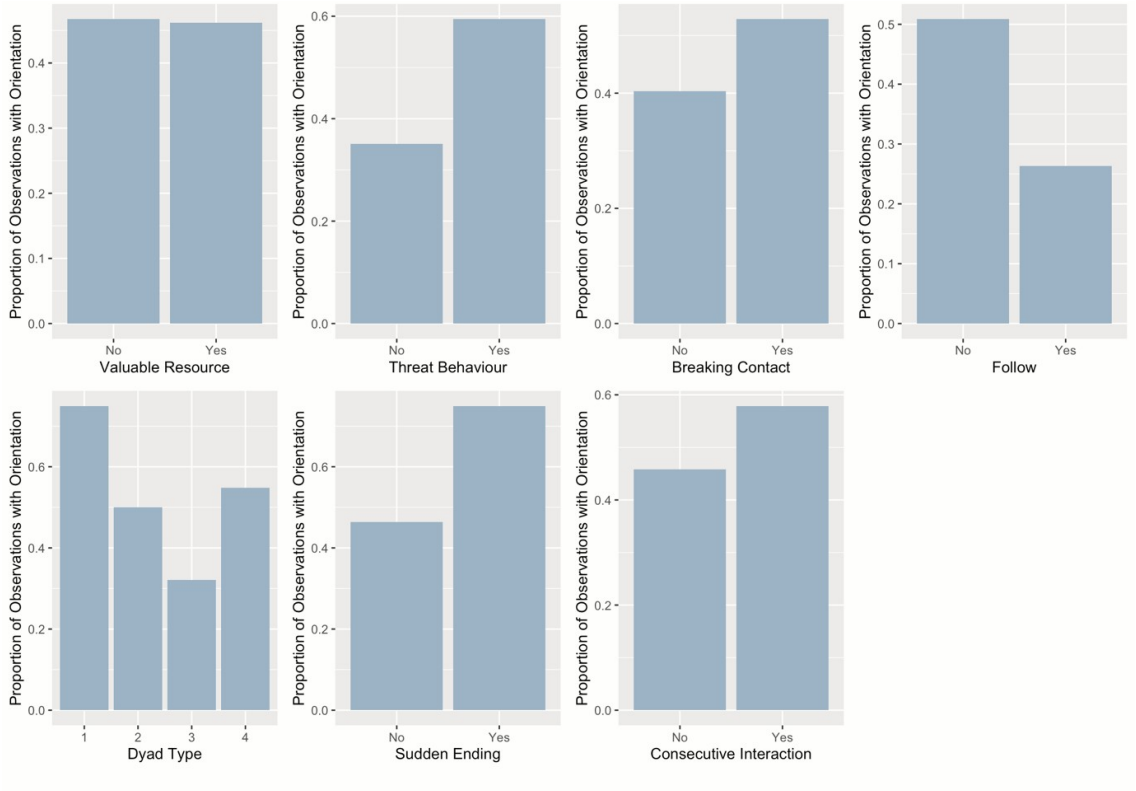


Figure 7.1: Probability of leave-taking based on each predictor variable value. Dyad type: (1) male-male, 2) male-female, 3) female-male and 4) female-female).

We next compare three hypotheses of leave-taking function: signalling separation, increasing social affiliation, and risk management. These are all non-competing and non-exclusive models that are tested and ranked. We analysed the 216 dyadic social interactions for each model representing the three hypotheses. The model comparison is summarised in Table 7.4 below, and the detailed models are presented below in Tables 7.5-7.8 in the Appendices.

Table 7.5: Results of multimodel inference ranking the three functional hypotheses.

Model	**K**	**AIC**	**ΔAICc**	**Weight**
Risk management	4	292.5	-	0.720
Social regulation	3	294.5	2.06	0.257
Separation	5	299.3	6.83	0.024

The three models represent the three hypotheses about the functions of baboon leave-taking. We sorted models by their AICc scores. K = number of terms included; AICc = Akaike's information criterion corrected for small sample size; ΔAICc = difference in AICc scores between the model with the lowest AICc and the following one; weight = model probabilities.

The comparison of the model weights in Table 7.4 between the three hypotheses provides greatest support for the risk management hypothesis. The risk model included whether leave-taking occurred after aggressive behaviour, around valuable resources, or included "breaking contact" behaviours. This had the highest model probability (0.72) of being the best model among those we compared. The other two models we tested, social regulation and separation, had very low probability, having only 0.28 probability between them. Results suggest that, amongst our three hypotheses, baboon leave-taking most likely serves to manage ends of social interactions where there is some level of risk, either threat from the conspecific or competition for resources. There is no set threshold for these models; indeed, the method is only intended to rank hypotheses in order of likelihood, given the available data. We can thus confidently say that risk management is the best supported model in our framework.

7.5 Discussion

Evidence of leave-taking has previously been found in wild chacma baboons, who demonstrate body shifting orientation towards the direction of parting at the end of social interactions (Chapter 4). Although this behaviour fulfils several criteria of intentional behaviour (Chapter 5), the function of leave-taking had never been empirically explored.

Overall, our results support the risk management hypothesis for chacma baboon leave-taking. This suggests that orientation shifting in the direction of parting is used primarily to manage competition for food, infants, or receptive mates and is also reflected in submissive or

"breaking contact" behaviours. Managing relationships in this way, instead of aggressive behaviour, conserves energy and is less costly, and contrasts more elaborate greeting behaviours e.g. those seen in Guinea baboons (Kalbitzer et al., 2015). As such, future research should focus on exploring leave-taking in other species of baboon, such as Guinea baboons, who might be expected to have more elaborate leave-taking behaviours which are more positive in nature and function instead to assess relationship quality and party membership (Dal Pesco and Fischer, 2020).

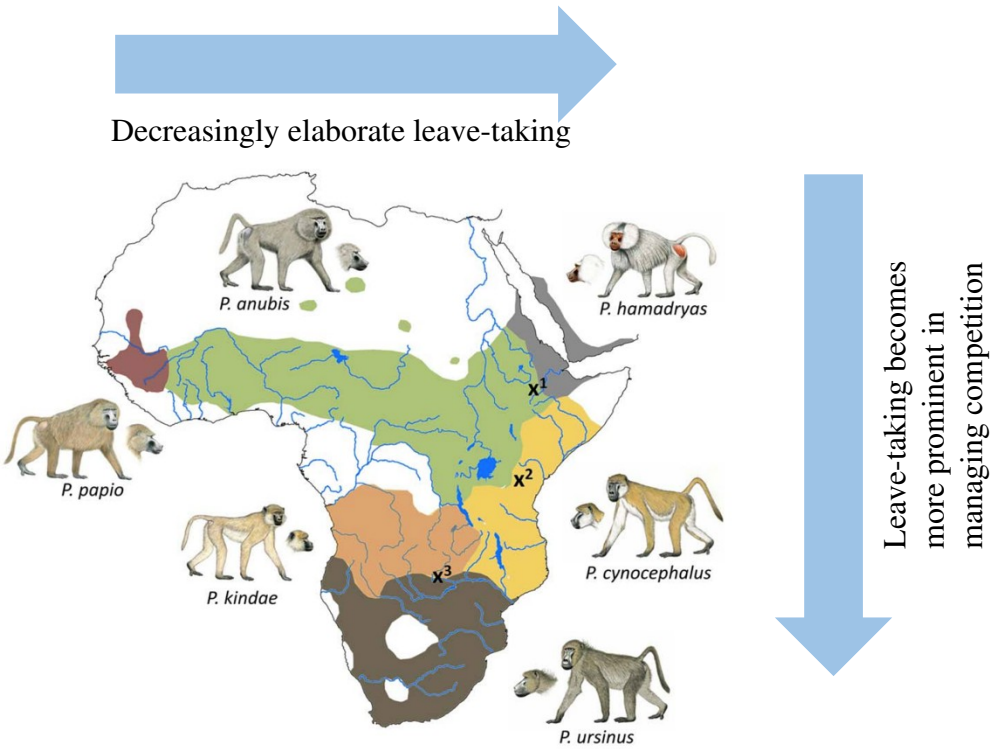


Figure 7.2: Adapted from Figure 3.1A from Rogers et al., 2019- Prediction of leave-taking form (elaborateness) and function (prominence in managing competition) across baboon species.

In the present study, swelling females, infants, and human food stuffs were all defined as valuable resources, and it should be considered that shifting orientation could also reflect protecting such valuable resources, not necessarily leave-taking. However, this behaviour did also occur in 47% of cases where there was no valuable resource, which suggests that it is not just a practicality of defending such resources but could involve managing other risk as reflected by the submissive or breaking contact behaviours. As these results were the product of a hypothesis ranking analysis, it is very possible that leave-taking serves multiple functions; the most likely from our predictor variables is to manage risk associated with social interactions.

The association of "breaking contact" behaviours with leave-taking, e.g. ending physical contact and averting gaze, supports a substantial literature on attachment and separation. Bowlby (1969) states that attachment behaviours are activated when proximity is threatened, for example, by separation. As infant survival depends on proximity to the caregiver, behaviours such as crying acts to alert the caregiver about the risk of separation. Although separation does not generally threaten survival post-infancy, some of these behaviours could remain to maintain close relationships. The fact that many behaviours in children reflect the

desire to maintain such closeness (e.g. holding out arms, reaching up to caregivers) could reflect this (Baehren, 2022). Particularly interesting in relation to our risk management hypothesis is the literature on the Violence Inhibition Mechanism (VIM), which suggests that there are universal appeasement behaviours that reduce the risk of aggression or even end aggressive attacks from other individuals (Lorenz, 1963). Murray (1980) and Camras (1977) have argued that infants and young children use distress signals to inhibit aggressive behaviour e.g. turning of the head, bowing, are submissive as they expose vulnerable parts of the body to the conspecific (Lorenz, 1963). Similarly, behaviours such as dropping physical or eye contact are argued to provide threat to breaking off contact Eibl-Eibesfeldt, 1970), which provides additional support to the idea of "risk of separation".

We found little support for the alternative two hypotheses, social regulation, and separation indication. Although leave-taking is considered "norm bound" in humans, it seems that many chacma baboon interactions do not need to be concluded with a leave-taking behaviour. Our ability to explore social regulation with regards to social bonding was limited by the fact that social bond measures (e.g. Elo-ratings) could not be gathered for this population, which would have provided stronger data for a hypothesis more focused on social bonding. Nonetheless, data on threat behaviour and dyad composition showed little relationship with orientation shifting. With regards to separation indication, this could be more prominent at higher levels of separation e.g. at the sub-group or larger-group scale (Baehren, 2022). This reinforces the idea that levels of separation should be considered alongside the social system to make predictions about leave-taking.

Our findings are consistent with previous research demonstrating that greeting in chacma baboons can reduce tension and avoid conflict (Faruat et al., 2019; Dal Pesco and Fischer, 2020). This is an interesting parallel and contradicts previous suggestions that greeting, and leave-taking could serve different functions (McGrew and Baehren, 2016). Instead, this raises the possibility that these two behaviours are indeed "bookmarks of interaction" (Adato, 1975) and could be driven by similar needs to manage the risks of interaction when living in social groups (Lehmann et al., 2007). Further research is needed to explore how closely greeting and leave-taking align across species, and whether this can be predicted by the varying costs and benefits of group living (Kappeler and van Schaik, 2002).

Our results should be taken as a starting point to prompt further investigation of leave-taking function across other baboon populations, and indeed other non-human primate species. Comparisons of leave-taking function would be important to investigate in baboon species with differing social structure, tolerance levels, and patterns of greeting behaviour.

Chapter 8: General Discussion

This thesis investigates leave-taking behaviour in wild chacma baboons (*Papio ursinus*), placing it in an evolutionary context. Previous literature on leave-taking is sparse, especially when considering non-human species and evolutionary perspectives are almost entirely unconsidered (McGrew and Baehren, 2016). Given the wealth of knowledge on greeting behaviour, this lacunae in leave-taking behaviour remains surprising and has been thought to reflect negative feelings towards endings, or a difficulty in the practicalities of studying them. As such, methods for studying leave-taking were not well established and indeed even definitions of the behaviour itself vary hugely across publications (Chapter 1). This is also reflected in the disparate nature of the literature itself, which spans several disciplines but with little reference to existing, historical literature (Chapter 2). As such, this thesis contributes to three main areas of leave-taking research: methodological understanding, understanding of proximate drivers, and understanding of ultimate drivers. This discussion will summarise and contextualise the intersection each chapters' results across each of the three themes.

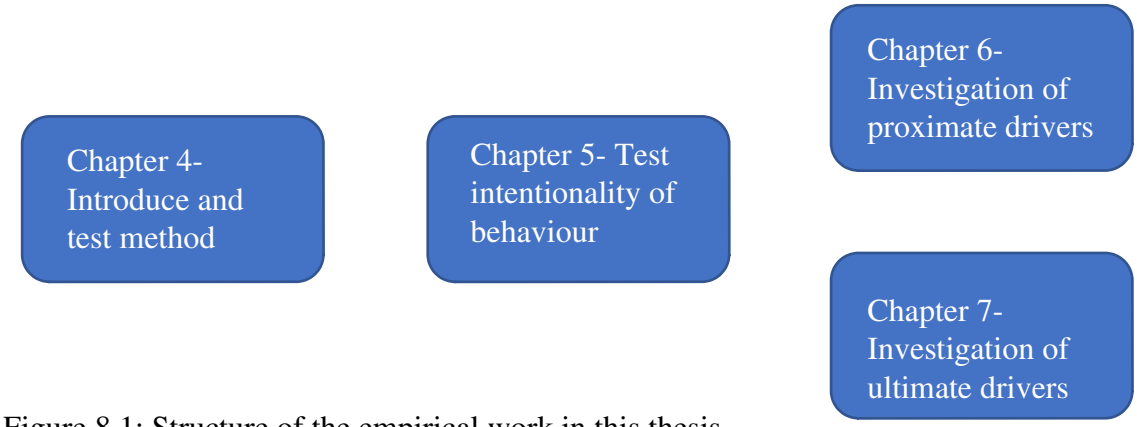


Figure 8.1: Structure of the empirical work in this thesis.

8.1 Methodological understanding

We established in Chapter 2 that the relatively small leave-taking literature that does exist is disjointed and risks "reinventing the wheel" each time the subject is addressed. The methods underpinning this thesis are inspired by historical literature; a main aim of the project was to develop and integrate those ideas which had already been established into a single cohesive framework. We illustrate this here using an updated Citation network from Chapter 2 using the R package igraph (Csardi and Nepusz, 2019), adding in Chapter 1 (Baehren, 2022) as reference 30 and highlighting its connectivity to existing literature. All references are connected to 30, except reference 7, Blurton-Jones and Leach as this had significant overlap with the other papers e.g., 26. Chapters 4, 5, 6, and 7 continue to add to this novel definition of leave-taking.

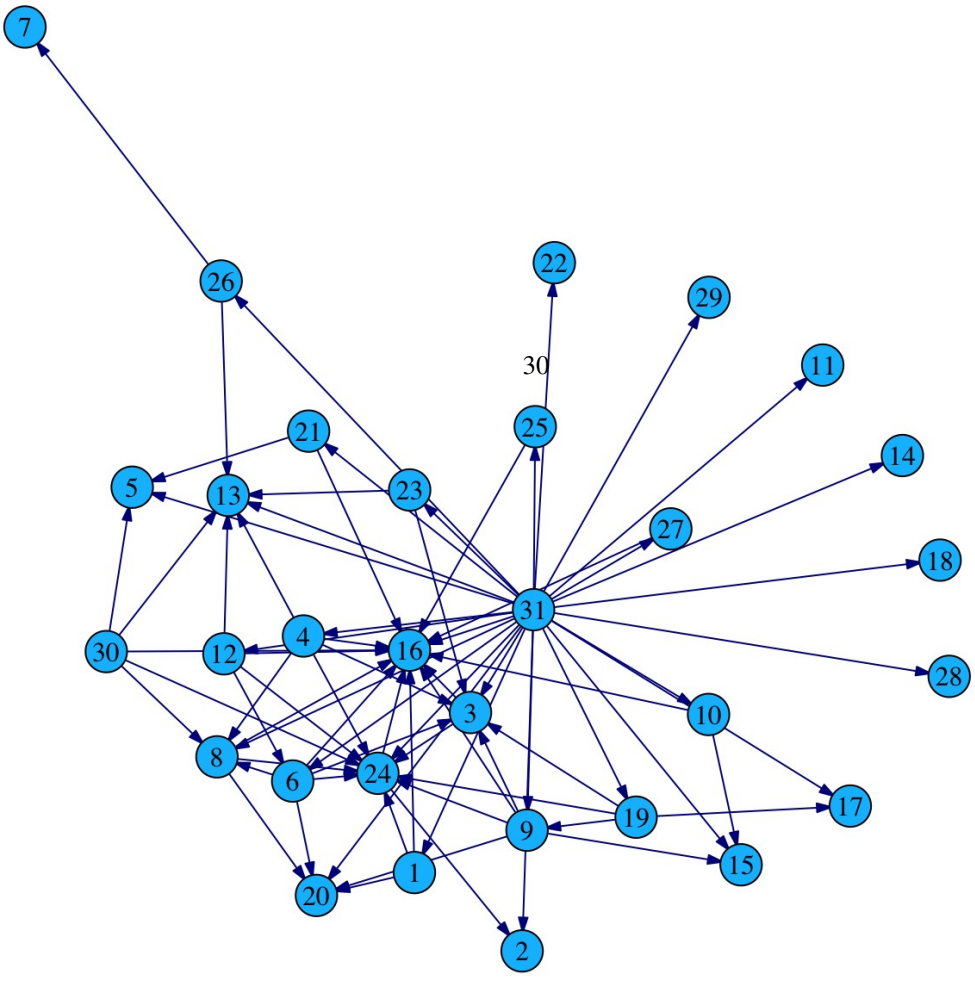


Figure 8.2: Citation network adapted from Chapter 2, adding in Baehren (2022) as reference 30 (highlighted in orange).

Chapter 3 introduces the animal behaviour approach: creating an ethogram, conducting fieldwork, and recording and measuring behaviour. This work is largely inspired by pioneers in animal behaviour and ethology, such as Kessler (1980) and Martin and Bateson (2021) and allowed data to be collected reliably and consistently in order to conduct the empirical analysis. We used well established protocols to conduct this research, for example, using electronic data collection to improve accuracy and allow inter-observer reliability with the software BORIS. Albert and Kessler famously predicted that research on leave-taking would be able to "take off" once technology had sufficiently improved to allow the fleeting and often unnoticeable behaviours to be recorded. We can confidently say that this project uses established methods in animal behaviour and technological data collection to fulfil this prediction.

However, the application of leave-taking to non-human species is new territory. Therefore, our approach was integrated with an idea inspired by the work of Grafanhein et al., (2009), where leave-taking in young children was measured using a social vs non-social control. We measured candidate leave-taking behaviours in social interaction departures, alongside departures from close proximity (non-social) activities, and solo activity departures. The results of Chapter 4 show that shifting orientation in the direction of parting occurs significantly in social separation, compared to the asocial control conditions. These results give support to our definition of leave-taking as a *behaviour occurring before social separation* from Chapter 1. Furthermore, it is the first evidence of leave-taking in a wild

population of a non-human species and challenges previously held assumptions that leave-taking is a uniquely human behaviour (McGrew and Baehren, 2016). As such, we are confident that this approach is a useful method for applying to other non-human species in expanding our knowledge of leave-taking.

We also demonstrated, in Chapter 5, that leave-taking fulfils some of the criteria of intentionality previously used in other areas of study. Specifically, audience presence and audience response were significantly associated with the presence of shifting orientation. Other criteria of intentionality were not supported by our data, giving a mixed picture of the intentionality behind chacma baboon leave-taking. Nonetheless, this study demonstrated that leave-taking could be used in a way that is sensitive to the type of recipient and the impact of the behaviour. We also suggest in this chapter that intentionality criteria are revisited in light of their relevance to separation contexts.

