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Every product needs a process: unpacking joint commitment as a process across species

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Joint commitment, the feeling of mutual obligation binding participants in a joint action, is typically conceptualized as arising by the expression and acceptance of a promise. This account limits the possibilities of investigating fledgling forms of joint commitment in actors linguistically less well-endowed than adult humans. The feeling of mutual obligation is one aspect of joint commitment (the *product*), which emerges from a *process* of signal exchange. It is gradual rather than binary; feelings of mutual obligation can vary in strength according to how explicit commitments are perceived to be. Joint commitment processes are more complex than simple promising, in at least three ways. They are affected by prior joint actions, which create precedents and conventions that can be embodied in material arrangements of institutions. Joint commitment processes also arise as solutions to generic coordination problems related to opening up, maintaining and closing down joint actions. Finally, during joint actions, additional, specific commitments are made piecemeal. These stack up over time and persist, making it difficult for participants to disengage from joint actions. These complexifications open up new perspectives for assessing joint commitment across species.

This article is part of the theme issue ‘Revisiting the human ‘interaction engine’: comparative approaches to social action coordination’.

1. Joint action and joint commitments in human and nonhuman cooperation

Individuals in many species cooperate to improve their outcomes [1,2]. But only humans are capable of participating in *joint actions* [3], assembling individual efforts into a coordinated whole on the basis of shared goals [4,5] and a sense of joint commitment [6,7]. Joint actions vary widely in their complexity, spatio-temporal extension and participants involved. Paddling a two-person canoe and gossiping with a colleague over coffee are joint actions, but so are building a ziggurat, shepherding a host of soldiers and elephants over the Alps to attack Rome or putting a human being on the moon. Much research has attempted to describe the uniquely human abilities and motivations that enable us to engage in joint actions [8].

One important feature of human joint action is *joint commitment*, the sense of obligation participants feel towards each other. Joint commitment is the ‘glue’ holding joint actions together [9] in the face of alternative actions tempting them to defect. Beyond single joint actions, joint commitment is important in maintaining personal [10] or professional relationships [11] in the modern

world. Indeed, many joint actions take place within long-term social relationships, and the commitment to the relationship facilitates the establishment of commitments to these joint actions (whereas the completion of the actions strengthens the relationship). Joint commitment is thus a central aspect of human social life that develops early (around 3 years old; [12]). Beyond the psychological and relational aspects described here, joint commitment underlies many economic [13], religious [14], political [7] and legal [15] phenomena.

The fundamental nature of joint commitment to human social life begs the question of how it may have evolved in the primate and human lineage. It is here that controversy is to be found. Prominent accounts of joint action emanating from philosophy [16,17] invoke high-level cognitive processes involving recursive attributions of intentionality [18]. In brief, joint commitments typically arise through the production of speech acts [19] like promises (but also threats, [13]) to perform particular actions. These speech acts create a reciprocal sense of obligation among participants. In these accounts, joint commitment is a binary phenomenon—a promise (*I'll buy tickets for both of us*) and its acceptance (*Great, thanks!*) instantaneously creating common ground about the nature and extent of the commitment.

These accounts of joint commitment have been foundational [20], guiding research in the linguistic coordination of joint action [3], but also on its ontogenetic and phylogenetic roots [4]. However, their treatment of the sense of obligation as a binary phenomenon leaves little room for understanding how it may have evolved from earlier forms of communication and cognition. Of course, any rudimentary sense of commitment in animals cannot match that in humans. At the very least, humans' cooperative nature, their social cognition, their capacities for symbolic communication and the institutionalized nature of their social life have transformed joint commitment phenomena [21]. However, such capacities did not appear *ex nihilo*, and many have proposed gradualist or naturalistic accounts of the evolution of the human arsenal of cognitive and motivational abilities for social interaction through the primate lineage (e.g. [22–24]). However, these accounts have not really focused on issues related to joint commitment. In this paper, then, we pull these threads and others together to build a conceptual framework for research exploring joint commitment using criteria appropriate for both humans and animals.