Another key methodological contribution of this thesis was the creation of "levels of separation" (Chapter 1), outlining a way of conceptualising separation. Low levels of separation can be thought of as those which are temporary and of more regular occurrence, whereas high-level separation can be thought of as those which are long-term or even permanent and happen less frequently. We also extend this idea to a third factor: the *unit* of separation, as seen in Figure 8.3. Using the R package scatterplot3d (Ligges and Mächler, 2003), we visualise separations in terms of their frequency, distance/duration, and unit in 3D space: the dimensions of separation. In the example below (Figure 8.3) the numbers and colours are arbitrary but can be used to generate various hypotheses. For example, a long distance, long duration, but small unit separation would be represented by the yellow colour

(250, 250, 0) such as the likely permanent separation of a male orangutan offspring and its mother. As distance and duration are likely to correlate, the red colour would be less likely, but could represent "virtual" interactions e.g. phone calls or even letter writing, where the distance is great, but the duration of separation could be shorter. The smallest unit on each axis (around 0, 0, 0) and represented by darker green, is the closest to what we see in the baboon separations of the current thesis. These separations are short distance, short duration, and small unit (dyad). Somewhere in the middle, the bright pink colour, are those separations of medium unit for some extended but not prolonged duration and of some distance. These could represent typical fission-fusion separations such as chimpanzee subgrouping patterns.

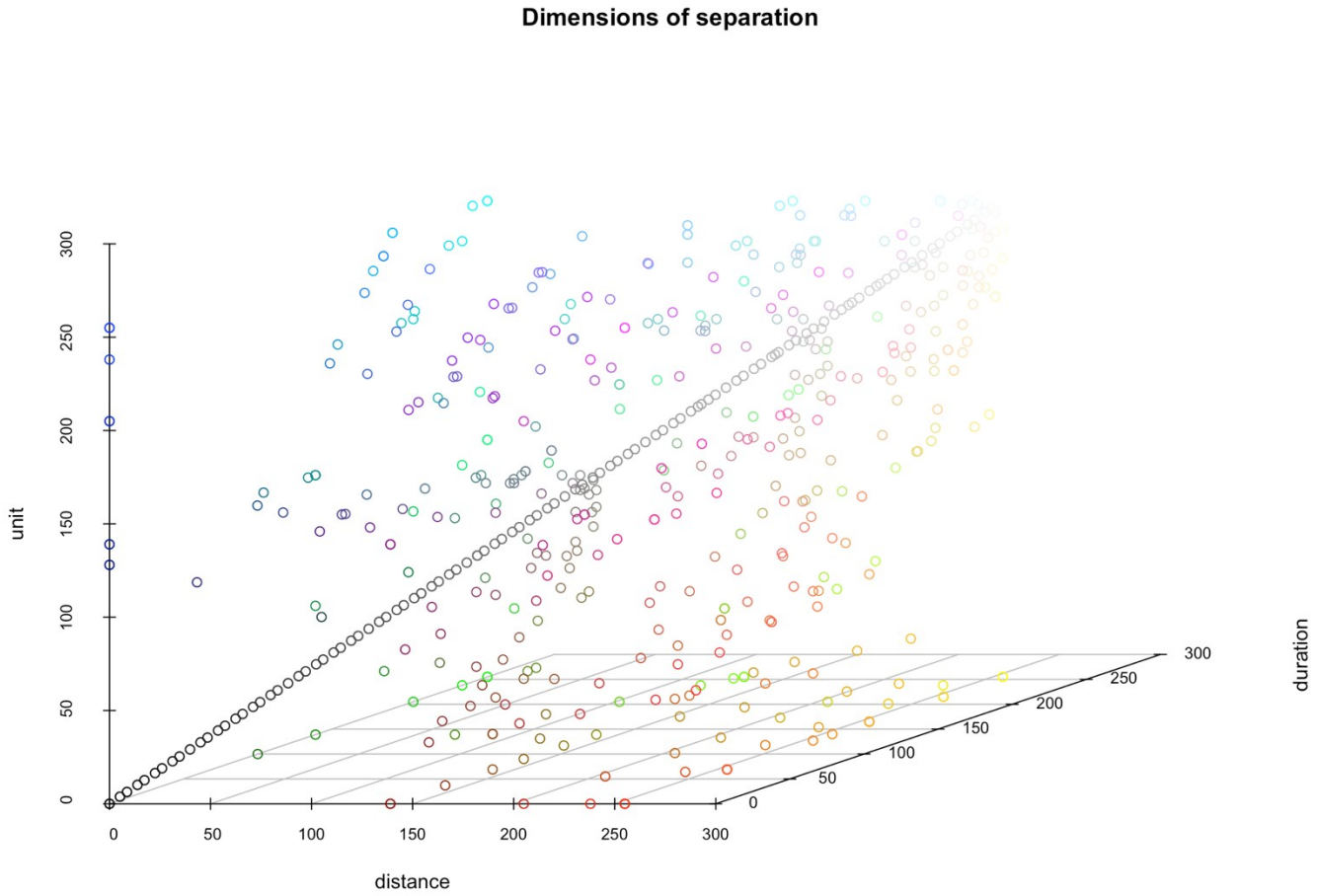


Figure 8.3: Dimensions of separation: gradients of separation across unit, distance, and duration.

We may expect these to parallel with one another, small units of separation (e.g. dyad level) to occur more frequently and for shorter distance/ duration, whereas larger units of separation (e.g. whole group) may occur infrequently and for long duration. Further research is needed into how these factors relate to one another, for example through investigation of wild chimpanzee separation as a fission-fusion species across different units of separation. It should also be investigated as to how leave-taking itself reflects these 3 axes of separation. This research focused on baboons, as they have the strong social bonds and communicative behaviours, whilst being a cohesive species, relative to chimpanzees. This allowed us to investigate leave-taking in a group which has low-level separations: ongoing social interactions which occur frequently, separation is short-term, and the unit is small. Measuring these three axes and placing species, or populations, accordingly on it, would be revealing for our understanding of the relationship between separation and leave-taking.

8.2 Understanding of proximate drivers

As outlined in Chapter 2, proximate drivers have been the focus of empirical leave-taking research in humans. This could be because the disciplinary focus has been mainly psychological (Chapter 1), where the research aims tend to be more concerned with short-term driver behaviour. Although this has received the most attention, the application to non-human species is still lacking. There is very little understanding of the proximate drivers of leave-taking in animal science, not least because it is assumed to not exist. The most promising investigation is that of Heesen et al., (2021) who determine ceasing all bodily

movement as a factor driving leave-taking in captive chimpanzees. This is a fascinating insight into behaviours at separation, though without controlling for non-social endings, it is difficult to conclude whether these can be considered proximate drivers of leave-taking (i.e., social separation), or rather, behaviours occurring before any activity end.

An understanding of proximate drivers can be gleaned from Chapter 4, Chapter 5 and Chapter 6. As summarised above, Chapter 4 concluded that social separation itself was a driver of leave-taking behaviour, and by extension, the social context of grooming. This supports our basic assumption that leave-taking is necessitated by the social condition coming to a close. In human literature this is considered norm bound e.g. leave-taking in non-social conditions would violate the normative nature of the behaviour (Goffman, 1974). The significance of social condition as a proximate driver in chacma baboons suggests that this could be the case in non-human species too, though other features of ritualised behaviour have yet to be explored.

Chapter 6 extended this idea to look more specifically at the motivations to end social interactions, inspired by the landmark paper from Albert and Kessler (1978). The findings from this chapter are illuminating, both internal motivations to end interactions drove shifting orientation more than external motivations. This highlights the relevance of Albert and Kessler's (1976) framework for understanding interactions ends in species beyond humans, whilst supporting the idea that there is a human distinction of internal and external motivations to end, which is not apparent in baboons. The reasons for this remain unexplored but could be related to the human ability to refer to the "real" and "perceived" reasons for ending. It also suggests continuity with human and baboon communication in relating to the

internal motivations to end and suggests that this proximate driver has a deep evolutionary history.

Chapter 5 revealed that female-leaving-male dyads were significantly associated with the production of leave-taking behaviour. Consistent with literature on human leave-taking, this indicates that social dynamic plays an important role in its expression. In humans, leave-taking is seen to vary based on relative dominance, sex, kin, friendship closeness and cultural politeness etiquette (Rababah and Malkawi, 2012). In the present thesis, dominance rank and relationships were not able to be established, but the significant relationship between sex-dyads and leave-taking is poignant in highlighting that these avenues should be further explored in non-human species.

8.3 Understanding of ultimate drivers

Chapter 7 considers the ultimate drivers of leave-taking, that is, the evolutionary function. Using an information theory approach, our data shows that risk management was by far the best supported hypothesis, compared to social bonding and separation management. This suggests that the main function of leave-taking in chacma baboons is to navigate the endings of socially tense situations e.g. surrounding high value food items, swelling females, or infants. Coupled with results from Chapter 5 indicating that female-leaving-male dyads have the most significantly pronounced leave-taking, this could relate to the "friendships" of male and females and the risk associated with male dispersal in female philopatric species. Function of leave-taking should be explored across baboon sub-species in order to determine how patterns of dispersal and male-female friendships impact leave-taking.

One limitation of the dataset was the lack of Elo-ratings or social bonding measures. It would be important to build on this study when relationships and relative dominance are known in order to test the social bonding hypothesis further. Although in humans, leave-taking is seen as elaborate in close friends, supporting the social bonding hypothesis (Firth, 1971), leave-taking is also discussed in relation to risky situations e.g. where there is pronounced hierarchical difference (DuFon, 2010) or specific politeness etiquette that must be adhered to (Rababah and Malkawi, 2012; Laver, 1981). Our results suggest that leave-taking could have a deep evolutionary origin that has an ancient function to manage risk. Perhaps this behaviour is an exaptation, from a social bonding mechanism, to expand its function in humans across the social domain.

It is important that dimensions of separation (Figure 7.3) are considered in future applications of our method to other non-human species. We expect that the function of leave-taking could differ based on those populations who experience greater duration and distance of separation, e.g. chimpanzee separation. Similarly, populations that have greater cohesivity, e.g. many species of fish who live in schools, would not be expected to express leave-taking. Across the 3D space constructed from our axes of unit, duration, and distance, leave-taking may differ in both form and function to account for its variable use.

8.4 Limitations

This thesis is the result of a project that was greatly impacted by both the 2019 Cylone Idai hitting Mozambique, and the COVID-19 pandemic from 2020 to 2022 that caused global disruption. The original project was designed to include more data from the Chitengo troop of baboons in Gorongosa National Park in late 2019 and 2020 which was not possible due to

travel restrictions. This meant that the troop was not fully identified by the end of the fieldwork period and also that further sampling techniques and data collection of other variables e.g. kinship was not possible. Furthermore, the original goal was to compare the results of baboon leave-taking with those of human populations; something I had arranged to do in the Senkenberg Archives in Germany in April of 2020. This was also not possible due to COVID-19 travel restrictions and by the summer of 2020 I decided to redesign the remaining empirical chapters to prevent a further loss of progress.

Other data on the study population, such as kin relations and social bonds, would have helped us to explore further questions of the sociality of this behaviour. As ever, a large sample size of video footage and the data itself would help us to test our hypotheses across greater time scale and contexts. The anthropogenic nature of the Chitengo Camp, within the habitat of Gorongosa National Park, while providing benefits such as close-range footage of behaviour and an easily accessible population, also raises uncertainty about the species-wide applicability of the results. Would leave-taking behaviours converge in such an environment regardless of species? Our methods and results should be interpreted as a starting point to expand the study of leave-taking across other populations.

8.5 Conclusions

This thesis presents the first evidence of leave-taking in a wild non-human species, and the first empirical test using controls of leave-taking beyond humans, on a population of chacma baboons in Gorongosa National Park, Mozambique. The research expands efforts to understand intentionality in animals by applying previously established methods to our data on leave-taking, concluding that chacma baboon leave-taking has some of the key features of

intentionality. This thesis then goes on to take a novel approach to animal studies by adapting Albert and Kessler's (1976) framework for understanding humans interaction ends to those of non-humans. This application highlighted the importance of looking at interaction ends themselves when considering leave-taking, and also provided the first evidence that non-human interactions are driven by both internal and external motivations, which furthermore relate to leave-taking itself. This thesis concluded with an investigation into the function of leave-taking, where the data was best explained by the risk management hypothesis.

Future investigations into leave-taking should aim to apply the framework established in this thesis to other non-human species, comparing their positions on the dimensions of separation with the production and expression of leave-taking behaviours, e.g. *how does extent of distance and duration of separation impact leave-taking? How does unit of separation impact leave-taking?* The same framework should also be applied across human cultures, improving the cross-cultural empirical research into this field in order to understand the variation in behaviour, e.g. *What are the measurable differences in human leave-taking across cultures? How do the proximate and ultimate drivers of leave-taking differ across cultures?* The developmental aspect of leave-taking is also important to consider, e.g. *Does leave-taking emerge at the same age across cultures? Is leave-taking behaviour transmitted via social learning? Does social learning account for the cultural variation we see in humans?* On the same lines, cultural variation within non-human species should also be investigated, e.g. *Do baboon species express leave-taking differently? Is there cultural similarity between neighbouring groups?* Here we provide a framework and an example of its application, which paves the way for a new area of study in the quantifying of leave-taking research.

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Appendices

Appendix 1: Published version of Chapter 1

Humanities & Social Sciences Communications

REVIEW ARTICLE

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Saying "goodbye" to the conundrum of leave-taking: a cross-disciplinary review

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Leave-taking behaviours habitually occur before separation from social interaction in most human societies. It is thought to be a human universal, providing ritual brackets around interaction. Despite Knapp's claim that leave-taking can tell us a good deal about human interaction, the topic remains critically overlooked from an evolutionary perspective. Cross-species data on leave-taking would be key to unveiling its evolutionary history and its role in sociality, but studies focusing on non-human species are rare. Here, leave-taking is reviewed using an evolutionary approach, pitting it against its symmetrical counterpart, greeting, and emphasising the lacunae in research on leave-taking. It is argued that leave-taking is overdue for serious, empirical attention regarding the ways in which leave-taking could contribute to understanding social evolution. Finally, methods are outlined to operationalise the study of leave-taking and propose the use of "levels of separation" to allow comparison of human and non-human species and to expand research efforts.

Greeting and leave-taking: bookends of interaction?

As widely recurrent features of the human ritual repertoire (Adato, 1975), greeting and leave-taking have been considered "bookends of human interaction" (Eibl-Eibesfeldt, 1971). Despite the scientific literature considering these phenomena in parallel, greeting is well-studied across human and non-human species, while studies of leave-taking are rarely empirical and almost non-existent for non-human species.

Greeting occurs when individuals are about to have increased access to other individuals and is claimed to be a universal across all human societies (Duranti, 1997; Goffman, 1971), as well as being present in many animal species including primates (Okamoto et al., 2001), cetaceans (Rendell and Whitehead, 2001), birds (Danchin, 1987) and fish (Sogabe and Yanagisawa, 2007). Although cross-cultural studies are limited, both greeting and leave-taking appear to show variation in form, e.g., how much the positive or emotional aspect of greeting is emphasised, and the relative importance of verbal and non-verbal greetings (Firth, 1972).

Despite the assumption that greeting and leave-taking should be considered in unison (Eibl-Eibesfeldt, 1971; Goffman, 1971), there seems little theoretical reason that this should be the case. Besides the positioning on either side of interaction, the two are likely to require different cognitive abilities (McGrew and Baehren, 2016). Factors such as age, sex, status and context may influence greeting behaviour (Rababah and Malkawi, 2012) and leave-taking (Goffman, 1971; Knapp et al., 1973; Akindele, 2007) but they are likely "socially charged" in different ways; serving different social functions (McGrew and Baehren, 2016). For instance, greeting by

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definition occurs at the beginning of an interaction, and thus the behaviours and associated functions set the stage for the anticipated interaction, e.g., mediating aggression (Okamoto et al., 2001), increasing group cohesion (Aureli and Schaffner, 2007) and encouraging social bonding (Nishida et al., 1999). On the other hand, leave-taking occurs at the end of the interaction and may have evolved to meet distinct functions such as dismissal, concluding the interaction, or maintaining the relationship throughout separation.

Evidently, there is discrepancy in the research efforts of these two supposedly parallel behaviours when considering non-human primates. Interest in the greeting behaviours of non-human primates is long-standing, presumably because of some striking parallels with human greeting (van Lawick-Goodall, 1968). Some of these behaviours seem to have similar functions, e.g., extending the hand as a gesture of reassurance, or a deep bow and nodding of the head as an act of submission (Simpson, 2009). Greeting is thought to have deep evolutionary roots because it is widespread across human cultures and its occurrence across non-human species includes baboons (Smuts and Watanabe, 1990), spider monkeys (Schaffner and Aureil, 2004), hyenas (Smith et al., 2010), chimpanzees (Laporte and Zuberbühler, 2010), howler monkeys (Dias et al., 2008) and macaques (De Marco et al., 2011). It is unclear whether leave-taking is similarly widespread given the lack of literature (Goffman, 1971); its absence in non-human primates would suggest leave-taking is a more recently derived behaviour in hominins, not paralleling the evolution of greeting (Eibl-Eibesfelt, 1970). The use of primates as models for human evolutionary processes is powerful; they share genetic, physical and social traits with humans (Muller, 2017), including aspects of communication (Seyfarth and Cheney, 2018) and as such can be used to quantitatively test a priori predictions of evolutionary hypotheses. As such, our extant primate relatives may offer crucial insights into processes and timescales on which leave-taking may have evolved. Even if behaviours differ across species, there may be components showing continuity and reflecting evolutionary precursors to leave-taking in humans.

Currently, such cross-cultural and cross-species empirical studies on leave-taking are lacking. Descriptive reports exist (e.g., Rababah and Malkawi, 2012; DuFon, 2010; Akindele, 2007), but there are almost no systematic or quantitative data on how people or non-human species end interactions (Albert and Kessler, 1978; Knapp et al., 1973). This contrast in the richness of scientific literature between greeting and leave-taking is striking (Fig. 1). The apparent recent increase in greeting publications may reflect a general growth in publication rates. However, the contrast of 618 publications concerning greeting, compared to 61 for leave-taking, shows an approximately ten-fold greater relative publishing frequency.

The lack of research on leave-taking is further highlighted when the types of publication are considered. Many of these publications have only brief mentions of leave-taking or short anecdotes, making the number of studies actually concerning leave-taking even fewer (Fig. 2). This distinction between greeting and leave-taking remains stark when disaggregated by discipline (Fig. 3). Disciplines taking an ethological approach have largely ignored leave-taking, despite taking a strong interest in greeting behaviour. Contrastingly, linguistic and ethnographic areas of research have shown more interest in leave-taking, though still minimal compared to studies on greeting behaviour. Part of this discrepancy between fields can be explained by the conclusion that leave-taking does not exist in non-humans, e.g., researchers at ten wild chimpanzee sites reported that each of their sites showed greeting, but none showed leave-taking (McGrew and Baehren, 2016). In addition, we are told that "although many animals have greetings similar to ours in both form and function, an animal version of goodbye is much harder to establish" (Goffman, 1971: p. 79).

For humans and non-human primates, at least part of this discrepancy can be attributed to ritualised greeting behaviours. These contrast with the less elaborate, subtle and in the case of non-humans possibly non-existent, leave-taking behaviours. One example is illustrated by descriptions of greeting and leave-taking in Andaman Islanders (Radcliffe-Brown, 1922), in which reunion of friends or relatives after some period of separation results in a ritualised form of wailing and weeping. In contrast, the behaviour before separation involves one person lifting the hand of the other towards their mouth and gently blowing on it: which is less elaborate than the greeting behaviour. As such, the rationale for conceptualising leave-taking within the bracketing framework no

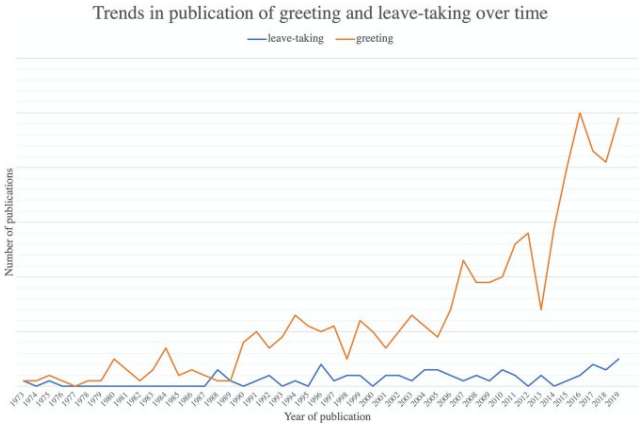


Fig. 1 Trends in publications of greeting and leave-taking. Data extracted from Web of Science using "greet*", and "leave-take*" in selected fields of Anthropology, Behavioural Sciences, Communication, Ecology, Linguistics, Psychology, Biology, Zoology. Text-mining limited to disciplines relating to behaviour and communication ensures including only publications in which these terms are used with the same meaning as defined in this review.

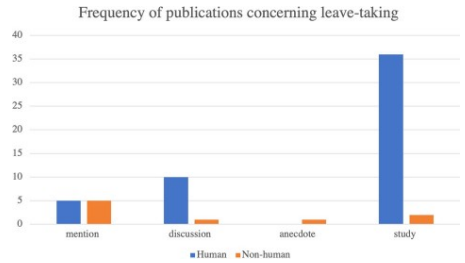


Fig. 2 Frequency of publications concerning leave-taking ($N = 60$). "Mentions" are publications that had one or two sentences about leave-taking. "Discussions" are lengthier texts that focussed heavily on leave-taking. "Anecdotes" briefly mentioned examples of leave-taking, while "studies" contained data, either measuring leave-taking empirically or a qualitative description.

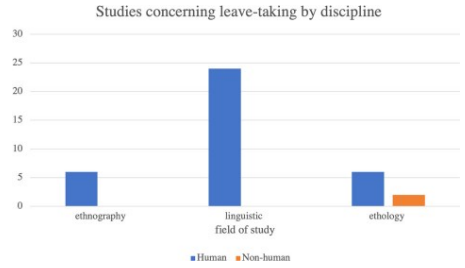


Fig. 3 Frequency of studies by discipline $n = 38$, as a subset of Fig. 2. Some studies ($n = 5$) referenced both humans and non-humans, thus the data points $n = 33$. Studies were classified as ethnographic if they had detailed description of the behaviour, linguistic if they included empirical conversational analysis and language structure, and ethological if they measured behaviour.

longer seems self-evident and it is worthwhile to consider leave-taking in its own right.

Leave-taking may not occur beyond humans: research on other primates, social animals, both wild and captive, yields few and vague reports of leave-taking. Firth (1972: p. 3) suggested that in both human greeting and parting, formal conventions of use of body (posture) and limbs (gesture) play such a major role that "animal parallels easily come to mind", although he gave no examples of such parallels. Similarly, Lockard (1980) suggested that the ethological method used in her earlier study could be extended for cross-species comparisons, where leave-taking could act as a way to signal intention to depart in social animals. However, neither study elaborates on these ideas. Social anthropologists have also attempted to establish an understanding of rituals (Radcliffe-Brown, 1922) and rites (Van Gennep, 2019) that involve separation, although work specifically on leave-taking behaviours is lacking. Although the (purported) absence of leave-taking in non-humans might explain the discrepancy in leave-taking studies between disciplines (e.g., lacking in primatology compared to linguistics) this fails to explain why other human-oriented fields (e.g., anthropology) have paid so little attention to leave-taking.

Several scholars have contributed to the topic of leave-taking, particularly Goffman (1952; 1955; 1967; 1971; 1974), and Kessler (Albert and Kessler, 1976; Albert and Kessler, 1978) but the topic failed to "take off" with other researchers and in other fields. Albert and Kessler (1978) suggested that this paucity of research may be due to the difficulties in studying properties of interpersonal endings, which are often brief and occur at high speed, making them hard to record or experimentally induce. They argued that to study leave-taking researchers need to: (a) be sensitised to fleeting nuances of behaviour; and (b) use technology to create a permanent record, which can be retrospectively examined. We now have such powerful and low-cost technology, but perhaps the short popularity of leave-taking seen in the '70s and '80s faded before these practical solutions became available.

From the literature

Definitions of leave-taking. Research on human leave-taking has received greater attention than it has in its non-human counterparts. Nevertheless, the available research spans several disciplines without attempting to integrate knowledge on the topic and often seems to be considered as an afterthought to greeting, receiving subsidiary attention. Operational definitions of leave-taking vary markedly by field and by variable studied. Linguistic studies use measures such as the final words in spoken exchange, whereas ethological studies include broader non-linguistic definitions, such as the end of a dyadic exchange, or the finishing of an interaction. Additionally, many papers that discuss leave-taking do not include a precise and workable definition, but subjectively refer to endings, partings, leaving, closings, etc. This vagueness has more serious consequences for research as it has led to incongruity in what is considered leave-taking, and a disparate and disjointed literature. Table 1 summarises a selection of definitions extracted from the scientific literature to: (a) illustrate their variety and discrepancies, and (b) aggregate the key values to suggest a universal definition. The definitions are not intended to be exhaustive but give a sense of the variation present.

I used the following key words for the search in *Google Scholar, Search Oxford Libraries Online* and *Web of Science*: "leave-taking", "leaving behaviour" "greeting and parting", "parting behaviour", "farewell(s)". I included publications from different academic disciplines such as anthropology, psychology, animal behaviour, linguistics, but excluded papers relating to other kinds of "taking leave" e.g., parental leave, medical leave, leaving abusive relationships etc. Articles were included only if they presented a clear, novel definition. Although it seems at first that leave-taking is a simple behaviour that should be intuitively understood, the variation in definitions across the literature highlights the challenge in identifying what this behaviour involves.

These definitions differ in crucial ways: (1) several are broad and theoretical, particularly those featuring a general discussion of leave-taking, e.g., Adato (1975), Albert and Kessler (1978), Goffman (1971), but failing to give examples of how to measure behaviour. Contrastingly, (2) other studies use narrow definitions, suitable only in a specific context, such as child–parent separation (e.g., Jones, 1972; Field et al., 1984), "mother-infant parking" (Scheumann et al., 2017), or mourning customs (Van der Hart and Goossens, 1987). While this specificity may help an empirical test in these contexts, the measurable variables (see far-right column of Table 1) vary greatly. I argue for the need to adopt a definition that is both broad enough to allow cross-species comparisons and includes specific variables to be measured to allow for empirical and comparative investigations (e.g., Knapp et al., 1973).

Additionally (3) associating leave-taking with departure, using terms such as "separation", "breaking contact" and "state of decreased access" seems valid, but a crucial distinction (4) is whether or not there is also reference to "routine", "ritual",

Table 1 Original definitions of leave-taking with reference to species and empirical measure used when available ($n = 30$).

Reference	Species	Definition of leave-taking	Empirical Measure
Adato, 1975	Human	"Ritually" required way of departing	Absent
Akindele, 2007	Human	Closing sequence of a conversation	Absent
Albert and Kessler, 1978	Human	Cessation of all verbal and non-verbal communication between two previously interacting individuals	Absent
Ameka, 1999	Human	Events that occur in terminating social encounters	Absent
Berne, 1968	Human	Stereotyped series of simple complementary transactions	Absent
Betholia, 2009	Human	Break in social contact	Absent
Jones and Leach, 1972	Human (children)	Maternal and child patterns of behaviour at separation	Absent
Clark, 1985	Human	Summarise the content of the contact they have just had; justify ending their contact at this time; express pleasure about each other; indicate continuity in their relationship by planning, specifically or vaguely, for future contact; and wish each other well·	Absent
Clark and French, 1981	Human	Reaffirm their acquaintance before breaking contact	Absent
Corsaro, 1979	Human (children)	Withdrawal strategy-ending of an interactive episode	Absent
de Waal and Waal, 2007	Chimpanzee	"Before separated"	Absent
DuFon, 2010	Human	"Occurs at the end of an interaction"	"Words that ask for permission to leave"
Firth, 1972	Human	"Patterned routine which is highly conventionalised" suggestion of parting after an encounter	Absent
Fitch, 1990	Human	Conversational exchange at the end of social gathering	Absent
Gleason and Weintraub, 1976	Human (children)	Last nuclear utterance in a routine	Absent
Goffman, 1971	Human-mentions animal	State of decreased access	Absent
Gräfenhain et al., 2009	Human (children)	Acknowledge their leaving	When child left the main game to play competing game, did they acknowledge their leaving (a) verbally or non-verbally, (b) acknowledged they were now playing a different game only after they had left, (c) whether they instead left without acknowledging
Hassall, 2006	Human	Act intended by the speaker to convey to the hearer that the speaker regards the encounter as at an end	Absent
Heesen et al., 2021	Chimpanzee and bonobo	The exit phase comprises all the coordinative actions necessary to get out of a social encounter once the main business of the encounter has been completed.	The moment all body movements typical of the activity ceased (e.g., movements of the hands on the body of the partner typical for grooming, and wrestling with, tickling or chasing each other for social play) until the moment that at least one partner gazed at the other before or while leaving (and at most after each partner gazed at each other once before or while separating), and if the interaction was not followed by a renewed interaction or attempt to re-engage partner within 2 min.
Hong, 1985	Human	Personal expression of parting	Absent
Knapp et al., 1973	Human	How interpersonal transactions are terminated closing of interaction	"Concluding remarks" "Analysis of non-verbal cues began 45 s prior to the subject's rising from a seated position and continued until the subject had left the interviewing room"
Lockard et al., 1978	Human (discussed in context of other species)	End of a dyadic exchange	45 s to 5 min before departure
McGrew and Baehren, 2016	Human and chimpanzee	Show leave-taking/farewell behaviour when they part after being together	(Purposefully not given)
Rababah and Malkawi, 2012	Human	"Greetings are the general rituals of beginning and finishing an encounter"	Absent

Table 1 (continued)

Reference	Species	Definition of leave-taking	Empirical Measure
Schegloff and Sacks, 1973	Human	Proximate solution to life utterance completion—a terminal exchange composed of conventional parts	Absent
Scheumann and Zimmermann, 2017	Grey mouse lemur	Mother and infant were together at sleep site before mother left the nest	Vocal behaviour 60 sec before a mother leaves the infant in nest
Sukwiwat and Fieg, 1987	Human	Closing of a conversation	Absent
Van der Hart and Goossens, 1987	Human	Ceremony used as a strategy in mourning therapy	Absent
Wang, 2005	Human	Art of saying "goodbye", extracting oneself from a communication event	Point that one of the parties signals his intention to leave to the final termination exchange
Whittaker et al., 1994	Human	Interaction closings	Formal farewells (bye", "see you"). verbal or visual orienting signs (e.g., turning away) given to indicate conversations were about to close: these only occurred on 21 % of occasions.

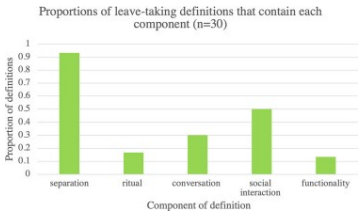


Fig. 4 Proportions of leave-taking definitions that contain each identified component ($n = 30$). Components are not mutually exclusive, e.g., some contain both separation and social interaction components. *Separation* includes the terms departure, ending, or parting; *ritual* includes the terms stereotyped behaviour, pattern or routine; *conversation* includes the terms verbal interaction and spoken word; *social interaction* includes the terms social encounter, exchange, contact; *functionality* includes reference to leave-taking as a strategy or solution to achieve a goal/solve a problem.

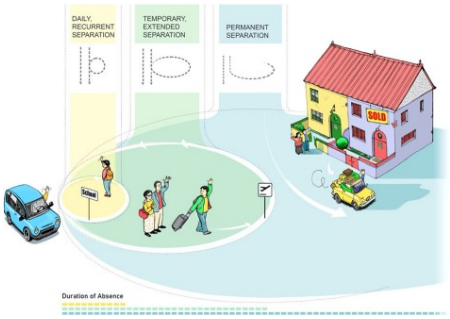


Fig. 5 Levels of separation across different durations of absence. Levels include recurrent separation, extended separation, and permanent separation.

"stereotyped" or "conventionalised" nature of leave-taking; which some see as critical (e.g., Adato, 1975; Firth, 1972; Berne, 1968). Some regard leave-taking as being specific to the end of conversational spoken word (5), which is applicable only in linguistic studies. Other studies (6) refer more generally to termination: "social contact", "dyadic exchange", "ending of an interaction", "encounter", "transaction", "episode". A broader definition beyond spoken language is useful when looking for behavioural comparisons with non-human species, such as Albert and Kessler (1978: p. 541): "By ending, we mean the cessation of all verbal and non-verbal communication between two previously interacting individuals". Finally (7), some definitions refer to functionality in leave-taking: "act intended by the speaker", "regard the encounter at an end", "withdrawal strategy", "proximate solution to utterance completion". Should behaviour be defined in terms of its functionality? What if the cause for leave-taking is opaque, is behaviour at the end of interaction necessarily leave-taking? In studies of animal behaviour (e.g., Horner et al., 2010), it is argued that definitions seek to reduce disagreements about interpretation, and not exclude other interesting, potentially relevant behaviours. One must distinguish the necessary properties of leave-taking from contingent causal properties. Accordingly, I have not included function in my definition of leave-taking as this remains unknown, even for humans where leave-taking occurs. Similarly in greeting studies, the behaviours are identified without necessarily investigating function (e.g., focusing just on the behaviour occuring at the start of a sequence, Kummer, 1968), and from this initiation, function is then investigated (Aureli and Schaffner, 2007).

Of the thirty definitions, only seven included an empirical measure. Twenty-five included a theoretical component. Proportionally, half of the definitions assume that leave-taking is a social behaviour, referring to final behaviours before individuals spatially separate (Fig. 4). I argue that using the aforementioned issues of definition, we should aim to be: (1) broad enough to encompass different behaviours and contexts, but also (2) provide specific empirical measures relevant to the study, (3) should pertain to the separation, (4) have an element of routine or behavioural sequence that is recognised at the group level (5) should not be limited to linguistic studies but include non-vocal, non-linguistic behaviours, and (6) be studied in social encounters. Finally (7), I argue that we should avoid using definitions that assume function until they have been specifically tested. To this end, I define leave-taking as *behaviours occurring before intended cessation and separation from a social interaction of two or more individuals*. The concept of separation is discussed in greater detail in Fig. 5, but involves as a minimum a breaking of contact e.g., turning away, but is situated along a scale of proximity and duration. Ideally, empirical measures should be specified, relevant to the study type and context allowing function, intention,

Table 2 Solutions to address current problems with the study of leave-taking.

	Problem	Solution
Theoretical	Lack of consistent definition	Define generally as "behaviours habitually occurring before intended separation from social interaction", from which to determine specific relevant measures within each study
	Lack of focus on level	Introduce levels of separation (Fig. 5)
Methodological	Lack of empirical study	Apply the definition and framework across populations, including non-human species
	Data collection doesn't capture leave-taking	Take advantage of video technology to record behaviour and use video data coding software
	Appropriate candidate behaviours	Pilot study leave-taking data collection across populations and species, with a focus on non-verbal behaviours and including behaviours suggested in the literature, e.g., scratching, weight shift, eye gaze and body orientation
	Lack of control variables	Use non-social condition to test leave-taking as a social behaviour, and control other influential variables such as length of interaction, context, individual difference

development, causes and consequences to be investigated subsequently.

Cross-cultural insights. Studies of human leave-taking span anthropology, psychology, linguistics and ethology. This breadth testifies to the wide-ranging nature of the topic but making it challenging to critically review the literature. Initial studies of leave-taking were pioneered by Goffman, who conceptualised the topic from multiple angles including "loss" requiring defence, strategies, and consolations (1952); as access rituals (1971), and as brackets relating to frame analysis (1974). Since Goffman's work, there has been some attention paid to leave-taking, though few replicated data, and Knapp et al. (1973) acknowledged this neglect by behavioural researchers, saying that scholarly investigations are few and far between.

Leave-taking appears in popular science literature, such as Lundmark's (2009) book "Tales of Hi and Bye". By the author's admission, his book is not a scientific work and focusses more on the greeting than the leave-taking. Nonetheless it draws on a number of disciplines to illustrate the variety and complexity of leave-taking. It also addresses the idea of temporal changes in leave-taking; noting that handshakes are a more recent expression of leave-taking compared to greeting, using historical and literary evidence to trace early presence of this behaviour in artwork (Herrenberg Altar, 1540) and in literature (Shakespeare, 1596; *Merchant of Venice*, Act 2, Scene 8).

Discussions of leave-taking make substantial claims about the universality (Eibl-Eibesfeldt, 1971), cultural variation (Firth, 1972) and function (Lockard, 1980) of leave-taking, but without providing evidence to support the claims. However, beyond "common knowledge" about different leave-taking styles, there is little empirical evidence as to how or why cultures vary in these behaviours. Among attempts at comparison, Firth (1972) stated that some goodbyes stress positive messages of well-wishing for the future, and others, sadness at parting. Ameka (1999) claimed that universalities exist in conversation closing, pre-closing, leave-taking and final departure, with varying degrees of elaboration across cultures in leave-taking.

Critical cultural variation does exist, however. Hong's (1985) comparison of leave-taking in eastern and western human cultures found that Mandarin Chinese has a greater focus on the setting of the verbal exchange and has less formulaic, religiously derived language than in English "well-wishing" (Ferguson, 1976). He found avoidance of personal pronouns that make leave-takings more personal than in English (Hong, 1985). Wang (2005) investigated this using a video coding method on leave-taking from clips of Chinese TV series, concluding that contextual, personal variables are more important than in English. In another example, Atika (2020) compares leave-taking in Sasak to English, finding that the Sasak form is more personal and demonstrates greater empathy and solidarity. Atika argues that this reflects the differences in culture, in particular reflecting Muslim values, for example using specific forms of address in leave-taking to those who have completed the *hajj*, the pilgrimage to Mecca.

Second language acquisition studies also highlight ways in which leave-taking differs linguistically and culturally. Study-abroad paradigms provide opportunities to understand the use of linguistic strategies in non-native speakers. Critically, these studies focus on language development, giving insight into stages of proficiency throughout acquisition. Understanding leave-taking conventions in one culture does not guarantee understanding in another: Conventions are highly variable, in manner and context, causing issues for language learners and leading to inappropriate address, formulas, and timing (e.g., Hassall, 2006; Cook, 1985; Sukwiwat and Fieg, 1987; Scarcella and Brunak, 1981). In French for example, leave-takings tend to be longer than greetings (Béal, 1994) and are generally more context dependent than English, e.g., the French tend to converse only with the waiter in a café, where interaction with customers is seen as inappropriate, in contrast to English culture (Carroll, 1987). Acquisition of French by native English-speaking students supports this contrast: Native speakers reported that they would not engage with other customers in a café, whereas non-native speakers were likely to, in a light-hearted and "chatty" way (Hoffman-Hicks, 1999). Such studies highlight significant differences in leave-taking and demonstrate specific contextual, linguistic cultural variation in the behaviour. Similar studies should be replicated across other cultures, to get a broader sense of the range of variation.

Comparative insights. Mentions of leave-taking are almost non-existent in the non-human literature, with few acknowledgements of its absence. Goffman (1971: p. 79) stated that "an animal version of goodbye is much more difficult to establish", compared to greeting and Firth (1972) suggested that parallels to human leave-takings were apparent in other species. Lockard et al. (1978) presented some non-verbal correlates of leave-taking in humans, such as eye gaze, body orientation and weight shifts, and unlike most leave-taking literature, hers was framed in an evolutionary context: It was based on the premise that social vertebrates rely on coordinating activities and suggested that postural movements may serve an analogous function in humans to signal imminent departure. Lockard (1980) mentioned that her ethological human study could serve as a comparison across species to signal intention to depart in social animals. However, these were passing comments that have not been investigated (Table 2).

The first example of non-human leave-taking was ad lib, as Gardner reported that chimpanzees in a sign language experiment began to use the "bye bye" signal to one another

(cited in de Waal and Waal, 2007). de Waal and Waal (2007) also reported that a gorilla in Arnhem Zoo would pat the keepers or blow kisses to them before she went indoors, apparently foreseeing the separation. Both of these reports are anecdotal, but perhaps more importantly, involve captive (likely) enculturated apes seemingly mimicking human behaviour. If so, this gives little insight into naturally occurring separation behaviours present in their wild counterparts. One paper that does feature wild chimpanzees is Harrod's (2014) review of chimpanzee responses to death. Drawing on secondary data from five sites, he finds that chimpanzees responded with "farewell behaviours" e.g., turning away and glancing back, lingering for a final touch and returning to look as they leave the deceased. Although intriguing, this report seems somewhat anthropomorphic; "farewell" behaviours are described only as assumed parallels to human partings. Furthermore, it raises the question of whether leave-taking applies to situations involving a deceased individual. Although understanding of mortality may be important in driving leave-taking (McGrew and Baehren, 2016), there could be other explanations of these behaviours, such as checking to see if the other individual is really dead. Regardless, these reports remain singular and so provide little evidence for systematic expression of leave-taking, e.g., if or how behaviours occur and vary as external factors affect them. Nevertheless, anecdotes remain important in behavioural science (Martin et al., 2021), in which a single observation may call attention and lead to further observations and form the basis for experimental, systematic study.