Such a framework needs to build on a richer understanding of joint commitment. As a first step (§2) we revisit a distinction [17] between joint commitment as a product and as a process. Joint commitment-as-product refers to the sense of commitment that participants feel, that is the feeling of normative obligation to each other and to completing the joint action. Joint commitment-as-process refers to the exchange of signals between participants that creates their sense of commitment. That is, the sense of commitment (the product) emerges from the signal exchange (the process). Research has tended to focus on joint commitment-as-product but neglected joint commitment-as-process.

Second, the sense of commitment is not necessarily an all-or-nothing experience. It can be gradual, with mutually known commitment as one end of a continuum of certainty [25]. In other words, the possibility of implicit commitments established by other means besides explicit speech acts like promises, needs to be recognized (§3).

A third step entails unpacking the complexity of joint commitment-as-process, which goes far beyond speech acts like promises. This is done (§4) by marshalling an authoritative but underappreciated body of research on human interaction [8] that describes how participants enter into, continue and exit from joint actions [3]. The orderly social processes by which they build and dissolve commitments to the various details of a joint action are amenable to cross-species comparisons of the complexity of joint commitment processes. Finally, we show how joint commitment-as-process and joint commitment-as-product are intertwined. The strength of the sense of commitment experienced is a function of the iterative exchange of signals: the more iterations participants go through to establish a commitment, the stronger is the mutual conviction about its force, that is, the sense of commitment. To paraphrase Schegloff [26], joint commitment is an 'interactional achievement'. Indeed, in joint actions, participants manage not one monolithic commitment, but multiple, stacked commitments that are continually re-negotiated [27].

2. Joint commitment: a brief state of the art

Philosophical accounts of joint actions emphasize the fact that participants in joint actions entertain 'mutual' beliefs about their acting as a part of a whole. Mutual knowledge, or common ground, involves each participant knowing that the other also knows x , and knowing that the other also knows that one knows x , and so on [28]. Various authors appeal to 'we-intentions' [29] or reduce them to individual intentions like 'I intend that we J' [16] (these accounts are well summarized in [18], or [30]).

For joint commitments, Gilbert [31, p. 146] states:

'The joint commitment of Anne and Ben is created by Anne and Ben together. A typical way in which this is done is for Anne to express to Ben her readiness to be jointly committed with him in some way, and for Ben to reciprocate with a similar expression of his own, in conditions of common knowledge. Roughly, something is common knowledge between two people if it is 'out in the open' as far as the two of them are concerned. As both understand, the joint commitment comes into being when and only when it is common knowledge that both expressions have been made'.

It is when reciprocal expressions of readiness to be committed become common ground that the normative sense of obligation to each other and to the joint action (joint commitment-as-product) arises. In Gilbert's words [17, p. 134]:

'Two or more people who jointly commit themselves in some way thereby impose a normative constraint on those two or more people as one. In other words they are the subject of this constraint, the 'one' who is constrained. This situation is the intended result of the process of joint commitment described above'.

Gilbert [32] points out that not all joint commitments involve agreements. However, this apparently simple image of how joint commitments are established is widespread, as in Kachel *et al.* [33, p. 1691]: 'Quite often humans initiate a collaborative activity by agreeing to do so; for example, one individual says 'Let's X' and the other says 'Okay' (or just begins collaborating). Gilbert [6] points out that this seemingly minor communicative act serves to create between collaborators a mutual obligation'.

The sense of mutual obligation is difficult to observe directly. However, its existence can be inferred when

participants do not uphold their part of a commitment, as when a participant is interrupted. Participants' behaviour during interruptions thus constitutes a gold standard for establishing evidence of joint commitments. For example, adults faced with an interruption of a joint action do not simply stop interacting, but take pains to suspend it in an orderly manner, by asking permission, giving explanations for the interruption, apologizing and making efforts to reconstruct the state of the action before the interruption [34].

Using experimental paradigms where participants in joint actions face defections from partners, Tomasello *et al.* have demonstrated that children react similarly to adults. Very young children (18–24 months) try to re-engage recalcitrant partners in a triadic social game [35], where the child interacts with an experimenter and an object (e.g. passing a ball back and forth). Children understand the normative force of joint commitments from 3 years on. For example, they protest when partners abruptly disengage from a collaborative game, but not when they ask permission [36], or when disengagement does not seem intentional [33]. Moreover, 3-year olds are sensitive to the difference between implicit and explicit commitments, being more likely to honour explicit commitments than implicit ones, whereas 5-year olds are equally likely to honour both kinds [37]. Further, 3.5-year-olds (but not 2.5-year-olds) keep working with partners on a joint task after having received an individual reward, until the partner also receives their reward [38].