To investigate this lack of leave-taking in the primate literature, McGrew and Baehren (2016) sought responses to a questionnaire from fieldworkers at ten wild chimpanzee field sites. The results were unanimous: greeting was universally present in chimpanzees, whereas leave-taking was universally absent. The authors did not give respondents a definition beyond "show leave-taking/farewell behaviour when they part after being together", so as not to constrain their responses, but it may be that such behaviour is not easily recognisable.

There seem to be only two empirical studies of non-human leave-taking published. The first, by Scheumann et al. (2017) report that grey mouse-lemurs (*Microcebus murinus*) reciprocally greet upon reunion of mother-infant dyads, but do not show leave-taking when separating. As a less derived primate species, the absence of leave-taking suggests a more recent origin within the primate order. Contrastingly, the presence of greeting in this prosimian indicates that it has a deeper evolutionary history in mammalian phylogeny. In this study, greeting and leave-taking were recorded in the context of mother-infant reunion and separation through "infant parking", whereby the mother forages solitarily after leaving the infant in a tree-hole. Owing to their nocturnality and constraints in the gestural and facial displays of the species, this study limited data to vocalisations. As such, it could not test non-verbal elements of leave-taking that seem important in humans and could have parallels in non-human species (Firth, 1972; Lockard, 1980). Empirically, Scheumann et al. (2017) conclude that there are vocal greetings, and no parallel vocal leave-takings, in at least one primate species.

A similar study in group-living primates that uses gestural communication (Fröhlich and Hobaiter, 2018) could give greater insight as to whether leave-taking has comparable elements across species. Using a mother-infant dyad paradigm provides opportunity to investigate parental care as a driving force to reconvene after separation that seems to be important in primate greetings (e.g., in marmosets, Takahashi et al., 2017). Leave-taking could link to attachment theory, representing an evolutionary survival instinct for offspring to stay close to the mother. However, in species such as *Microcebus murinus*, who have evolved the "infant parking" system enabling mothers to forage, an infant vocal signal could be maladaptive and increase predation risk (Zeifman, 2001).

The second, a more recent study by Heesen et al. (2021), finds evidence that captive chimpanzees and bonobos mark the entries and exits of joint activities with gesture and mutual eye gaze. These findings are important in our understanding of leave-taking as it provides the first published empirical evidence of non-human behaviour at the end of social interactions, where the research concluded that the apes demonstrated mutual gaze and communicative signals prior to and after engaging in joint activities with conspecifics. However, to consider this behaviour leave-taking a number of factors need to be addressed. The length of the interaction (so called "joint commitment") is argued by Lockard et al. (1978) to be a driving factor in the production of some behaviours towards the end of social interaction, but Heesen et al. (2021) used no such controls in this study. We cannot conclude that these exit behaviours are truly leave-taking unless they are found to occur in greater propensity in social separation, compared to solo or proximity separation. For example, we may exhibit behaviours when getting up and leaving alone, possibly gazing where we are planning to move to, e.g., making preparations such as zipping up a jacket, checking the seat to make sure we have not left anything; these behaviours occur because humans exit the scene and not because of social separation, thus should not be considered "leave-taking". The gestures and eye gaze should be shown to occur in these joint commitments compared to, for example, close proximity (see study by Gräfenhain et al., 2009). This paradigm should be further applied in free-ranging, natural settings to establish the ecological validity of the results.

Proximate drivers. Proximate drivers are mechanisms that directly underly the production of behaviour. Specifically, they refer to events immediately responsible for causing behaviour, and can help us understand what behavioural patterns encourage leave-taking. In humans, certain classes of verbal behaviour have been shown to increase in the terminal phase of conversation, broadly categorised into content summary statements; affective summary statements; continuity, justification, well-wishing statements; and statements of positive affect (Albert and Kessler, 1978). There is also evidence that these statements are sequentially arranged and influenced by various factors including how structured the conversation is. However, these findings are from English-speaking student subjects and so the results may not be generalisable. "Normative structures" rely on conventionalised contexts well understood by members of the society (Wang, 2005) and cross-cultural interpretation of these contexts may influence leave-taking perceptions.

One of the most extensive contributions to our understanding of the structure of leave-takings is Kessler's (1974) Ph.D thesis. Some of the most important findings include differences in summary statements and justification of leave-taking between structured and unstructured conversation, greater positive and well-wishing statements between strangers than friends and greater continuity between friends than strangers. This is probably the most extensive attempt to date to understand the linguistic and structural nature of verbal leave-taking seen.

Schegloff and Sacks (1973) also look at the structural organisation of ending conversations, concerned with how individuals navigate turn-taking in leave-taking. They report a pre-closing section to the conversation, including verbal markers e.g., "Well…", "Ok…", plus clearer statements that prohibit further talk, known as "adjacency pairs", where an utterance from one speaker directs the successive utterance from the other,

completing the exchange. Experimentally, when one individual is instructed to give no termination cues, the other attempts to adopt leave-taking structures, e.g., buffering, to terminate the interaction (Knapp et al., 1973).

Laver (1984) provided another structural framework, focussing on mitigatory and consolidatory comments, providing well-wishes for the future. These were often used together with some formulaic leave-taking such as "goodbye". In contrast, Kinnison (2002) classified speech acts into 13 categories with categories varying across populations, e.g., announcing, excuses and consolidating were more frequent in Chinese speakers and appreciation and compliments more common for Americans. Broadly, there seems to be significant structure to the verbal element of leave-taking, although classification itself varies.

Furthermore, several authors have described leave-taking as a multiactivity, in which behaviours are co-ordinated to bring interactions to a close. In an example from Haddington (2019) leave-taking at car drop-offs is outlined as a process with two simultaneous "action streams", leading to the closing of the encounter and bringing the car to a stop. In a medical consultation context, Heath (1985) shows how verbal leave-taking is co-ordinated with embodied action of preparing to leave the room. Similarly, in a study of guided walking tours, Broth and Mondada (2013) describe the role of orientation during sequence closings. Haddington (2019) argues that these examples demonstrate how physical action is reflexively co-ordinated with the leave-taking itself, and that movement can help achieve the closing of a sequence. Thus, the expression of leave-taking seems to be multimodal across different contexts.

Ethnographic studies of leave-taking point to influential factors in its expression in different populations. Akindele's (2007) study of discourse in the South African language Sesotho found that age, sex, context and time of day are all important in leave-taking, usually expressed as reason to leave and well-wishes. Similarly, DuFon (2010) highlights importance of status and hierarchy in leave-taking in Indonesian. Rababah and Malkawi (2012) report similar patterns in partings in Jordanian Arabic: age, sex, context and time of day are important, although their main focus is greeting with little explanation of leave-taking. How precisely these factors influence behaviour given their descriptive nature is difficult to determine, though Laver (1981) consolidated this as "politeness-oriented linguistic routines", in which the formulaic phrases should be consistent with social status, degree of acquaintance and nature of the situation.

The importance of contextual variables and in-person cues is also highlighted in linguistic literature on telephone and computer mediated communication, where speech is the only medium for communication. For example, Tang's (2007) study focused on the lack of non-verbal cues in phone conversations, and the subsequent lack of information about status and interpretability of the other individual. He reported that phone conversations have extra verbal cues compared to in-person interactions, to compensate for this lack of information. More acquainted individuals are more likely to say "goodbye", but this is optional for those less acquainted (Clark and French, 1981). The percentage of "goodbyes" in the terminal exchange also increases if some useful information was exchanged, or when operators revealed more about themselves. This suggests that verbal leave-takings are mediated by social relationship and contextual information about the interaction. Major drawbacks of these language-only approaches involve the omitting of non-verbal behaviours and focussing only on a few developed populations, limiting generalisability of the results to the evolution of species-typical leave-taking.

Adaptive value and function. The functions of leave-taking may not be mutually exclusive. One possible recurrent function is social bonding, to signal the continuance of social ties (Lockard, 1980). For instance, Goffman (1967) stated that a farewell is needed to sum up the effect of the encounter on the relationship and outline expectations for the next meeting. Many definitions stress social interaction as a necessary pre-condition for leave-taking, then maintaining the relationship throughout separation and reassuring that contact will commence at some point (Bethlia, 2009). A positive and successful leave-taking could send a relational message regarding feelings and attitudes that bolsters the relationship for the time apart (DuFon, 2010) and could even be adaptive in facilitating social relationships (Firth, 1972). These hypotheses remain to be tested.

Studies on emotional attachment have demonstrated that separation from the caregiver results in anxiety and distress in children, contrasting pleasure and security when in physical presence. Bowlby's (1969) attachment theory states that attachment to a primary caregiver aids survival and acts to provide a continuing emotional tie and ensure the relationship continues, inspired by earlier studies of imprinting across species (Lorenz and Fischer, 1963). Attachment behaviours are activated when proximity is threatened, for example, by separation. As infant survival depends on proximity to the caregiver, and human infants are altricial and unable to follow, the act of crying has evolved as a signal to alert the caregiver, whereas smiling acts as a way to reinforce bonding (Newson and Newson, 1963). This pattern is found across primate species, where Bowlby argues that chimpanzees and baboons can be seen as the template for how infant care evolved in humans, and that the dread of separation is the motivating factor in the lives of all young primates (1969). Furthermore, more responsive mothers increase offspring survival (Hrdy, 2011). Once young children progress beyond the phase of specific attachment around 3 years of age, separation no longer risks survival (Bowlby, 1969), but attachment mechanisms could remain at separation to maintain social bonds in close relationships. Parallels in infant distress at separation and expression of leave-taking (for example, crying, holding out arms, following) could suggest that a function to increase social bonding is a result of attachment innately present to increase survival chance. Hrdy (2011) argues that there is no universal pattern of infant care across primates and suggests that babies for whom care is shared between adults could develop behaviours to manage this, such as seeking eye contact and looking at their surroundings earlier. This connection between infant attachment and separation and ritualised leave-taking in adults also remains to be studied.

Further insight into the social importance of leave-taking comes from Gräfenhain et al.'s (2009) study of joint commitments in children. By two years of age, children join in group games and co-ordinate roles, with results suggesting that children are more likely to demonstrate leave-taking in joint games, as opposed to when playing solo games alongside another individual. This demonstrates an emerging understanding of joint commitments, but also provides evidence that leave-taking manages shared commitments and is intrinsically social: Joint activity relates to leave-taking in children, and this could be a useful paradigm to investigate leave-taking across species.

Several mentions of leave-taking describe it as norm-bound (Knapp et al., 1973), for example its definition as a "ritual of a stereotyped series of complementary transactions programmed by external social forces" (Berne, 1968: p. 34), or Betholia's (2009) description of leave-taking as a ritualistic event. This stereotyped sequence provides evidence that leaving without proper leave-taking violates social expectation (Adato, 1975), e.g., leave-taking

that is too abrupt or too prolonged can leave participants ill at ease with one another (Dufon, 2010), and casual leave-taking from subordinates to high-ranking officials is problematic (Goffman, 1971). Goffman's "failed departure" examples further illustrate this: when two individuals' part but then reconnect, e.g., say goodbye but walk in the same direction, the behaviour seems improperly profuse. Similarly, when children wave as they leave a public place, it is amusing because it fails to qualify as proper leave-taking (Adato, 1975). These examples exemplify the "social expectations" (Adato, 1975) and "norm bound" (Knapp et al., 1973) nature of leave-taking rituals. Dulaney and Fiske (1994) provide an overview of the similarities between features of rituals and behaviours of obsessive compulsive disorder (OCD) patients. One of these features, "attention to threshold", refers to thresholds of interactions, i.e., entrances and exits. They argue that this feature, along with others, is significantly represented in rituals such as birthing and initiation ceremonies, and is also a symptom of OCD. Rather than arguing that rituals are in any way pathologic, this suggests a shared psychological mechanism, distorted or hyperactive in pathological individual ritual, and could help to explain the widespread human concern with parting and thresholds.

Corsaro (1979) found that two-thirds of child–child interactions have no withdrawal and concludes that children do not need to mark the cessation of activity ritualistically, compared to adults. Simultaneously, children focus more on the access ritual (greeting) than the withdrawal (leave-taking). Gleason and Weintraub (1976: p. 134) offered insight into this, suggesting that for "termination routines", there is importance of training by adults, following performance, "only later, long after he has learned to say bye-bye or thank-you—might the child come to know what, if anything, it all means". They also stated that "bye-bye" is one of the earliest routines in development, non-verbal in its first performances, altogether suggesting that elaborate leave-taking may not be important for children, but that the non-verbal ritual develops even before verbalising referential language. This gives an important insight into the development of leave-taking, possibly relevant also for non-vocal behaviour in non-humans, and the role of adults in shaping early social rituals.

Leave-taking requires not only social interaction, but also the expected separation afterwards, or "decreased access" under Goffman's (1971) framework, and thus another possible function could be to inform conspecifics of imminent departure. He predicted that the lengthier and more absolute the separation, the more expansive the ritual, an idea reiterated by DuFon (2010). Longer separations have higher investment leave-taking; farewell parties only precede extended time apart. For example, Wang (2005) shows that in television interactions, concise and efficient farewells occur when the separation is very brief, as opposed to longer term separations. This idea is evident in "real life contexts", where temporary leave-takings during the comings and goings of the workday are fewer, briefer and less formal (Whittaker et al., 1994). Lockard et al. (1978) presented a short study of human postural changes preceding departure, reporting that increased frequency of unequal weight stances and weight shifts signal imminent departure, especially when combined. These behaviours were apparent when individuals left a place together but were more exaggerated when the pair actually separated, suggesting a social signal driven by impending separation. This is one of the few ethological studies focused on non-verbal behaviour that also controlled for other factors, e.g., length of interaction. Although small in sample size, this provides the start of an ethological framework from which to further investigate how these behaviours contribute to leave-taking (Table 2).

Comparing differing separation lengths with associated behaviour also gives an insight into the effects of separation. Betholia (2009) gives an example of temporal change in the Meitei of Bangladesh, a previously close-knit society in highly cohesive groups, where continuing relations were expected, and leave-taking was not an elaborate behaviour. The longitudinal study showed that as the society's complexity and separations increased over time, leave-taking became more elaborate. This gives particularly powerful support to the idea that leave-taking is driven by the separation experienced in most social groups.

Despite such studies on the importance of separation to leave-taking, it remains unclear why separation should drive such behaviour. Studies on leave-taking at death are relevant, as final leave-takings take place at death and mourning (Van der Hart and Goossens, 1987). This is compatible with the theory that leave-taking in its human form is possible due to our conceptualisation of time and the future (Firth, 1972), understanding of separation, and the permanent separation of mortality (McGrew and Baehren, 2016). However, such possibility does not necessitate selective pressure. Field et al. (1984) described leave-taking behaviours of children and parents, highlighting distressed behaviours, especially in younger children, supported by a similar study (Jones, 1972), where behaviours included crying, holding out arms and gesturing to be picked up. They suggest that the leave-taking behaviours function as a survival instinct: to stay close to the caregiver, not to become separated, and to protect young children by favouring proximity, while allowing independence in older children through more positive separation. Furthermore, developmental psychology literature suggests that adult and peer training is critical in children's acquisition of leave-taking (Corsaro, 1979). As with the grey mouse lemurs, this parent-offspring interaction might only be adaptive when leave-takings do not alert predators to the presence of solitary infants. Studying parent-infant dyads limits the potential to understand more general leave-taking and how it becomes established ontogenetically. These suggestions could explain the negative results of the grey mouse-lemur study. Interesting questions arise from these results: What species should we investigate with regards to leave-taking? What contexts are appropriate to investigate? What behavioural measures might give most insight? Does this behaviour occur intentionally to transfer information? These questions have not, as far as I am aware, been investigated in any human or non-human species and thus the adaptive value remains unknown.

A third possible function of leave-taking could be to reduce aggression. This idea comes primarily from the literature relating to the Violence Inhibition Mechanism (VIM) (Blair, 1993). Previous work across many species suggests that there are universal appeasement behaviours that reduce the risk of aggression or even end aggressive attacks from other individuals (Lorenz and Fischer, 1963). These behaviours are mediated by the VIM in which conspecifics use distress signals to inhibit violent or threatening behaviour (Blair, 1995). A similar pattern has also been found in human infants (Murray, 1980) and young children (Camras, 1977) where sad facial expressions in 4–7-year-olds result in the termination of aggression. Some of these behaviours e.g., turning of the head, bowing, are submissive as they expose vulnerable parts of the body to the conspecific (Lorenz and Fischer, 1963). However, others have been argued to reflect a threat of breaking off contact (Eibl-Eibesfeldt, 1989) as aggression blocking behaviours can include turning away and breaking eye contact. This threat of breaking contact, as well as demonstrating submissive behaviours, could provide an alternative theory for the function of leave-taking as a way to minimise aggression.

Evolutionary perspectives

Knapp et al. (1973) shows that although leave-taking may seem mundane and ordinary, it could tell us a good deal about human interaction "since unique and terribly human interpersonal forces are unleashed when people say goodbye to one another" (1973: p. 182). This point highlights both the importance and presumed uniqueness of human leave-taking. The need for studying leave-taking is not just warranted from the absence of literature; plenty of phenomena remain unstudied purely because they are mundane or self-evident. However, the plausible universality of human leave-taking, which is likely integral to most social interactions, merits investigation.

Investigating the behaviours that occur at the end of interactions could have implications for the evolution of sociality, in understanding why departing intention is important. As argued by Albert and Kessler (1976), studying interpersonal endings is important to theories of social psychology, such as consistency models and exchange theories. Such research would complement theories of human behaviour that describe motivational intention for ending a social encounter, e.g., dissonance (Festinger, 1957) or imbalance (Heider, 1958), but not the mechanism for doing so. Furthermore, understanding leave-taking variation across human societies should provide new insights into the similarities and differences in the expression in this behaviour: Are there similar patterns that suggest leave-taking as a primitive trait ancestral to *Homo sapiens?* Or has leave-taking converged across species to solve common challenges that entail separation, such as fission-fusion societies? By contrast, evidence of leave-taking in more distantly related non-human species would suggest deeper evolutionary roots for this social behaviour.

The desire to understand how species have evolved to manage social separation is not new. However, that leave-taking could be a way to synchronise movement or to signal intention to depart in social animals (Lockard, 1980) challenges an important point: that leave-taking is inherently *different* from synchronised, collective cohesion. The former refers to a separation of individuals and an ending of social contact, whereas the latter relates to co-ordination that aims to keep the group together. The latter is also well-studied across the animal kingdom, in birds, social insects and fish (King and Cowlishaw, 2009). For primates, Schamberg et al. (2017) described bonobo branch-dragging before long group travel, and Rowe (2017) examined factors influencing collective decision-making on group movement in Tibetan macaques. This is inherently *different* to leave-taking because there is no separation and is usually referred to as group movement (Schamberg et al., 2017), group travel (Rowe, 2017), or group co-ordination (King and Cowlishaw, 2009). This highlights the need to distinguish leave-taking (i.e., notification of social separation) from intention to depart, where other individuals notify of a joint cohesive departure, moving away together.

Many species have fission-fusion group structures of varying degrees (Aureli et al., 2008), evolved to balance the benefits of group-living in environments in which resources are clumped and dispersed (Lehmann et al., 2007). The costs and benefits of group-living vary between individuals and across species (Kappeler and van Schaik, 2002), which leads to variation in group size and cohesiveness. Specific ecological factors also influence the extent and patterns of fission-fusion, such as variable availability of key resources (Ramos-Fernndez and Morales, 2014). Consequently, the extent of group cohesion affects the evolution of communication patterns. For example, in highly cohesive species, communication is expected to be advantageous for high information acquisition and to reduce competition resulting from the constant presence of conspecifics (Aureli et al., 2008) and to maintain cohesion through co-ordinated movement (e.g., Boinski, 1996; Rowe, 2017; Cords and Killen, 1998). On the other hand, fission-fusion species are expected to have developed signals that re-establish relationships and resolve uncertainty, as well as cognitive skills that help interpret indirect information about conspecifics when not in view (Aureli et al., 2008). Aureli et al.'s predictive framework generates a series of testable hypotheses about communication, which could, but currently do not, include leave-taking. For example, this framework hypothesises that chimpanzees might have evolved signals to resolve the uncertainties associated with low cohesion, whereas more cohesive primate species, such as baboons, would be expected to have signals that maintain cohesion. In this sense, we can think about fission-fusion in terms of a gradient that varies within and between taxa, and subsequently could predict the differing need to use signals to manage separation. Research efforts into leave-taking across the radiation of baboon species could provide a particularly fruitful avenue of enquiry; allowing us to compare the effects of their varied social systems in phylogenetically close species.

We might predict that leave-taking is more likely to exist in those species that exhibit classic "fission-fusion" (e.g., chimpanzees, spider monkeys, hyenas, Aureli et al., 2008), driven by their regular extended periods of separation. However, even within cohesive societies, such as the genus *Papio*, distancing between individuals exists (Patzelt et al., 2011). Although there is no definitive fissioning of subgroups, individuals socialise with multiple conspecifics, break into smaller distinct groups, and are most cohesive at night and early mornings, as they aggregate to sleep in trees (Anderson and McGrew, 1984). By recognising that fission-fusion exists to some extent in all social groups and abandoning the fluid versus cohesive dichotomy (Aureli et al., 2008), I reveal a potentially important factor to study leave-taking: the level of study. How we collect data is a crucial decision when studying behaviour, as it impacts what questions we are able to answer, and which patterns are revealed (Martin et al., 2021). For example, behaviour at occasional short-term "fission events", e.g., in chimpanzees (Aureli et al., 2008) would set the stage for studying subgroup leave-taking (Fig. 5). However, these events do not seem comparable to most studies of human leave-taking that focus on frequent, daily interaction endings between individuals (Albert and Kessler, 1978; Schegloff and Sacks 1973; Lockard et al., 1978). Instead, they seem more similar to extended periods of separation (Goffman, 1971; Firth, 1972). There could be much potential in studying the recurrent daily separations that happen often in other species, when brief interactions between individuals come to an end. Comparatively, these interaction endings seem more similar to ethological studies of interaction analysis in humans (Gräfenhain et al., 2009; Knapp et al., 1973; Lockard et al., 1978). Conversely, examples of permanent departure in other species are perhaps more akin to human separations before emigrating, leaving to enter risky circumstances such as war, or even before death (Van der Hart and Goossens, 1987; Radcliffe-Brown, 1922). Similar to the gradient of cohesion seen across species and contexts, we might expect to see a gradient of leave-taking, in which different forms of impending absence drive different patterns of behaviour, although defined in distinct levels for the purpose of this framework. I propose that levels of separation should reflect the social entity that is being departed from, where low-level reflections separation from individual interactions, medium-level reflects subgrouping of small social groups, and high level reflects departure from an entire social group. This may often parallel duration and distance, e.g., separation from an entire social group is more likely to be extended than separation from a social interaction where one stays within the main group and likely encounters the same individuals repeatedly. However, the relationship between separation of social unit, duration and distance remains poorly

understood; such levels should be used as guidance to establish what level of social unit is separating, and on what scale.

At present, our understanding of leave-taking is limited by lack of data across species (Table 2). Despite the apparent similarities between humans and other species in factors that cause leave-taking, such as status recognition (Chiao, 2010), strengthening of social bonds (Lehmann et al., 2007) and understanding of separation (De Marco et al., 2011), Firth (1972) argues that humans have greater flexibility, length of time, conceptualisation of the future, formality and correctness. Some non-human species show propensity for mental-time travel (Cheke and Clayton, 2010) and anticipatory behaviours (Mulcahy and Call, 2006; Osvath and Karvonen, 2012), but McGrew and Baehren (2016) argue that we lack evidence that this extends to the social domain. They also suggest there could also be differences in the costs and benefits of leave-taking across species: in cohesive groups in which the separation is never longer than a number of hours versus species that exhibit more definite fission events (e.g., chimpanzees) this could affect any information that is exchanged about how long they will be apart. This constrained temporal factor could result in less frequent and conspicuous leave-taking behaviour compared to greeting.

It seems likely that non-human species have no elaborate leave-taking, unlike humans who engage in leave-taking "ceremonies" (Van der Hart and Goossens, 1987), sometimes involving elaborate behavioural sequences. However, "evolutionary components" may exist in the non-human animal repertoire, which reflect the ancestral state of the behaviour, or its possible function(s). Furthermore, when considering the proposed levels of leave-taking (Fig. 5), subtle changes in frequency or timing of behaviours during the day-to-day separations, could easily be missed unless they are the focus of specific study. Commentaries on this so far (McGrew and Baehren, 2016; Scheumann et al., 2017) take into account only obvious medium-level partings at fission-fusion. Focusing on interaction level separations and subtle changes that may indicate leave-taking may be more fruitful in non-human species. Investigation of these subtle but frequent leave-takings in daily partings of non-human species need to be undertaken (Table 2).

A new framework for leave-taking

Future efforts to address limitations in the study of leave-taking should fall broadly into two categories: its framework and empirical predictions. A dual focus on these areas will help to simultaneously strengthen the methods used to collect data and advance the evolutionary nature of hypotheses tested.

The lack of a robust framework links to the lack of empirical studies on leave-taking. Here, I have proposed an operational definition of leave-taking summarised as: behaviours occurring before intended cessation and separation from a social interaction of two or more individuals. I have advocated using levels of separation (Fig. 5) as a way to navigate the gradient of leave-taking seen across different types of separation and reveal potentially interesting behaviours across species. Taking advantage of technological advances, video recording and behavioural coding software (Cristani et al., 2013; Friard and Gamba, 2016) can help address methodological issues and allow more effective study.

A comparative method should be part of this framework, in order to place leave-taking in an evolutionary perspective and identify candidate behaviours comparable across species. Variation across species could suggest different selection pressures of social system, environment, and context, and provide further opportunity of empirically testing. The apparent universality of this behaviour in humans suggests a deep evolutionary history in the hominin clade, but it remains unclear whether elements of leave-taking behaviour were present in our Last Common Ancestor with the genus *Pan*, or even with the Order Primates as a whole.

In most, if not all, human populations leave-taking is seen prominent and important, and as such deserves careful attention from those interested in behaviour. The discrepancy between the literatures in greeting and leave-taking is stark. In part, this contrast is due to difficulties in studying leave-taking, but also due to a fragmented and underdeveloped theoretical framework. I argue that our understanding of leave-taking would benefit from greater consideration in the disciplines concerned with behavioural evolution, and that cross-species methods should now take advantage of technological advances to do so. Confirming some of our proposed predictions on leave-taking could inform us on critical aspects of its evolutionary origin, variation and function.

Data availability

No primary data is generated in the paper. The literature data that support the findings of this study are available from online sources associated with the references cited in the paper.

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The author declares no competing interests.

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As a review article, this manuscript does not contain any studies with human participants performed by the author.

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Appendix 2: Published version of Chapter 4

animals

Article

Yet Another Non-Unique Human Behaviour: Leave-Taking in Wild Chacma Baboons (*Papio ursinus*)

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Simple Summary: Although greeting is well-studied across animal species, its counterpart, leave taking, is little studied in nonhumans. Here, we review the previous limitations of leave-taking research and use this to develop a new method for studying leave taking in nonhumans. Using videos of chacma baboons in Gorongosa National Park, Mozambique, we compared behaviours at the end of social departures to nonsocial departures. We found that shifting orientation towards the direction of parting was significantly more likely in social departures compared to nonsocial departures. As the first evidence of leave taking in a wild nonhuman species, we suggest that leave taking is not uniquely human as previously argued, and that our method could be used to further explore the presence of leave taking in other nonhuman species.

Abstract: Leave taking is a common, possibly universal, feature of human social behaviour that has undergone very little empirical research. Although the importance remains unknown, it has been suggested to play an important role in managing separations, mitigating the risk, and increasing social bonding beyond the interaction itself. In nonhuman species, the literature is virtually absent, but identifying leave taking beyond humans may provide unique insights into the evolutionary history of this behaviour and shed light onto its proximate and ultimate function(s). Methods to study leave taking are not well-established, and the variation in definitions, measures, and control variables presented in past studies poses additional challenges. Baboons are a valuable model for investigating human behavioural evolution: as a flexible, highly adaptable, and social primate whose radiation is, similarly to humans, associated with the emergence of the African savannah biome. Using the framework and definition proposed by Baehren, we investigated the presence of leave taking in a wild, generalist primate and tested a range of candidate behaviours on prerecorded video footage: (1) self-scratching, (2) eye gaze, and (3) orientation in the direction of parting. Using multivariate analysis, controlling for interaction duration and individual variation, our results show that orientation in the direction of parting occurs predominantly before social separation events. These results indicate evidence of leave taking in a wild nonhuman population and contrast with previous ideas that this is a uniquely human behaviour. The presence of leave taking in baboons suggests a deep evolutionary history of this behaviour, warranting further investigation into its function and presence across other nonhuman primate species.

Keywords: *Papio ursinus*; greeting; leave taking; separation; parting

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1. Introduction

1.1. Lack of Leave-Taking Study

Compared to the study of greeting, the ways in which interactions end are much less well-studied. This difference is exacerbated when looking at nonhuman species [1].

Nonhuman primates provide useful models for understanding how behaviour has evolved in humans, or how adaptive behaviours have converged [2]. For example, studies of greeting in chimpanzees suggest that these behaviours function to reduce tension and increase social bonding upon meeting [3]. The presence of greeting in nonhuman species suggests that this behaviour has an ancient origin that precedes the emergence of *Homo sapiens*, or in fact, the entire primate Order [4]. Indeed, Jane Goodall claimed that some of the most convincing similarities between animal and human studies are shown in greeting behaviour [5]. In contrast to this, studies of leave taking in nonhuman species are largely absent, and the origins in our lineage remain unknown.

The reason for this discrepancy in nonhumans remains unclear, as the behaviours have typically been considered together in humans. A handful of suggestions have been made as to why leave taking has not 'taken off' in the same way as greeting: it is hard to measure in animals, requiring more advanced technology to capture retrospective behaviours [6] or it may simply not exist [7]. However, other sources suggest that there may be some evidence of nonhuman leave taking, even if it is does not parallel human leave taking as greetings often do [8]. There are anecdotal reports of primate species showing possible leave-taking behaviours (e.g., [9]), although these reports have never been subject to empirical study.

Furthermore, although the studies on human leave taking are greater in number, they mostly concern the linguistic structure of conversational endings [1]. Although these methods are appropriate for answering questions of conversation and language, they are less useful for tackling questions of evolution, especially across species. A potentially more useful avenue is to consider nonverbal correlates of parting, across cultures and species. This is useful in two ways: (1) behaviours independent from articulated language may show continuity across species and cultures, and thus inform us of similarities and differences [10]; and (2) may reflect basal aspects of shared communication across primates, as with greeting behaviours [8]. It has been suggested that leave taking should be studied in nonhuman species, for example, where postural signals may serve an analogous function [11], or when considering studies of group movement [12]. Ethological studies of leave taking are lacking, and those that do exist (e.g., [11,13]) are not robust in providing replicable methods. Below, we consider and address possible ways to overcome these limitations.

1.2. Addressing Previous Limitations

In the review from Baehren [1], there is a thorough discussion of the ways in which definitions of leave taking vary. This is a significant methodological issue, in part because it makes studies impossible to compare or reproduce, as the phenomenon of leave taking varies. Almost all definitions relate leave taking to breaking contact, and many seem to also include breaking "social" contact, i.e., that moving apart is not enough; rather, it involves the ending of interaction. In short, significant variation in leave-taking definitions exists, with many studies omitting an operational definition entirely, making it difficult to compare studies. Additionally, Baehren [1] also discusses the need to define the level of study, i.e., what conceptualisation of separation is used. This varies considerably across the existing studies and makes it hard to ensure similar phenomena are being compared. Can we include the everyday comings and goings and ends of conversations, even when individuals remain in the same place (e.g., [13])? Can we only include departures which mark a complete removal from sight and contact (e.g., [4])? We argue that these levels of separation should be considered and acknowledged, including the everyday separations in nonhuman species. One reason for the shortage of previous studies could be the lack of appropriate data collection methods for leave taking: a necessarily difficult phenomenon to study due to the retrospective nature of it, i.e., the behaviour occurs before the visible separation. This point is raised by Albert and Kessler [6], who claim that the properties of leave taking make it difficult to study, in part due to the shortness and high-speed nature of the behaviour. Their suggestion that leave taking could only be properly studied once technology allowed a permanent record to be created and retrospectively examined seems to have now been realised. Several studies attempt this in humans (e.g., [13–15]) but there

of research available [29]. Within their communicative behaviour, baboons are known to coordinate group movement [31,32] and display ritualized greeting when they come together [18]. Furthermore, evolutionary continuity between baboons and great apes, as well as similar neural specialization, suggests that such gestural communication could have an ancient Catarrhine origin 25–40 million years ago [33]. In short, savannah baboons provide promising close-knit social groups to investigate short-term departures within cohesive groups, and are a good model for investigating the origins of potential leave-taking behaviours. The presence of such behaviour in baboons would be significant, implying a deeper evolutionary history of the behaviour or convergent evolution to meet a similar socioecological need.

In this study, we present a new framework for studying leave taking in nonhuman primates, using chacma baboons *Papio ursinus* as an example. We first test the definition and framework for leave taking presented in Baehren's work [1]. Additionally, we determine which behaviours are useful as candidate leave-taking behaviours. We then employ the use of new data collection methods to collect and control for behavioural patterns, determining whether this framework can highlight the importance of social interaction in leave taking, and allow more nonhuman species to be studied. We predict that, based on the social definition [1], leave taking is significantly more likely in social separation compared to proximity or solo departure. Finally, we discuss the results in an evolutionary context, highlighting the advantages of applying our approach to further studies of nonhuman primates.

2. Materials and Methods

2.1. Addressing Methodological Issues

2.1.1. Using a Considered Definition

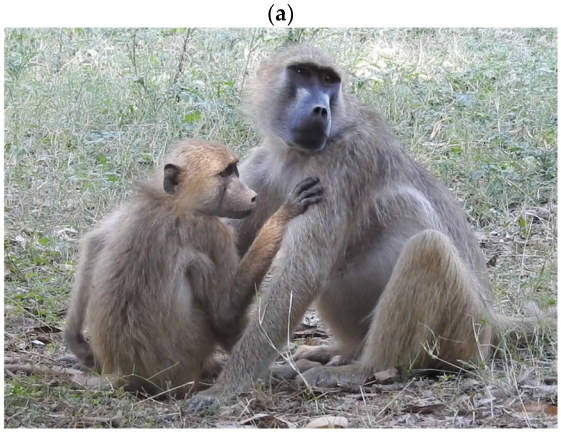
Here, we used the definition "behaviours occurring before separation from social interaction" to refer to leave taking, as outlined by Baehren [1]. To this end, we focused on the sociality of interaction as a necessary precursor to leave taking, which allowed us to differentiate between behaviours that just occur before movement versus the socially charged ending of an encounter.

2.1.2. Defining the Level of Study

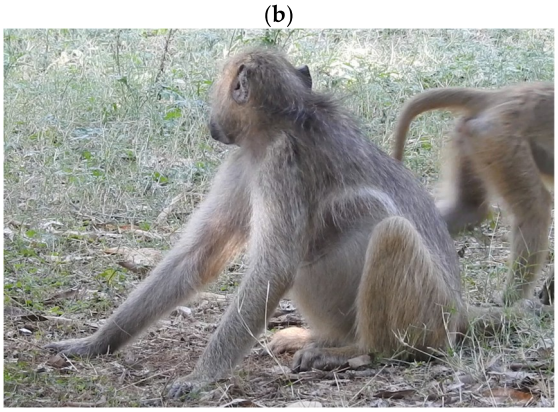
In Baehren's review [1], the level of study is discussed as being an area of particular confusion across studies of leave taking. In the daily following of free-ranging wild populations, it is often not possible to see great numbers of long-term separations, e.g., group departure, transfer, etc. These events are relatively infrequent and would not yield high amounts of data to investigate the associated behaviours. However, in cohesive groups, it should be possible to look at the endings of daily interactions that happen frequently between individuals of the same social group. Although these interactions may not have the "finality" of longer separations, the frequency of their occurrence and their potential function in the ongoing social relationships within the group might mean that they are in fact particularly important for our understanding of leave taking. In this study, we looked at the low-level leave takings, endings of social interactions within a cohesive group of chacma baboons (Figure 1a–c). This allowed the practical benefit of an increased sample size of separation events, but also the detailed investigation of these "every day" social separations from dyad interactions.



(**a**)



(**b**)



(**c**)

Figure 1. (**a**): An activity is occurring between a dyad. (**b**): The preparting window two minutes before departure; individuals often stop the activity and may perform "leave-taking" behaviours. (**c**): An individual departs, moving away from the other individual in the dyad by >1 m.

2.1.3. Data Collection Methods

Video footage was taken during daily following on a Nikon P900 83X Optical Zoom (Nikon, Tokyo, Japan) mounted on a tripod. This was carried out in an opportunistic way from when at least one individual was visible until all the group had moved out of the shot, thus maximising footage of spontaneous interaction, solo behaviours, and parting events. Details of the footage can be found in the results. The footage was then uploaded to the behavioural coding software BORIS 8.6.5 (Olivier Friard and Marco Gamba, Torino, Italy) [34] and the video was played repeatedly to capture fleeting movements, as well as allowing for easier and more accurate intercoder reliability. This method is particularly important for behaviours that happen retrospectively, i.e., to rewind from parting events allowing the coding of behaviours which precede them.

2.1.4. Determining Candidate Behaviours

Pilot observations of baboon self-scratching prior to parting prompted the selection of this behaviour in the present study. Such behaviour is also referenced in published work, within the broader category of "self-directed behaviours". For example, "explosive hand contact" is a leave-taking behaviour in humans defined as "a rapid striking movement in which the hand(s) came in contact with either another part of the body (usually the thighs) or a foreign object (e.g., schoolbooks)- usually a slapping or striking motion" [35]. As a common behaviour in baboons, self-scratching is not unique to separation or anxiety contexts. However, investigating an increased likelihood before separation could suggest similarity with human self-directed leave takings. In this case, self-scratching could reflect anxiety around separation or the decision to separate, although testing such causation is beyond the scope of the present study.

Further to this, previous leave-taking studies suggest the importance of changing orientation (e.g., [11]) which Knapp [34] includes as part of the behaviour of "major trunk movement" and "positioning". Visual orientation in the direction of parting [13], such as "breaking eye contact" to look away [34], is also a potential parallel across species. Orientating behaviours could be important in leave taking as they may represent a subtler intention to depart than simply moving away, as a gradual shift to the departure [11]. This contrasts with orientation towards each other which usually occurs during interaction [36], signalling the opening and closing of the dyad. In infants, turning away has been argued to represent the threat of breaking off contact [37] suggesting that it can be used intentionally to manage the ends of interactions.

Similarly, breaking eye contact or gazing away from the conspecific could act as an intermediary state where the dyad is no longer completely engaged but before final departure [6]. Similar to the example above, maintaining eye contact represents an ongoing social interaction as the channels for communication are open, whereas "turning the shoulder or refusing to make visual contact" [38] is an aggression-blocking behaviour, threatening to break off contact.

Specific, measurable, and varied candidate behaviours must be carefully chosen and justified in order to address the methodological issue of ensuring relevant behaviours are captured.

2.1.5. Control Conditions

Combining the efforts of previous studies, we included length of interaction as a control variable. We did so by including the number of seconds from the start of the social behaviour (or activity in the case of solo condition), until the move away, as a factor in the models. This allowed us to control for the fact that restlessness could lead to some behaviours disproportionately occurring in long interactions [11]. We also included the parting type as a key variable in the model: whether the individual was parting from a social activity, leaving a solo activity, or leaving a solo activity in close proximity to another individual (see Table 1). We categorised these conditions based on whether activities were a social activity (grooming, playing, copulating) and whether they were in close proximity

(estimated 1m) to another individual. This is important in our new framework because it helps us understand whether behaviour is happening significantly more at the endings of social interactions than asocial activity endings, i.e., whether such behaviour is really socially charged.

Table 1. Parting types and their definitions.