Whether nonhuman animals pass the gold standard is controversial. An influential study [35] found that chimpanzees playing cooperative social games with a human experimenter did not attempt to re-engage experimenters who suddenly stopped playing. The authors interpreted the results (p. 640) as evidence for a 'uniquely human form of cooperative activity involving shared intentionality that emerges in the second year of life'. This conclusion has been challenged because of confounds [39], the small sample (three individuals) and the fact that only chimpanzees were tested, in artificial interactions with human partners. Later studies with bonobos [40] and bonobos and chimpanzees [41] show substantial re-engagement rates after interruptions. Moreover, when interacting with conspecifics, bonobos re-engage social activities (e.g. social grooming) more often than solitary ones (e.g. self-grooming), suggesting an additional sensitivity to 'jointness', above and beyond the potentially pleasurable nature of the activity itself [42].

An empirical controversy about whether great apes experience a sense of joint commitment or not does not necessarily constitute a problem for philosophically based accounts of joint commitment. Indeed, it may potentially attest to the usefulness of the account for interspecies comparisons. However, this account obscures a range of animal and human behaviours potentially relevant to joint commitment and is not even a realistic model of joint commitments in humans.

3. Problems with philosophical accounts of joint commitment

Several commentators have pointed out issues with philosophical accounts of joint action and joint commitment. They are overly intellectualized, which makes them difficult to apply to cooperation not involving adult humans (e.g.

children, nonhuman animals or artificial agents), they tend to emphasize planning at the expense of implementation, neglecting lower-level cognitive processes and knowledge structures, and they remain difficult to apply to animals [18,24,39].

Philosophical accounts are difficult to apply to animals because they emphasize symbolic communication at the expense of other means of expressing commitment. As such, they are difficult to reconcile with, for example, the extensive literature on honest signalling developed in economics [43,44] and evolutionary biology [45]. This literature suggests that overt and explicit linguistic expressions of readiness to commit are not credible signals of commitment, but 'cheap talk' [46]. Indeed, the emergence of efficient means of communication like language may have created an adaptive challenge for cooperation, by increasing the opportunities for Machiavellian individuals to manipulate partners and for free-riders to benefit from public goods. The evolution of costly credibility-enhancing displays [47] like religious rituals or difficult-to-fake evidence of emotional states [48] or physiological dispositions [49] points to the importance of nonlinguistic behaviour in communicating commitment. In summary, then, natural selection has probably led to the emergence of the ability for commitment even before the human lineage.

A closer look at the account of joint commitment as a process of reciprocal expressions of readiness to be committed becoming common ground suggests it may not even constitute a necessary nor a sufficient condition for joint commitment in humans [30].

It is not a sufficient condition because many speech acts that explicitly entail commitments do not necessarily function that way. A case in point concerns *ostensible invitations* (*let's do lunch sometime*, [50]), proposals that are not meant to be taken seriously. Such invitations can even be accepted by invitees (*yes, let's*), but the process by which they are established makes it clear for all parties that they are only pretending to extend and accept the invitation. The ubiquity of ostensible invitations robs even seriously intended invitations, proposals or promises of their potentially binding character without sufficient effort by participants to demonstrate that they are indeed to be taken seriously. Imagine Aaliyah suggests to Bashir *Want to go to the concert tomorrow?*, and intends this invitation to be taken seriously, and imagine further that Bashir replies enthusiastically, and seriously (*Great idea, I'm in!*). Without subsequent follow-up, probably neither Aaliyah or Bashir will actually proceed to ordering tickets online. The difference between an ostensible and a seriously intended invitation thus lies in the subsequent actions that participants undertake to make their expressed commitments credible to each other [50]. That, in turn, points to the importance of the processes by which joint commitments are achieved (§4).

Explicit expression of readiness to commit is not a necessary condition for the emergence of a sense of commitment. Building on an example from Gilbert [51], Michael *et al.* [52] describe some minimal requirements for a theory of *implicit* joint commitment. Gilbert's [51] example concerns two workers, Polly and Pam, who happen to start talking to each other during a cigarette break. They repeat this practice multiple times. One day, Polly does not turn up. The next day, she apologizes for her absence, explaining that she was sick. According to Gilbert, this example illustrates that it

has become common knowledge between Polly and Pam that they meet each day for a cigarette and a chat, even though this was never explicitly agreed upon. Joint commitments can emerge gradually and implicitly [32]. Michael *et al.* [52] describe a minimal framework for the sense of commitment, that does not require explicit statements like promises. It specifies the motivational states, cognitive processes and situational factors that lead to a sense of commitment. In brief, that an individual has a particular goal and perceives another individual as being in a position to contribute to fulfilling it can generate expectations of commitment. Conversely, individuals who perceive expectations on the part of others can feel pressured into fulfilling those expectations. The authors give an example where Victor is in an elevator with the door about to close when Carla arrives, visibly in a hurry. Carla may have a sense that Victor is committing to pressing the button to keep the doors open, and Victor may feel committed to doing so because he senses Carla's expectation.

Subsequent empirical work has supported Michael *et al.*'s [52] framework. Bonalumi *et al.* [53] presented scenarios to participants describing existing implicit commitments (participants take the perspective of a protagonist) and probing their reactions to violations of those commitments. Normative opprobrium and negative emotional reactions were stronger when the protagonist on the receiving end of the violation was described as having invested more effort to maintain their part of the commitment, or when the joint action had been repeated more often. Using similar scenarios, Bonalumi *et al.* [25] showed that perceptions of whether a commitment is in effect or not depend on the degree to which those commitments (one protagonist relying on the other) are perceived as mutually known, irrespective of whether this has been explicitly expressed or not.

These studies open the door to understanding joint commitment as a graded phenomenon [52]. Participants in an unfolding joint action may feel more or less committed to it. Explicit agreements lead to strong perceptions of joint commitments being in place and probably represent one end of the continuum. However, other cues may fuel this sense of commitment. Some of these may be nonverbal signals. Children playing a cooperative game interpret particular kinds of gaze as a sign of commitment [54]. Even incidental, non-communicative behaviour is interpretable: agents perceived to be highly coordinated are also perceived to be more committed to a joint action than agents perceived as less coordinated [55]. These examples hint at the cues participants may use to infer joint commitments, but they do not exhaust the question of how mutual knowledge of commitment comes about.

4. Joint commitment as process: how the sense of commitment is interactionally achieved

Previous research is silent on the *process* by which joint commitments are achieved. Processes are usually illustrated by the trite armchair examples described in §2, or participants in the studies by Bonalumi *et al.* [53] are asked to make sense imaginary interactions (e.g. text messages to arrange meetings). Some research on children or great apes [35,54] has looked at actual communication or behaviour, but focusing on controlled situations and specific outcome variables.

We examine the process of establishing joint commitments more systematically, drawing on an authoritative body of research on human interaction, prominently featuring conversation analysis [56,57] and the psychology of language use [3], that has examined social interaction and cooperation [58] processes in detail. As we will see, this literature substantially complexifies the question of process. Joint commitments are not constituted of a single, monolithic agreement, but rather a multitude of incremental agreements that are built up, maintained and dissolved in the course of interaction. Initial, generic commitments to interact are built on existing ones even prior to interaction, and even getting participants' bodies into a spatial configuration where explicit agreements are feasible and appropriate requires coordination [59].

We examine three aspects of joint commitment processes that are more complex than previously assumed, and their implications for cross-species research on joint commitment: prior interactions, generic joint commitment processes and the incremental construction of specific commitments.

(a) Joint commitments prior to interaction

(i) In humans

Many consequential social interactions occur within existing social relationships. Humans live in environments (e.g. work, school, the home) where they repeatedly encounter the same people [60]. This often creates situations of *incipient talk* [61] where lapses in conversation do not constitute the end of the interaction. As such, most encounters are repeats of previous encounters (as in the Polly-and-Pam example, [51]). At the very least, they feature *precedents*, a powerful resource for coordinating joint action: simply doing something once creates expectations about how it could be done again [62]. Repeated precedents give rise to conventions [63], which spread among communities and self-perpetuate [64]. Massively recurring joint actions are built into institutions that populate everyday social life, in the form of routines, roles, frames, scripts or plans which create accountability, predictability and shared understanding [65].