	Solo Departure	**Interaction End**	**Proximity Departure**
Individuals present	Solo individual (no individuals within 1 m)	Dyad (within 1 m)	Dyad (within 1 m)
Activity end	End solo activity, e.g., rest, forage, self-groom	End joint activity, e.g., groom, play, or copulate	End solo activity (at least one of the dyad), e.g., rest, forage, or self-groom
Movement	Moves away from current spot (>1 m)	Move away from one another (>1 m)	Move away from one another (>1 m)

2.2. *Analyses*

All analyses were conducted in R version 3.6.3 (R Core Team, Vienna, Austria). Analyses were conducted at the observation level, where each observation contributed one data point. Each observation had all independent variables associated with it (parting type, individuals in dyad, and duration of interaction). The dependent variables for each observation were measured in the three-minute preparting window and included the presence or absence and the frequency of each candidate behaviour. We predicted, based on the social definition of leave taking [1], that leave taking would be significantly more likely in social separation, compared to proximity separation or solo departure.

A multilevel approach was applied to account for the fact that repeated individuals are used across observations in order to avoid pseudoreplication, i.e., each individual contributes to more than one observation and, therefore, more than one data point. This approach is ideal for a situation of repeated individuals and multiple levels, avoiding the atomistic and ecological fallacies [39] by modelling individuals and their contexts simultaneously. It also allows for missing data and the imbalance of the model, while accounting for individual differences [40]. Ultimately, this allowed an understanding of whether the current framework for measuring leave taking is both appropriate and useful.

The analysis took a multivariate approach. As leave taking had never previously been studied in this context, we began with a descriptive investigation of what behaviours occur in the preparting window. Although these behaviours are defined and measured as distinct occurrences, it is possible that there is correlation between occurrences of different behaviours, e.g., individuals that exhibit self-scratching might also be more likely to show other behaviours such as directional eye gaze or weight shift. In this sense, we cannot treat these independent variables as truly independent of one another, and, therefore, we must use a multivariate approach. These outcomes were nested within each observation, and the structure of the model allowed both the relationship of the independent variables to be assessed, as well as the effects of other factors on these variables.

"Choice" of behaviour can be modelled in two ways: multinomial and multivariate. Multinomial models assume the independence of irrelevant alternatives, i.e., the choices are mutually exclusive. Behavioural choices, such as those in the current study, are not mutually exclusive and may relate to more than one correlated behaviour at once. For example, in each observation, self-scratch and weight shift are not mutually exclusive; both are possible to co-occur. Therefore, we used a multivariate model, allowing for possible contemporaneous correlation in the three candidate leave-taking behaviours.

This study took two approaches: binary leave-taking presence/absence and frequency count of the behaviour in the preparting window. Thus, we needed a model that could account for multivariate binary and count outcomes. There were two types of correlation that we needed to be aware of: correlation within individuals and correlation between

possible outcomes. The General Linear Mixed Models (GLMMs) generally work well for the clustered or multilevel aspect of data analysis, but can also be extended to allow for multivariate comparisons. This is performed by creating multiple GLMMs for each response variable, and combining the responses in a single model by imposing a joint multivariate normal distribution for the variable-specific random effects. A multivariate probit model estimates several correlated binary outcomes jointly, and the Poisson version of this model can do the same for count (frequency) data. The package McGLM provides a general statistical modelling framework for normal and non-normal multivariate data analysis, designed to handle multivariate response variables. Thus, the predictions were that the candidate leave-taking behaviours would be significantly more likfmczffely to be present (binary model) and greater in frequency (frequency model) in the social condition, than the proximity or solo conditions.

2.3. Study Site, Subjects, and Protocol

2.3.1. Gorongosa National Park

Videos were taken for this study across three months of field work (August, October, and November of 2018) in Chitengo camp, Gorongosa National Park. The first month was to test recording protocols and collect ad libitum data [41]. Following this, daily following of the baboons was conducted and videos taken during the latter two months, totalling over 65 hours of footage. This was carried out opportunistically (albeit trying to randomize across subgroups) while following to capture as many interactions as possible, rather than filming individual focal dyads.

The park itself covers 4067 m^2 across central Mozambique, where the base camp, Chitengo, is the home range of two troops. One of these troops, comprising of 37 individuals (Table 2), is the focus of this study, chosen due to previous identification of these individuals. Within this troop, 15 juveniles were excluded, leading to a sample of 22 adult individuals in the present study. Infants were also excluded due to a lack of comparable separation with the adult counterparts. Although future studies would benefit from valuable data on infant and juvenile separations, lack of identification at the present time prevents the control of individual replication. Additionally, we would benefit from first establishing an understanding of adult baboon leave taking, before expanding this to investigate the developmental process of the behaviour.

Table 2. Summary of population demographics.

Adult Males	Adult Females	Juveniles	Troop Total
10	12	15	37

Importantly, baboons of Gorongosa National Park experience a mosaic of habitats including closed-canopy savannah, rainforest, montane grasslands, rivers, and caves [42–45]. Modern environments analogous to the ones inhabited in the past by Australopithecines 4.2 to 2.3 million years ago "certainly included present day Gorongosa National Park" [46]. The camp is a tourist camp with cabins, a campsite, a restaurant, and safaris and, thus, the population is well-habituated to observer presence at close range. On the other hand, this means that the behaviour of these animals is contextualised in an anthropogenic environment, which could lead to some idiosyncrasies that are not necessarily representative of the species. Despite this, the open terrain and well-habituated troop make this setting and population ideal for recording everyday interactions of baboons.

2.3.2. Data Collection Protocol

Open access event-logging software, BORIS, was used to collect behavioural data from digitally imported videos [34] (Figure 2). This gave the advantage of rewinding from separation to record prior behaviour, something that is almost impossible to collect in real time. The unit of measurement for this study was "observations", which was defined as

being from the start of an activity (solo or joint) to the moment where the departure (solo or joint) occurs. Dyads were chosen opportunistically and exhaustively throughout the video footage, and the parting individual was defined as the first to leave the dyad (or the only individual in the case of solo activity). For each observation, the unique video ID was recorded and the observations numbered.

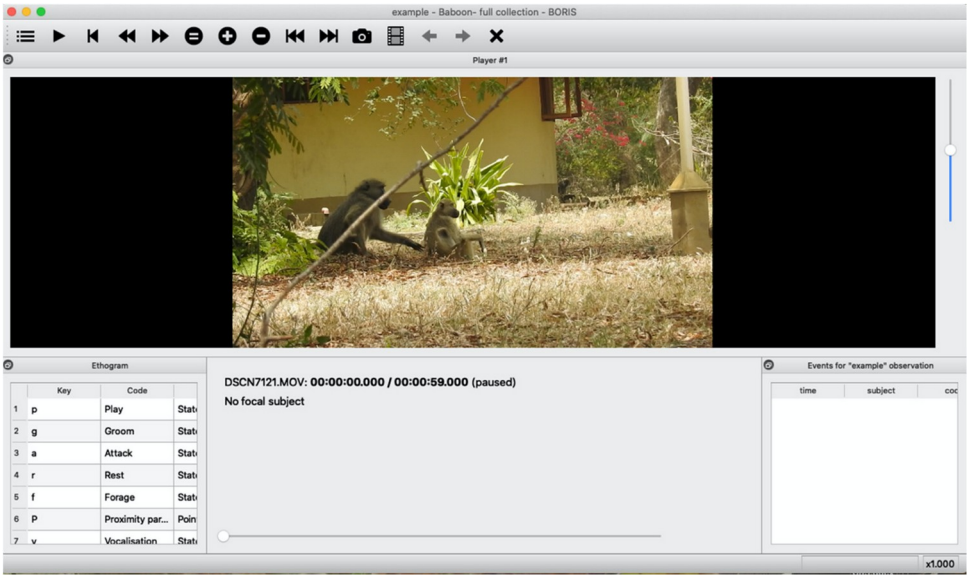


Figure 2. Screenshot of BORIS software.

Over 500 dyad observations were initially identified from the 65 hours of video footage. This number is relatively low due to excluding nonadult and unidentifiable dyads. Additionally, low visibility impacted the final number of analysed observations. Those including behaviours that could not be fully coded were removed, such as observations where foliage or other individuals obscured view. Furthermore, some observations had no clear separation, for example, if the camera cut out or vision became impaired by another individual. Observations in which the ending was caused by the joining of the third individual (or a second in the case of solo observations) were also excluded. Finally, observations that were interrupted or where the parting individual was followed were removed, as they did not meet the criteria for intentional separation. Thus, the sample of fully coded behaviours was reduced to 204. Although this sample was small, we were able to control for interindividual variation and test the presence of candidate leave-taking behaviours in social interaction endings.

3. Results

These observations fall across the three categories outlined above: solo, proximity, and social. The numbers of observations in each category can be seen below in Table 3. The variation in number between the three types of separation is controlled for in the analysis.

Table 3. Number of observations by parting type.

Parting Type	Number of Observations
Solo	100
Proximity	43
Social	61
Total	204

The context of observations was limited; the majority included contexts of rest, foraging, and grooming. However, as context correlated so strongly with parting type (see Figure 3), only parting type was used in the present analysis, due to the focus on the social driver of leave taking.

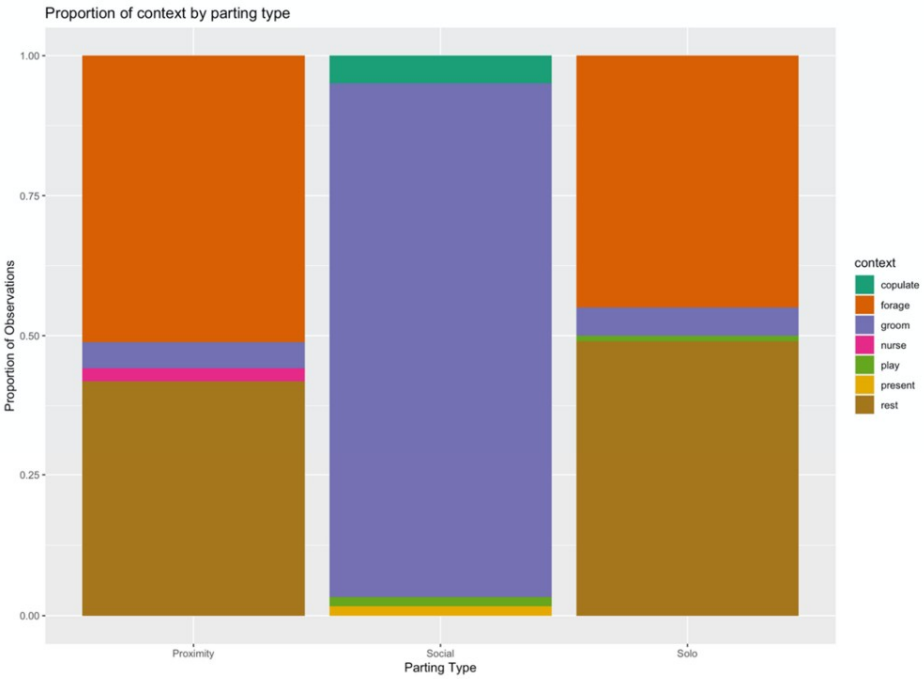
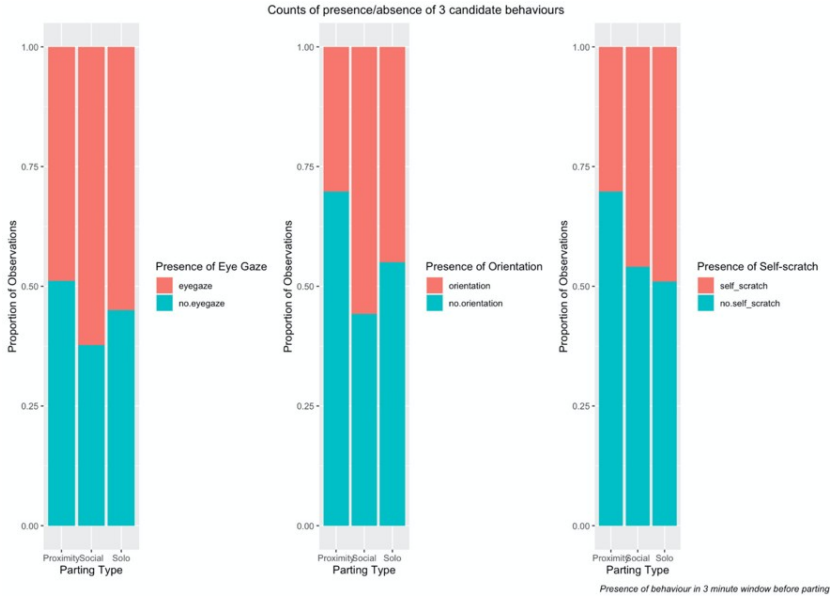


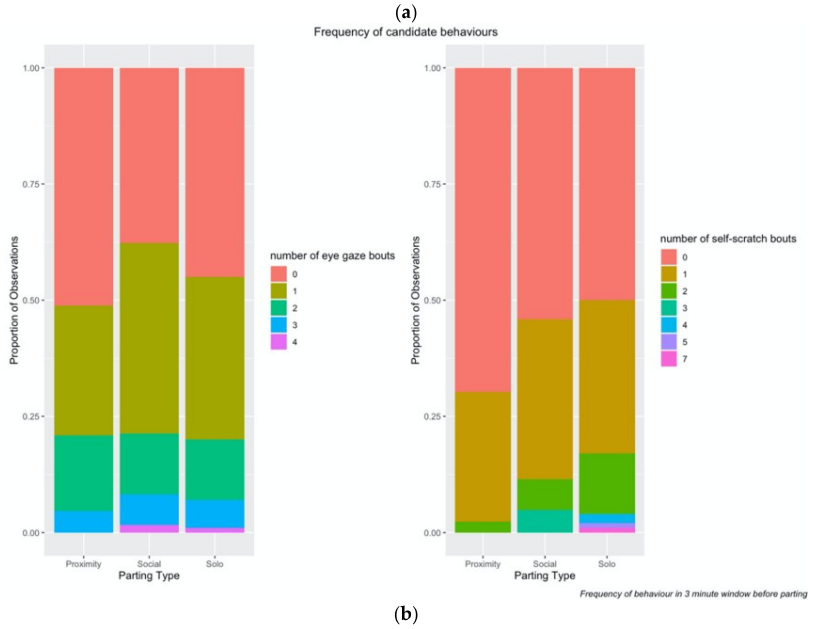
Figure 3. Proportion of context by parting type.

There was also variation in the number of observations per individual, likely due to the variation in habituation. In the final sample of observations, only 22 individuals were identified out of the possible 37 due to the exclusion of juveniles. Furthermore, adult females Zoe (n = 3) and Maddie (n = 3) were observed much less frequently. Others, such as adult male Arrow (n = 16), were over-represented in the sample. Individual ID was included in the models to account for this.

Figure 4a,b illustrate the exploratory analysis of the data. Figure 4a shows the proportion of total observations (n = 204) where each of the three candidate behaviours was present and absent. Similarly, Figure 4b shows the frequency of each candidate behaviour across total observations (n = 204). These two outputs (presence/absence and frequency) reflect the basis for the two strands of investigation.



(**a**)



(**b**)

Figure 4. (**a**): Proportion of observations where candidate behaviours were present/absent. (**b**): Proportion of observations with each count of candidate behaviours.

3.1. IO Reliability

We assessed interobserver reliability with a second person who was naïve to the hypotheses coding over 10% of the observations. The observations used in interobserver reliability were taken at regular intervals throughout the full dataset to ensure a true cross-section of the data was compared. We considered our data to be reliably collected if the proportions of agreement between two observers using Cohen's kappa were significantly different from those expected by chance. Cohen's kappa values (CK) are considered fair if ranging from 0.4 to 0.6 and good if between 0.6 and 0.8 [47]. Interobserver reliability was deemed good; all measures produced similarity that was significantly more than would be expected by chance (presence of self-scratch, CK = 0.741, $p \leq 0.000$; frequency of self-scratch, CK = 0.652, $p \leq 0.000$; presence of gaze, CK = 0.502, $p = 0.004$; frequency of gaze, CK = 0.551, $p \leq 0.000$; and orientation, CK = 0.584, $p = 0.001$).

3.2. Statistical Analysis

We used focal sampling to record the possible leave taking of chacma baboons, investigating which of the candidate behaviours occurred, and how often, in the three minutes before parting. We analysed 205 observations in 22 individuals across solo, proximity, and social endings. We predicted, based on the social definition of leave taking [1], that behaviours would be significantly more likely in social separation compared to proximity separation or solo departure.

Self-scratching was produced in 90 observations, eye gaze in the direction of parting in 114 observations, and orientation towards parting direction in 92 observations. Observations had a mean duration of 163.66 seconds and a range of 5.05–913.86 s.

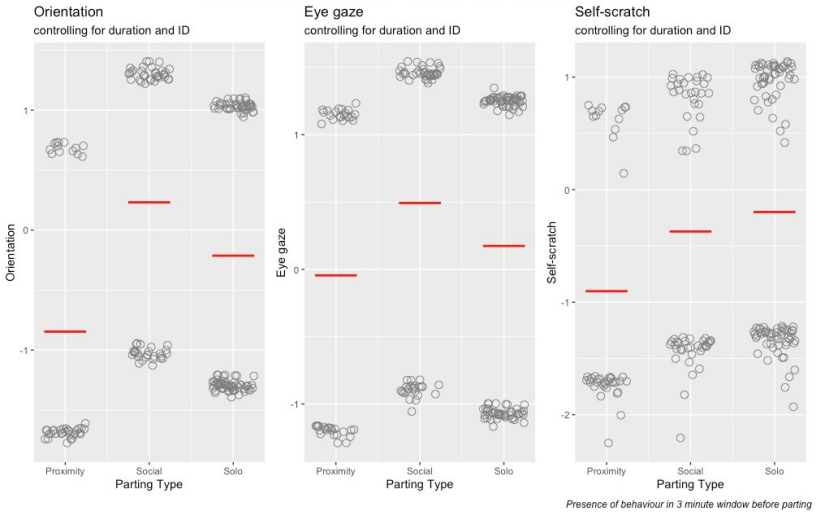
We calculated Cook's distances to look for influential observations that could affect the models [48]. We identified around six potentially influential observations for self-scratch, four for eye gaze, and six for orientation that could be considered outliers; however, we decided not to remove them as this variation could reflect true differences in the frequency of behaviour. Thus, we decided to run and interpret all observations to obtain first insights into leave-taking behaviour that is, as of yet, unstudied in its own right in wild nonhuman species.

Multivariate response variable regression models allow multiple response variables to be included within one model (while holding them constant) instead of conducting several models separately, and they estimate the correlation between each response variable [49]. The models included the duration of interaction and parting type as covariates. Duration was a continuous predictor covariate and parting type had categories of social, proximity, and solo context. We included individual ID for the leaving and remaining individual as random effects to account for the repeated measures and avoid pseudoreplication. We ran two multivariate models. The first had the three response variables measured as binary outcomes (0 = behaviour absent, 1 = behaviour present, in the three-minute window prior to parting) for self-scratch, eye gaze in the direction of parting, and orientation in the direction of parting, and are referred to hereafter as the "binary" models. The second had eye gaze in the direction of parting and self-scratch measured as counts, i.e., frequency of occurrences in the three-minute window prior to parting, together with the original binary measure for orientation, and are referred to hereafter as the "frequency" models.

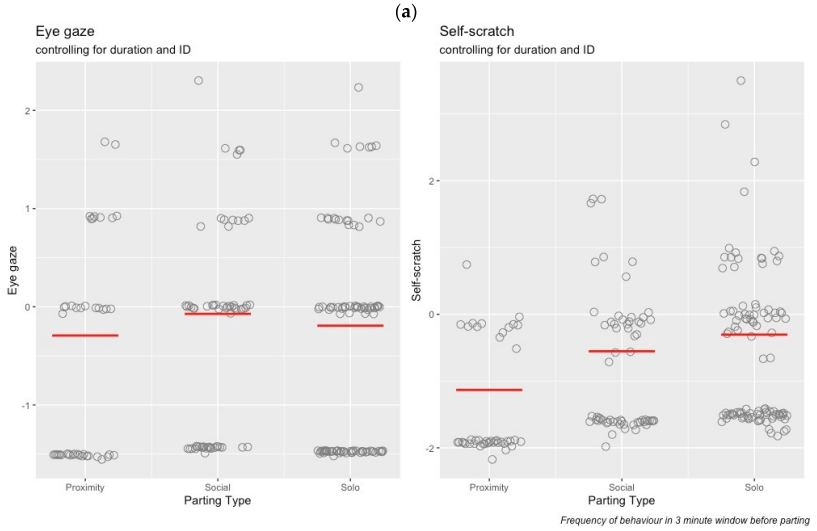
A combination of logit and gamma-log error distributions was used in the models depending on the residual normality of each response variable. We used pseudo-Akaike's information criterion (pAIC) values calculated in 'mcglm' to determine model selection [49]. The pAIC is similar to Akaike's information criterion (AIC) used in model selection but contains penalty terms to account for multiple response variables in the model.