As a result, many joint actions do not require explicit expressions of agreement [7]. Getting behind the wheel of a car implies a commitment to following the rules of the road; walking onto the tennis court as a player implies a commitment to play tennis according to the rules; and standing in line at Starbucks implies a commitment to order coffee [66]. Institutionalized commitments efficiently enable complex joint actions. A simple drive through town involves intricate predictions about how other drivers or pedestrians will behave, and the vast majority of the time, these predictions are correct.

A sense of commitment can thus emerge from the cognitive and material residues of previous interactions. These can be precedents, where the historicity of the previous interaction is still fresh for participants, or in conventions, rules, routines, and scripts, where it may be lost in the mists of the past. These constitute common ground [28], knowledge that participants mutually assume they share. Repetition of joint actions thus affects the sense of commitment, probably by providing cues about participants' expectations [25]. However, repetition also affects the processes by which joint commitments are established. It is important to note that the mutual knowledge from past interactions is not only shared in participants' brains, but encoded in the material

surroundings of institutionalized life [67], like turn signal lights on cars, lines on a tennis court, or a barista's uniform at Starbucks. These traces embody normative expectations that constrain participants' actions, making those actions predictable and the participants accountable [66,68].

(ii) In animals

Interactions between animals also occur within existing social relationships, which opens up the possibility of rudimentary forms of commitment being based on precedents encapsulated in those interactions. Social animals keep track of past interactions they have had with partners (e.g. affiliative, aggressive) or they have observed as a third party. They also represent their social relationships with others and of others (hierarchy, social bond and kinship) [69,70]. This knowledge can create precedents and expectations about how to behave with a specific partner, and how to communicate [71]. Thanks to pragmatic inference, nonspecific signals can convey highly specific information [72]. Based on a mental representation of the type of signal, the signaller's identity, recent events, the signaller's dominance rank and kinship affiliation and the signaller's and receiver's relationships with others, receivers assess the meaning of signals [73]. For instance, in baboons, listeners respond with surprise to calls violating the dominance hierarchy, suggesting they have expectations about 'rules' of call production and knowledge of the relative ranks of individuals [74]. Similarly, great apes adjust their communication to their partner's identity [42,75,76] and to their shared knowledge [77]. The development of their communicative repertoires also depends on the extent of their interactional history and social exposure [78,79]. Animals can also behave appropriately based on expectations. Chimpanzees possess expectations about the behaviour of others towards themselves as well as 'personal norms' [71]. For instance, they are more likely to cooperate with individuals known to be more tolerant [80] and other non-human primates even penalize violations of those rules [81].

Many ape and monkey species build coalitions to hunt prey or attack ingroup conspecifics or isolated outgroup individuals. Coalitions decrease risk of injury for their members but present a 'volunteer's dilemma' [82]: Individuals jumping into the fray may not be followed by partners, who have a selfish incentive to hold back, profiting from the outcome without risking injury. Coalitions thus would benefit from coordinating about joint commitment; but do they? Experiments with pairs of chimpanzees in a stag-hunt-style foraging game suggest that individuals do not coordinate before forsaking a lower-value food source for a higher-value one, with one individual taking the initiative and presumably hoping the other will join them [83]. On the other hand, in border patrolling, pairs of male chimpanzees who groom together and form within-community coalitions are more likely to patrol together [84], again suggesting a role of pre-existing relationships in coordinating commitments.

(b) Generic joint commitments

(i) In humans

Joint actions entail solving *generic* coordination problems: reaching agreements on participants, their roles, the content of the actions, and their timing and location [27]. In institutionalized interactions like ordering coffee at Starbucks, many elements are predetermined and require little to no explicit

agreements (indeed, it would be odd for participants to discuss them). Customers play their role by standing in line, and ordering and paying when it is their turn. Baristas play their role behind the counter, preparing coffee and handing it to customers. But what about impromptu joint actions? When no institutional scripts or routines are available, participants need to solve these problems *ad hoc*. When participants are physically co-present, additional coordination problems must be solved: reaching an initial commitment as to the possibility of joint action, performing the joint action and maintaining commitments to it in the face of competing joint actions, and closing down the commitments once the action is complete. There are procedures for solving these problems, which Goffman [85,86] described as the *interaction order*, that is, the rules and rituals governing social interactions in everyday life. As a result, joint actions typically unfold in three macro-level phases [3]: the opening, the main body and the closing (figure 1). In the following, we describe the generic coordination problems that must be solved in each phase and the behavioural and communicative outputs produced to those ends. These problems and outputs are described in a language-agnostic manner to maintain the potential applicability of the framework in figure 1 to humans and nonlinguistic animals alike.

Generic coordination problems in the opening phase involve *selecting partners* and *establishing mutual attention* before making intentions clear. Participants need to understand who is involved (*establish participation framework*), what type of actions are to be performed, where and when, and what the respective roles will be (*determine nature and content of activity and roles*) [27,87–89]. In the main body, transitions from one part of the action to another can be coordinated via linguistic signals like discourse markers (e.g. *and, so, but*, [90]) or back-channel utterances (*mhm, uh-huh*, [91]). In committing themselves to a joint action, participants renounce opportunities to engage in other activities and their commitments need to be continuously re-affirmed. If joint actions are interrupted, participants coordinate on suspending them by *justifying the necessity to suspend*, to avoid perceptions of breaking the commitment (thus threatening their partners' face and their own reputation, [86,92]), before *breaking mutual attention* and attending to the source of the interruption. Later, they coordinate on *reinstating the joint action*, by *checking their partners' availability* and *re-establishing mutual attention*, and resuming the previous action. Finally, in the closing phase participants coordinate on *reaching agreement to end the joint action* [61]. They then *ensure the continuity of their relationship* before *taking leave* of one another and *breaking mutual attention*.

To solve these problems, in the opening phase, various communicative and behavioural outputs are produced. The establishment of participation frameworks is evidenced by *approach* towards potential partners [88], *mutual orientation of bodies, gaze* to select participants and *mutual gaze* [93,94] to display availability [88,94] and establish mutual attention [87,95]. The opening phase also features *greeting signals* [59,96–98], and signals to determine the content (*activity-specific initiation signals*), location and timing of the joint action [3] and the respective roles of participants. Partners *greet* each other and display intentions to touch, hug or kiss each other before they even start talking [88,89,97].

In the main body, communicative and behavioural outputs include *mutual gaze*, which represents feedback and a