Figure 5a,b were created using the package "visreg" [50] and illustrate the conditional relationship between the candidate behaviour and parting type. They take account of the other factors of interest, specifically, duration of interaction and individual ID. The fitted model was used to predict values of the response variable (depicted as grey circles), across the range of the chosen explanatory variable (x axis), along with the regression line. The

other variables were set to their median value (for numeric variables) or most frequent category (for categorical variables). Thus, for Figure 5a, we can see that controlling for ID and duration, there were differences in the presence of candidate behaviours across the parting types. Similarly, for Figure 5b, we can see that there was some difference in frequency of self-scratch across parting type, controlling for ID and duration, whereas there was little difference in the frequency of eye gaze in the direction of parting when controlling for the same factors. The following models in the next section will investigate whether these apparent differences are statistically significant.



(**a**)



(**b**)

Figure 5. (**a**,**b**) Relationship between candidate behaviour presence and parting type.

After residual analysis and diagnosis (see Tables S1 and S2, and Figures S1–S4), the interpretations of the models are presented. We predicted, based on the social definition of leave taking [1], that behaviour is significantly more likely in social separation, compared to proximity separation or solo departure. Tables 4–7 present the estimates of the regression parameters by the models, where 4 relates to the binary model (a for orientation, b for eye gaze and c for self-scratch) and 5 the frequency model (a for eye gaze and b for self-scratch). The tables show the regression parameter estimates, standard errors (SE), odds ratio (OR) with 95% CI, and z-statistics and p values. Table 4 illustrates that social parting type is significantly associated with orientation. Table 5 illustrates that presence of orientation is associated with social parting type, and frequency of self-scratch is associated with solo parting type.

Table 4. Regression parameter estimates for joint binary model.

	Effects	Estimate	SE	z-Statistics	p-Value
Eye gaze	Intercept	−0.0649759376	0.3287922059	−0.1976201	0.8433423
	Duration	0.0002494702	0.0008174598	0.3051774	0.7602310
	Parting type (social)	0.5343620581	0.4121778865	1.2964355	0.1948255
	Parting type (solo)	0.2090787868	0.3727807890	0.5608626	0.5748912
Self-scratch	Intercept	−1.106534038	0.3591822027	−3.080704	0.002065119
	Duration	0.002242691	0.0008856267	2.532321	0.011331019
	Parting type (social)	0.526836372	0.4339131629	1.214152	0.224689829
	Parting type (solo)	0.697408563	0.3983954436	1.750544	0.080024571
Orientation	Intercept	0.8690858410	0.3574207691	−2.4315482	0.01503445
	Duration	0.0002375434	0.0008119219	0.2925692	0.76985144
	Parting type (social)	1.0857820340	0.4292195876	2.5296656	0.01141713 *
	Parting type (solo)	0.6328640846	0.3964570247	1.5962993	0.11042198

* denotes statistically significant values (p-value < 0.05).

Table 5. Standard errors (SE), odds ratio (OR) with 95% CI, and z-statistics and p values for joint binary model.

	OR	2.5%	97.5%	p-Value
Solo	1.000	0.999	1.002	0.760
Proximity	1.706	0.761	3.828	0.195
Social	1.233	0.594	2.559	0.575

Table 6. Regression parameter estimates for joint frequency model.

	Effects	Estimate	SE	z-Statistics	p-Value
Eye gaze	Intercept	2.87×10^{-4}	0.1913975773	−1.50156733	0.1332089
	Duration	1.35×10^{-5}	0.0004388482	0.03064973	0.9755489
	Parting type (social)	2.12×10^{-1}	0.2297794091	0.92129348	0.3568972
	Parting type (solo)	8.94×10^{-2}	0.2161082851	0.41380489	0.6790170
Self-scratch	Intercept	−1.2261484383	0.3109283951	−3.943507	0.0000802985
	Duration	0.0008138371	0.0004770604	1.705942	0.0880189587
	Parting type (social)	0.5824369726	0.3587461767	1.623535	0.1044750885
	Parting type (solo)	0.8417835343	0.3312493396	2.541238	0.0110460580 *
Orientation	Intercept	0.8690858410	−0.3574207691	−2.4315482	0.01503445
	Duration	0.0002375434	0.0008119219	0.2925692	0.76985144
	Parting type (social)	1.0857820340	0.4292195876	2.5296656	0.01141713 *
	Parting type (solo)	0.6328640846	0.3964570247	1.5962993	0.11042198

* denotes statistically significant values (p-value < 0.05).

Table 7. Standard errors (SE), odds ratio (OR) with 95% CI, and z-statistics and *p* values for joint frequency model.

	OR	2.5%	97.5%	*p*-Value
Solo	1.000	0.999	1.001	0.976
Proximity	1.236	0.788	1.939	0.357
Social	1.094	0.716	1.670	0.679

4. Discussion

4.1. Evolutionary Context

This was the first time that control conditions were used to investigate the presence of leave taking in a wild nonhuman primate: here, the chacma baboon (*Papio ursinus*). We showed that, through controlling for leaving close proximity and solo activities, it is possible to measure leave taking in the wild. This is the first indication of leave taking, as a measure of ending social behaviours [1], existing beyond humans.

Our results support the significance of shifting orientation to the direction of parting in the three-minute window before social separation. Increased frequency of self-scratch was associated more strongly with the solo condition, which could be due to increased anxiety of staying with the group, moving away alone, or beginning a social interaction.

This provides preliminary evidence that social separation in baboons drives behaviour, specifically orientating in the direction of parting, and opens up a number of research hypotheses about the function of leave taking across species, such as managing separation [11], increasing the affiliative nature of interactions [51], or mitigating risky ends to interactions [52]. The results also extend Lorenz's idea of "intention movements" [53] (p. 256), where initiating behaviours are understood by conspecifics. The current study distinguishes itself from Lorenz's framework by eliminating instances where the behaviour is "imitated" or "contagious", i.e., where the conspecific would also leave. The current study is concerned only with those instances where separation of dyads occurs, not "synchronised, collective cohesion" [1] (p. 10).

The presence of leave taking in baboons could suggest a deep evolutionary history of the behaviour, present since the last common ancestors of humans and baboons. Further investigation would be needed to determine the presence of leave taking in other baboon species and in more closely related species to humans such as chimpanzees or other great apes. Compared to a lack of association with orientation in the direction of parting in solo and proximity separations, this suggests that the behaviour plays a uniquely social role that could have evolved for a social function. This paves the way for understanding how leave taking functions in natural, spontaneous interactions; for example, it may assist in strengthening social bonds [51] or in minimising aggression [54].

4.2. Towards a New Framework for Leave Taking

4.2.1. Definition

This study provides evidence that a social definition [1] is a useful way of determining leave taking, and that separation from close proximity is not enough to drive leave-taking behaviours. This echoes earlier assertions that leave taking is a uniquely social behaviour (e.g., [6,55,56]) and parallels assumptions about human leave taking occurring solely to manage social interaction and expectations (e.g., [6,57]). This builds upon Lockard's previous work [11] claiming that "focused interaction is a necessary pre-condition", from using a control of moving away together in the same direction.

4.2.2. Control Conditions

Thus, by extension, this study supports the use of definitional controls, such as separation from close proximity and solo departure, to infer the presence of leave taking before social separation. Similarly, using the length of interaction prevented behaviours that could be due to restlessness being attributed to leave taking. Such a paradigm could,

and should, be applied across species and populations to further investigate the evolution of leave taking in nonhumans.

4.2.3. Levels of Separation

This also strengthens the idea of levels of separation, including the idea that leave taking could exist even in cohesive groups because of the need to successfully end social interactions [1]. This framework suggests that we need to include enquiry on different levels of separation, e.g., daily recurrent separations, and not just group-level separations such as fission or permanent separations such as group transfer. Thus, the presence of leave taking in a species such as baboons, that is typically considered cohesive [58], parallels what we see in the literature on human leave taking where both short-term, low-level separations (e.g., [11,13,59]) and long-term, high-level separations exist and are of interest [60].

4.2.4. Data Collection Methods

This study pertains to the comment from Albert and Kessler [6] on the methodologies of leave-taking study, where they hypothesise that good research will only be possible once technology improves sufficiently to capture the fleeting nature of leave taking. This is exactly what our method achieves, both through the use of recorded high-quality video footage and the video-coding software, allowing behaviours to be retrospectively coded in minute detail at greater speed and accuracy. It means that videos can be rewound, rewatched, and slowed down to improve data validity, especially cross-observer validity. Furthermore, video archives are more accessible as they can be studied remotely now and in the future. The data collection software with a predetermined ethogram means that the same method can be applied across species and populations.

4.2.5. Candidate Behaviours

Unlike most of the literature on human leave taking, this study focused only on nonvocal behaviours. Pilot observations prior to this study and indications from existing literature were able to help us identify orientation behaviour that appears to be significant prior to parting. Compared to studies such as that by Knapp et al. [35], a narrower range of candidate behaviours were used due to the application to nonhuman primates. However, it seems that there is some overlap in leave-taking behaviours across species. For example, body orientation is found in both baboons and humans, where greeting involves orienting to face one another [56] (p. 74), and leave taking involves visual-orienting signs such as turning away [13]. This is suggested in humans to signal readiness to depart, rather than simply moving away [11]. In humans, these behaviours are thought to be used to buffer verbal cues, although there is no evidence that this is the case in chacma baboons. Interestingly, conversation analysis has recently been extended to baboon behaviour with regard to orientation in greeting sequences [61]. Such studies provide support for our findings of shifting orientation as a way to break social contact and offer an exciting method to extend baboon leave-taking research.

In summary, this study provides a definition with controls, a method, and novel candidate behaviours, which together facilitate cross-species research on leave taking. Together, this gives a clear advantage over previous definitions, not least because it can be applied across species, but also because it strengthens support for the presence of such behaviours. This allows us to further investigate the evolutionary origins of leave taking, to understand how and when it has evolved as a universal behaviour in humans.

4.2.6. Limitations

There are several limiting factors of this study, most notably that this method has thus far only been tested on a single population. It remains to be seen whether it will provide evidence for leave taking in others. Despite the sample population providing a good basis for close-range video footage and behavioural-data collection, our archive gave a limited context of behaviours, possibly affected by the anthropogenic environment. The sample

size was also regrettably limited by external factors which did not allow all individuals to be identified or endings to be coded. More data collection was impossible to achieve due to the constraints posed by the COVID 19 pandemic. Automated video identification and behavioural recognition software would speed up the data collection process and account for less human error than manual coding [62].

We cannot assume that these leave-taking behaviours have been produced intentionally. Support for the social definition suggests that shifting orientation occurs significantly before ending social interactions. However, we do not yet know enough to determine whether this behaviour could constitute an intentionally produced signal of departure. One alternative explanation could be that this behaviour is more likely at the end of social interactions because of increased anxiety, in the same way predator calls were once understood [63]. Nonetheless, we cannot rule out the possibility that this is an intentionally produced gesture. Further research will test this hypothesis using previously established methods to deduce intentionality.

5. Conclusions

One of the most interesting aspects of these results is that orientation in the direction of parting is more likely when leaving the social condition, as compared to the close-proximity condition, suggesting this behaviour is dependent on social interaction itself and not just the presence of other individuals. Ongoing research will look in greater detail at the dyad to determine whether this is an intentional signal of departure and whether there is a social function. Context is also important, as our results suggest that baboon leave taking is variable and not a social constraint upon leaving as in humans [56].

Interestingly, self-scratching prior to parting was significant in the solo condition. This also warrants exploration, particularly with regard to anxiety of separation from the group. Although not significant in the social condition, self-scratching did occur in many social partings, deserving further investigation as to whether there is a particular social context for its occurrence. The signal precursor route hypothesis suggests that social signals can arise from unintentionally produced asocial behaviours [11] and become specialised over time to convey information more effectively [64]. Self-directed behaviours, e.g., head scratching and beard stroking, are reported in humans as relating to uncertainty or anxiety [65], similar to their counterpart behaviours in nonhuman primates, e.g., scratching or fumbling [66]. Despite this, there is little relating these behaviours to separation specifically. Features of human cognition such as theory of mind and empathy could explain why human leave taking has become more elaborated, although potentially rooted in similar emotional, anxiety-related responses. This should be further investigated in relation to self-scratch behaviours to determine their role in solo departures.

These results also open up the possibility of repeating the study across baboon subspecies, increasing our understanding of the cultural and ecological variation that may exist in leave taking, as it does for greeting [67]. Differences in aggressive behaviour, social cohesion, and female-bondedness may affect this propensity to leave take, and baboons would offer an ideal model species to investigate this given the radiation of related species across Africa [68]. The lack of risk in Gorongosa National Park could also impact these results: baboons there spend more time on the ground compared to other populations [45] and this could increase opportunities for such short-term, recurrent social interactions. Such opportunities increase visual proximity, and as such, leave taking may be a necessary adaptation to social life on the ground. Expanding this framework across other predominantly terrestrial species, such as chimpanzees, would help to begin exploring this idea.

The results of this study demonstrate that leave taking may not, after all, be a result of "unique and terribly human interpersonal forces", as claimed by Knapp [35] (p. 182). Instead, as Goffman stated, animal versions of goodbye are much harder to establish than human versions [69], but the improvements in animal behaviour research and technology have indeed made this feat possible, as predicted by Albert and Kessler [6]. Our results expand previous work on non-human leave-taking [70,71], to provide a replicable frame-

work to compare across species. The benefits of a measurable definition, control conditions, levels of separation, digital methods, and choice of candidate behaviours demonstrate the value of this new framework for studying leave taking beyond humans. The conclusions of this study provide the first evidence of leave-taking behaviour—orientation in the direction of parting—in a wild nonhuman population. The study offers insights into the evolutionary origins of leave taking, which could have a much deeper ancestral history than previously thought [7]. The function of this behaviour and presence in other primate species will be important in determining how it has evolved to become so prominent in modern humans.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/ani12192577/s1, Figure S1: Pearson residuals for all regression models; Figure S2: Cook's distance for all regression models; Figure S3: DFFITS for regression models; Figure S4: Half-normal plots for frequency models; Table S1: Pseudo-maximised log-likelihood values (plogLik), degrees of freedom (df), and pseudo-Akaike (pAIC) and Bayesian (pBIC) information criteria by structure; Table S2: Wald statistics (Wa), degrees of freedom (df), and p values for each model.

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Informed Consent Statement: Not applicable, as this research did not involve humans.

Data Availability Statement: The data presented in this study are available on request from the corresponding author. The data are not publicly available due to further expansion of the current study.

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Appendix 3: General Ethogram

Candidate leave-taking behaviour	**Description**
Gaze directed in direction of movement	Line of sight is in the direction the individual will move to imminently for 2 seconds or more
Self-directed touch including scratch (not groom)	All behavioural events directed towards one's own body and that have been interpreted in other studies as indicative of anxiety, including scratch, self-touch, nose touch, and body shake
Shifting body weight or orientation	Move weight from one side to the other in a shuffling motion, can include change in orientation of body

Variable	**Category**	**Definition**
ID		
Sex		
Age		
Time of day		
Parting type	Proximity departure	Individuals leave an approximate 1m radius of one another
	Joint activity end	Individuals end a shared (social) activity
	Forced ending	An interruption of the observation that disturbs the behaviours of the individuals
	Solo departure (control)	An individual moves 1m away from where it has been doing an activity
	Solo activity end (control)	Individual stops engaging in an activity it has been doing alone
Temporal and spatial	Interaction duration	Length of time (mm:ss) that shared activity lasts
	Separation duration	Length of time (mm:ss) that an individual leaves approximately 1m radius with another individual and ends interaction until it interacts with the same individual
	Follow	When an individual leaves the 1m radius and another individual moves in the same direction
	Sudden ending	
Measures of behaviour	Presence / absence	Do the candidate leave-taking behaviours occur or not in the 5 min parting window before departure?
	Frequency	How many distinct times do the candidate leave-taking behaviours occur in the 5 min parting window before departure? Distinct times refers to none continuous behaviour i.e. a pause in between
	Start time	What time (mm:ss) before departure (within the 5 min parting window) do the candidate leave-taking behaviours occur
Function criteria	Social bond	
	Rank difference	
	Valuable resources	
Intention criteria	Receiver/ signaler attention	Line of sight is in the direction of the conspecific they are in close proximity with for 2 seconds or more
	Behaviour change	Behavioural context changes i.e. because an activity stops, and can include starting a new activity

Proximity change	Individual moves closer to or further away from conspecific

a) Social affiliative contexts

Behavioural context	Description
Groom	Use both hands, pushing the hair back with the thumb or index finger of one hand and holding it back while picking at the exposed skin with the nail of the thumb or index finger of the other
Play	Wrestling, chasing non-aggressively, grappling in trees, fingering, tickling, and/or finger-wrestling
Contact	Have physical contact with another individual but without
Food share	Allow another individual to take food that is under the control of the owner
Present	Move so that perinneal region is pointed directly toward another. The tail must be at least a little raised, but can occur with a full-out tail up.
Copulating	Intromission and pelvic thrusting between male and estrous female
Mount	Position body over another from the rear, so their genital region is just behind the other's genital region
Inspect	Look over, sniff or otherwise investigate another individual
Nursing	Infant is suckling from adult female

b) Social agonistic contexts

Behavioural context	Description
Attack	Aggressive physical contact between two, or more individuals, includes "push", "pull", "kick", "hit", "grab", "slap", "bite", "drag", "charge", "stamp", "pinch", and "scratch"
Chase	Run after a fleeing individual, in order to grab it in aggression
Displace	A move toward B and takes the position in which B was previously while B moves away (there may be bodily contact during this shift, and there is at least one moment when A & B are within 1 meter of one another

c) Non social behavioural contexts

Behavioural context	Description
Eat	Remove foodstuff from the substrate, process, put into mouth, bite and chew, wadge and swallow it
Forage or process	Stationary use of hands to manipulate parts of plants, turn over rocks, or dig in ground/leaf litter in an apparent search for food, often but not always followed by consumption of food items
Self-groom	Use hands, pushing the hair back with the thumb or index finger and holding it back while picking at the exposed skin
Move	Locomotion, including walking, running, and climbing
Rest	Remain immobile 'sit' or 'lie', including 'sleep'
Use tool	Extract an object from the outer environment and use it with certain

purpose e.g. hammer and anvil in Bossou chimpanzee to crack nuts

Appendix 4: Chapter 4 supplementary material

Table S4.1: Inter-rater reliability scores across the independent variables

	Kappa	**z-score**	**p-value**
Self-scratch	0.741	4.19	2.78e-05
Eye gaze	0.502	2.86	0.00421
Orientation	0.584	3.31	0.000947

Table S4.2 – Pseudo-maximised log-likelihood values (plogLik), degrees of freedom (df) and pseudo-Akaike (pAIC) and Bayesian (pBIC) information criteria by structure

		plogLik	**Df**	**pAIC**	**pBIC**
Independent binary	MV	-428.14	18	892.28	971.7812
	UV	-429.99	15	889.98	956.2310
Joint binary	MV	-427.87	21	897.74	990.4914
	UV	-429.75	18	895.50	975.0012
Independent frequency	MV	-678.77	18	1393.54	1473.0412
	UV	-694.58	16	1425.16	1491.8277
Joint frequency	MV	-678.57	21	1399.14	1491.8914
	UV	-694.54	18	1425.08	1504.5812

Table S4.3- Wald statistics (Wa), degrees of freedom (df) and p values for each model (*denotes statistically significant covariates)

Model	Effects	Covariate	Wald (Wa)	Df	p-value
Joint binary	Eye gaze	Duration	0.0931	1	0.7602
		Parting type	1.7964	2	0.4073
	Self-scratch	Duration	6.4126	1	0.0113*
		Parting type	3.0663	2	0.2159
	Orientation	Duration	0.0764	1	0.7823
		Parting type	6.4438	2	0.0399*
Joint frequency	Eye gaze	Duration	0.0009	1	0.9755
		Parting type	0.9330	2	0.6272
	Self-scratch	Duration	2.9102	1	0.0880
		Parting type	6.8474	2	0.0326*
	Orientation	Duration	0.0856	1	0.7699
		Parting type	6.4263	2	0.0402*

Figure S4.1 – Pearson residuals for all regression models

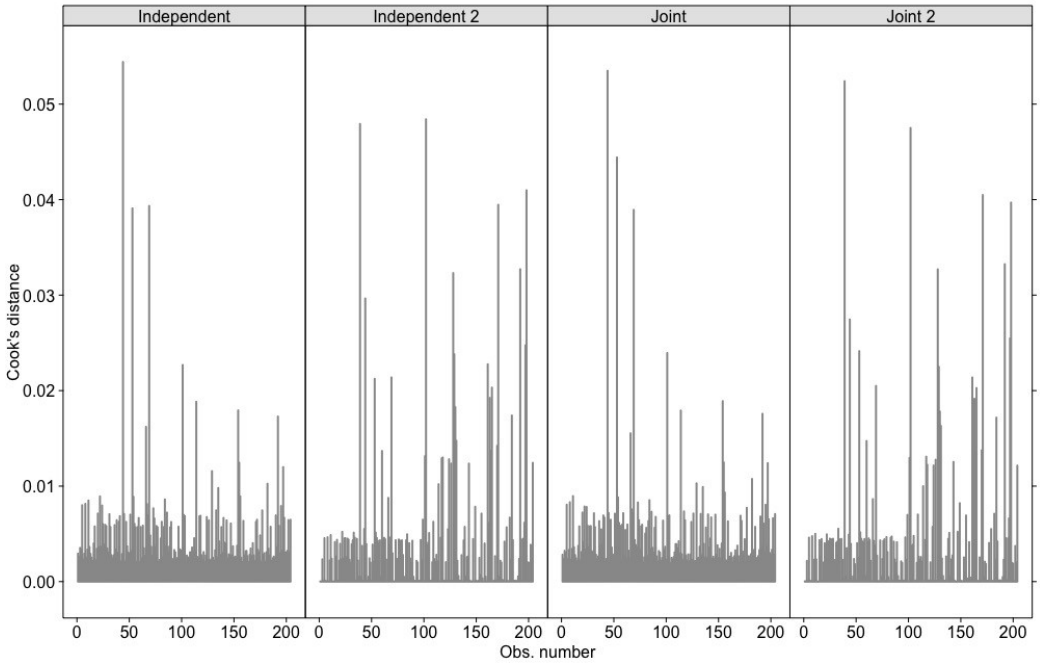


Figure S4.2 – Cook's distance for all regression models

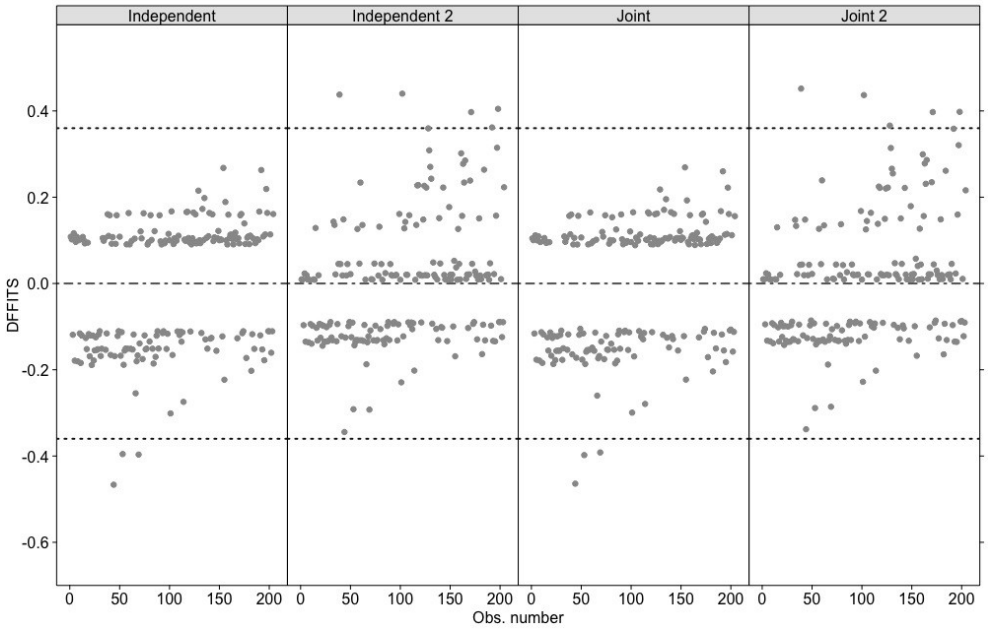


Figure S4.3 – DFFITS for regression models

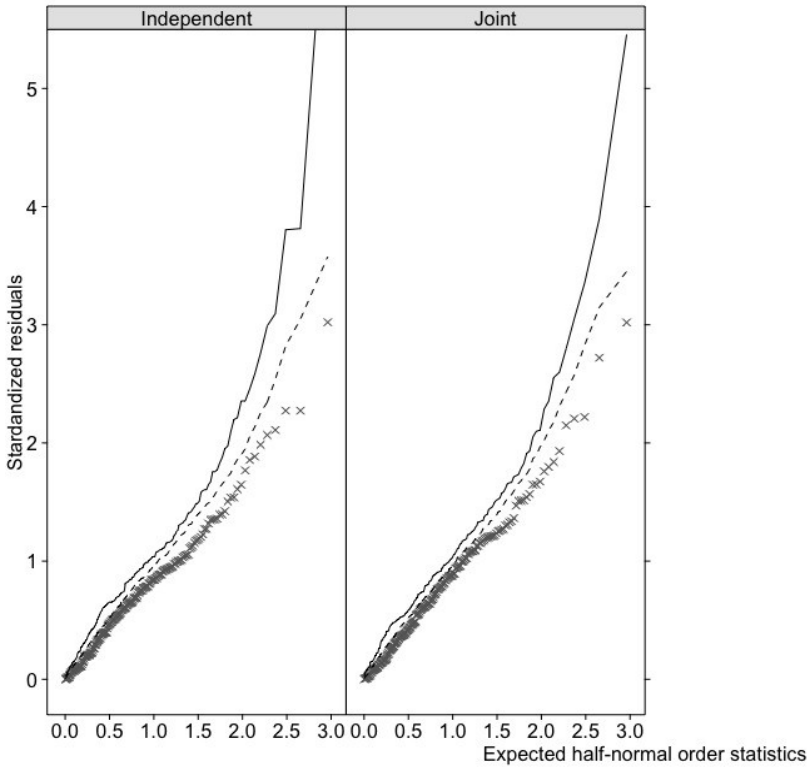


Figure S4.4- Half normal plots for frequency models: independent and joint

Appendix 5: Chapter 5 supplementary material

Table S5.1: Inter-rater reliability scores across the independent variables

	Kappa	**z-score**	**p-value**
Orientation	0.468	2.47	0.0134
Audience attention	0.459	2.44	0.0146
Audience checking	0.444	1.99	0.0469
Audience response	0.5	2.58	0.00982

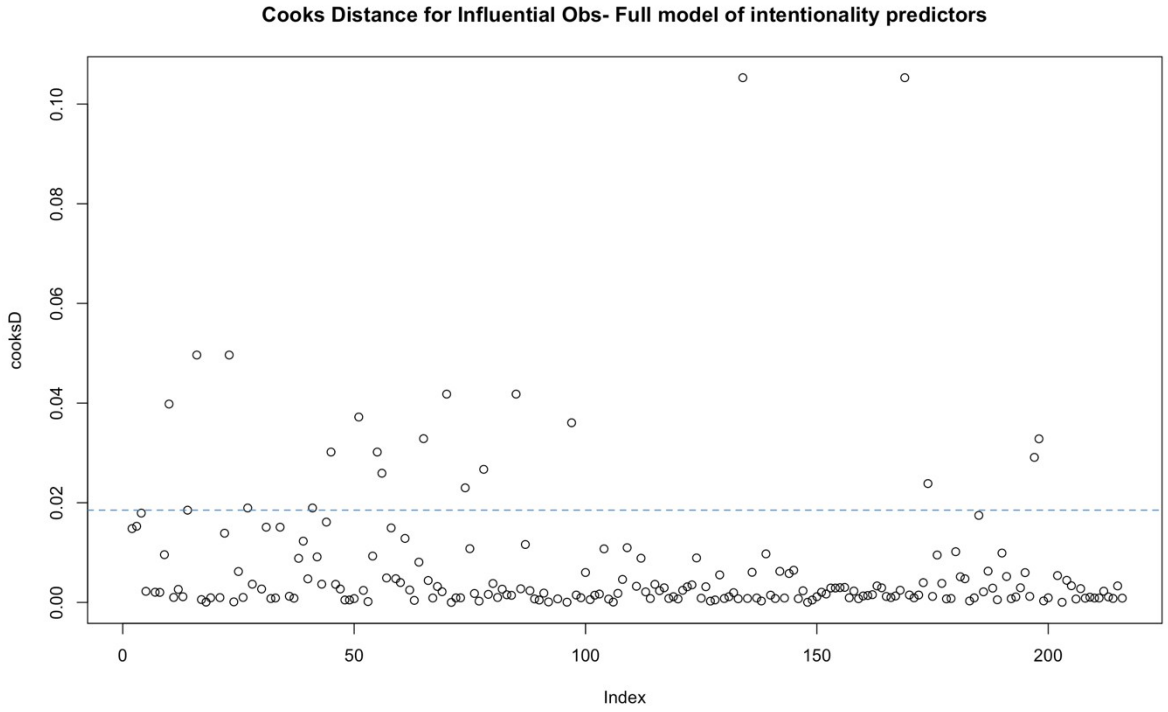


Figure S5.1: Cooks distance for each of the intentionality variables with 4/n threshold marked

Table S5.2: Comparison of null and full models

	AIC	**BIC**	X^2	**df**	**p-value**
Null	304.9	318.40	-	-	-
Full	305.9	349.77	17.006	9	**0.04863***

Table S5.3: VIF values for each of the predictor variables

Variable	**Duration**	**Dyad**	**Audience checking**	**Audience attention**	**Audience response**
VIF	1.003464	1.030218	1.190564	1.168797	1.007917

Appendix 6: Chapter 6 supplementary material

Table S6.1: Inter-rater reliability scores across the independent variables

	Kappa	**z-score**	**p-value**
Orientation	0.468	2.47	0.0134
Social exchange	1	4.47	7.74c-06
Valuable resource	0.579	2.85	0.00431
Distract	0.643	3.08	0.00208
Imitate	0.643	3.08	0.002008
Replace	0.444	1.99	0.0469

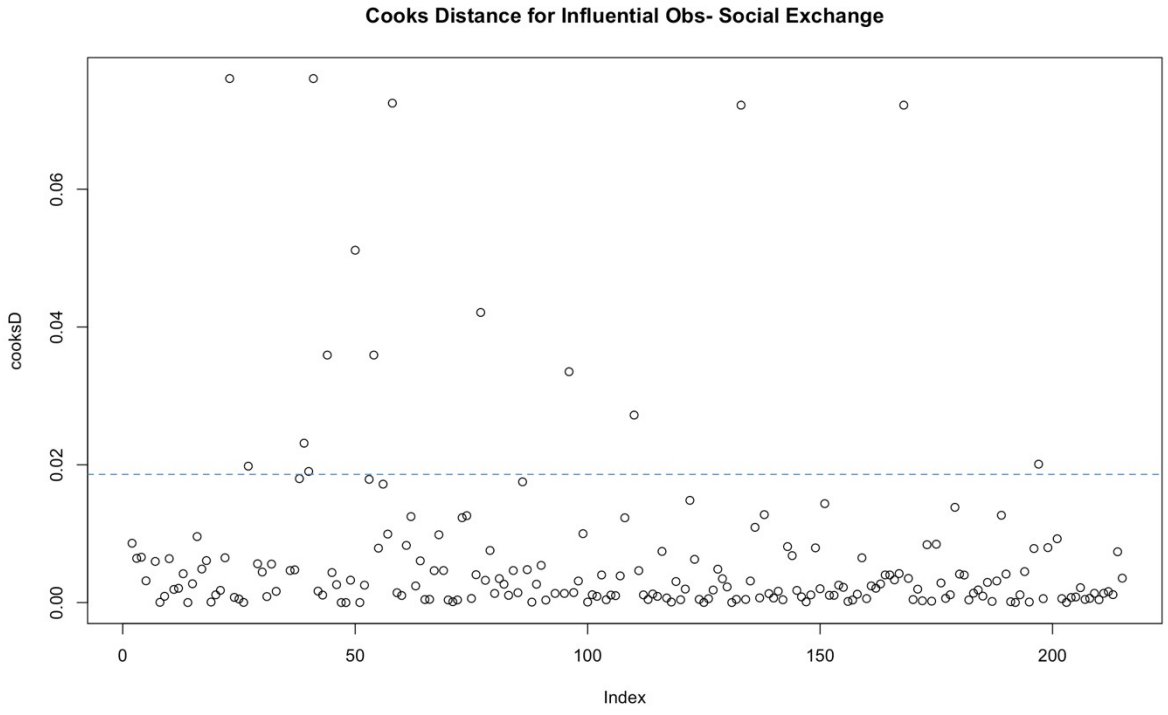


Figure S6.1: Cooks distance for each of the intentionality variables with 4/n threshold marked

Table S6.2: Comparison of null and full models

	AIC	BIC	X^2	df	p-value
Null	303.01	313.12	-	-	-
Full	286.46	320.17	30.546	7	**7.534e-05 ***

Table S6.3: VIF values for each of the predictor variables

Variable	Distract	Imitate	Replace	Valuable Resource	Social Exchange	Duration	Copulation call
VIF	1.016865	1.011589	1.004848	1.020652	1.017587	1.008177	1.011030

Table S6.4: Results of the GLMM testing effect of all internal and external predictors on orientation at the end of social separation

	Estimate	SE	Z	CI	P
Intercept	0.3426258	0.2441980	-1.403	-0.8212449931 to 0.135993384	0.160597
Social exchange	-1.1687205	0.4162972	-2.807	-1.9846479440 to -0.352793047	0.004994*
Duration	0.0005181	0.0005617	0.922	-0.0005829206 to 0.001619031	0.356401
Copulation call	-1.1031231	1.1974057	-0.921	-3.4499951683 to 1.243748981	0.356914
Infant grab	1.0741322	0.2969876	3.617	0.4920472965 to 1.656217117	0.000298*
Distract	-0.7952663	0.5146261	-1.545	-1.8039150218 to 0.213382409	0.122267
Imitate	-0.2581361	0.4500440	-0.574	-1.1402061487 to 0.623933938	0.566252
Replace	0.6181325	0.6181325	-1.860	-2.3610233957 to 0.062011537	0.062936

Table S6.5: Results multimodel inference comparing the internal and external models

Model	K	AIC	ΔAICc	Weight
Internal	4	287.7	-	1
External	3	303.7	16.04	0

Appendix 7: Chapter 7 supplementary material

Table S7.1: Inter-rater reliability scores across the independent variables

	Kappa	**z-score**	**p-value**
Orientation	0.468	2.47	0.0134
Follow	0.5	2.58	0.00982
Breaking contact	0.5	2.34	0.0191
Valuable resource	0.579	2.85	0.00431
Consecutive interaction	0.883	3.55	0.000387

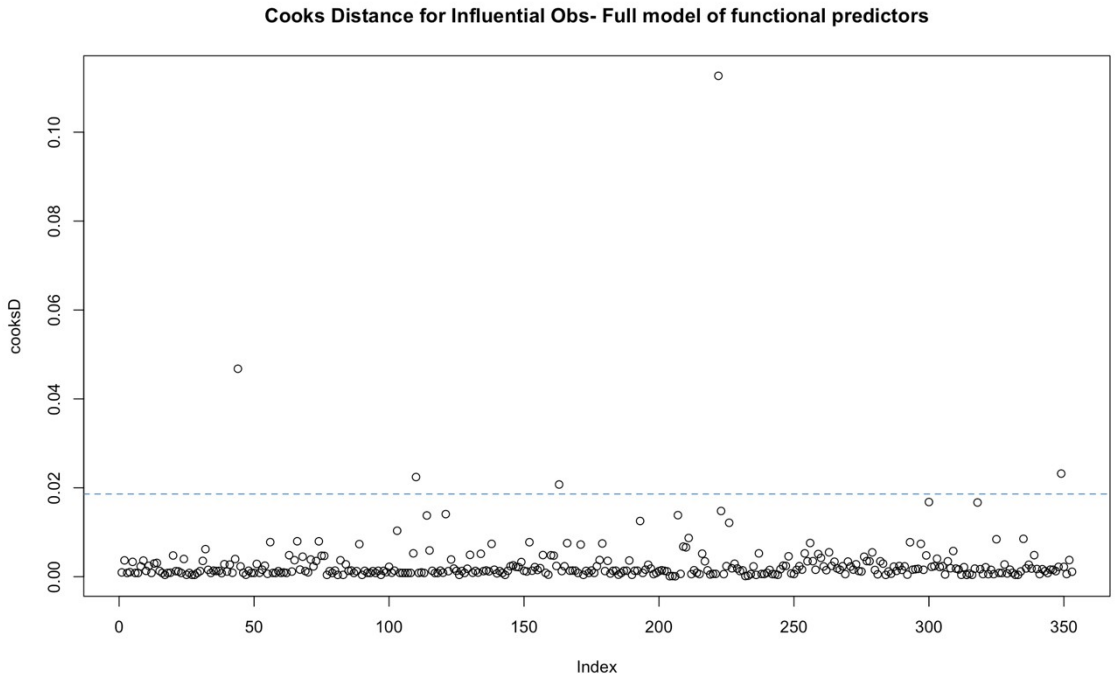


Figure S7.1: Cooks distance for the full model with 4/n threshold marked

Table S7.2: VIF values for each of the predictor variables

Variable	**Follow**	**Valuable Resource**	**Breaking Contact**	**Dyad**	**Duration**	**Sudden Ending**	**Consecutive interaction**
VIF	1.013239	1.294123	1.047086	1.124291	1.018712	1.033895	1.033554

Table S7.3: Comparison of null and full models

	AIC	BIC	X^2	df	p-value
Null	303.70	317.18	-	-	
Full	291.82	328.90	25.878	7	**0.0005296 ***

Table S7.4: Results of the GLMM testing the risk management hypothesis

	Estimate	SE	Z	CI		P
Intercept	-0.8608144	0.2627698	-3.276	-1.375833723	to	0.00105*
				-0.345795078		
Valuable resource	-0.4202783	0.3189021	-1.318	-1.045314892	to	0.187540
				0.204758363		
Breaking contact	0.5132532	0.2906928	1.766	-0.056494202	to	0.077460
				1.083000599		
Threat behaviour	1.1122033	0.3021602	3.681	0.519980153	to	0.000232*
				1.704426410		
Duration	0.0004794	0.0004546	1.055	-0.000411568	to	0.291614
				0.001370361		

Table S7.5: Results of the GLMM testing the separation hypothesis

	Estimate	**SE**	**Z**	**CI**	**P**
Intercept	-0.3373885	0.2231493	-1.512	-0.7747530369 to 0.09997599	0.13055
Sudden ending	1.3046833	1.1813681	1.104	-1.0107555136 to 3.62012216	0.26943
Follow	-1.0676212	0.4074476	-2.620	-1.8662038356 to -0.26903866	0.00879 *
Breaking contact	0.5063820	0.2835322	1.786	-0.0493308640 to 1.06209491	0.07410
Consecutive interaction	0.3317466	0.4964951	0.668	-0.6413657893 to 1.30485904	0.50402
Duration	0.0003734	0.0004296	0.869	-0.0004685702 to 0.00121542	0.38471

Table S7.6: Results of the GLMM testing the social affiliation hypothesis

	Estimate	**SE**	**Z**	**CI**	**P**
Intercept	-0.6046479	0.4550764	-1.329	-1.4965812600 to 0.287285532	0.183956
Threat behaviour	1.0315551	0.2844870	3.626	0.4739708046 to 1.589139461	0.000288*
Dyad type	-0.0463799	0.1599331	-0.290	-0.3598429790 to 0.267083208	0.771820
Duration	0.0005186	0.0005003	1.036	-0.0004620357 to 0.001499172	0.299979