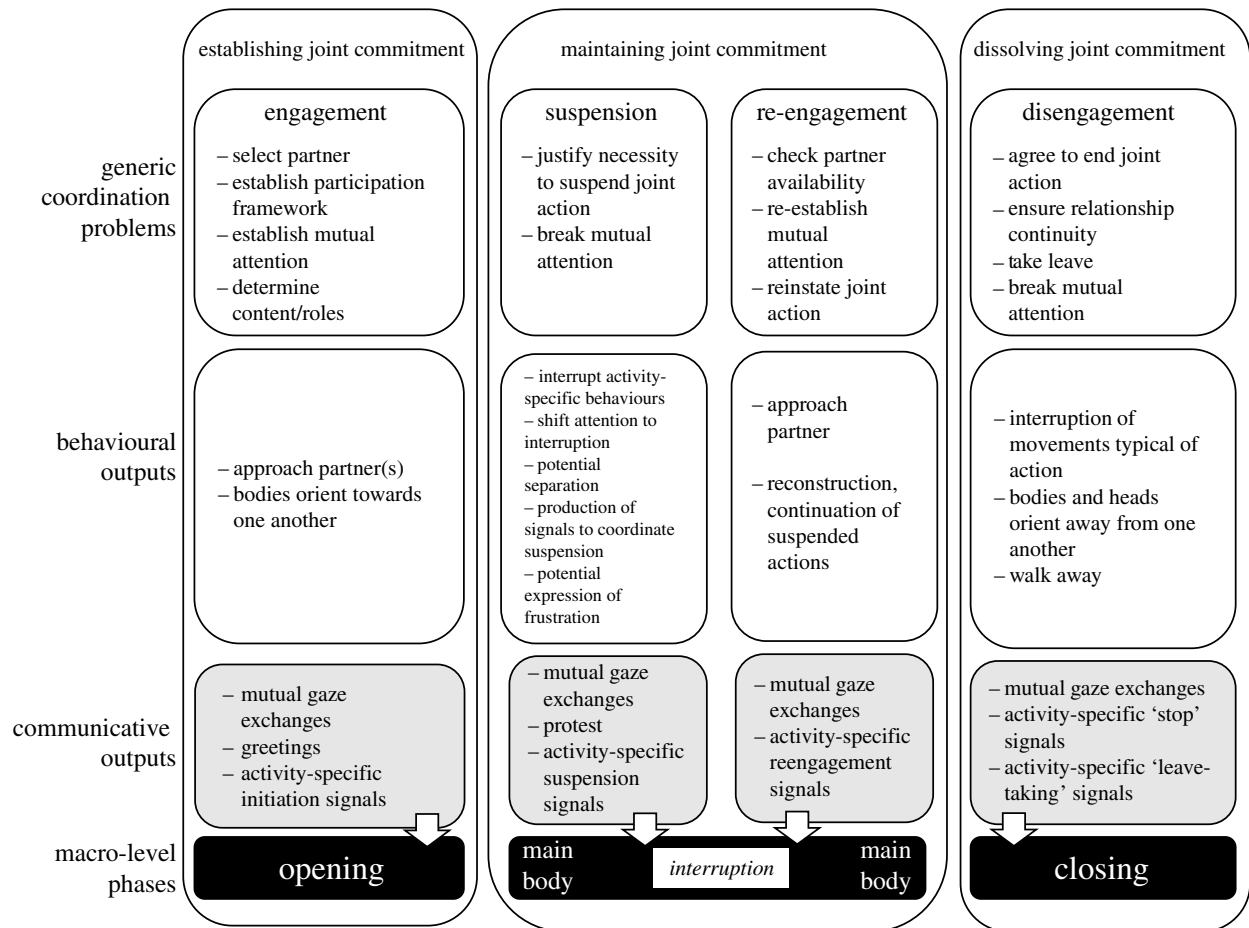


Figure 1. Joint commitment as a process. Solving generic coordination problems, behavioural and communicative outputs and corresponding phases.

way to monitor each other, or to elicit evidence of continued engagement in the activity [99]. If an interruption occurs, participants may communicate to suspend the interaction (*'suspension' signals*). The person responsible might also apologize for keeping their partners waiting (*Sorry, I have to deal with this*). If commitments are broken without appropriate acknowledgement, *manifestations of frustration, protest or sanction* can be observed. Participants reinstate the action by checking availability of their partner via *mutual gaze* [34] before re-engaging them, potentially via communicative signals (*re-engagement signals*). The activity is then reinstated by continuing the action suspended before the interruption (*continuation of behaviour*), e.g. reconstructing the topic of conversation (*Where were we?*).

In the closing phase, communicative and behavioural outputs include displays of the intention to end the interaction by *stopping related behaviours*, disrupting mutual attention and *turning bodies and heads away*, thus suggesting the upcoming end of the interaction, which remains negotiable until officially agreed upon [100]. Readiness to end is expressed through sequences like *'okay – okay'*. Once agreement has been reached, participants engage in *leave-taking*. This includes reminiscing about the encounter, expressing pleasure at having shared company, projecting continuity of the relationship to future encounters (e.g. *see you tomorrow*) and well-wishing (*good-bye*) before walking away [61,100–102].

The processes described in figure 1 reflect participants' relationship. This is evidenced in the use of politeness to manage face [92]. Threats to face increase with social distance and power difference between partners, and are compensated

with politeness. People are more polite when interacting with higher status and unfamiliar individuals, compared with lower status and familiar individuals. For instance, in closings, strangers produce more external justifications, more well-wishing statements, and more statements of positive affect than do friends [103], and friends produce less head-nodding and look away more than do strangers [104].

(ii) In animals

The phenomena in figure 1 represent a framework to compare joint commitment processes across species. For example, it can be extended to describe similar phenomena like shared intentionality in different species in the context of play [105] or grooming [106]. Some studies have documented establishment of participation frameworks in bonobos and chimpanzees [78,107]. Heesen *et al.* [42] conducted targeted interruptions of bonobos engaged in social activities. Bonobos often (greater than 80% of the time) resumed the activities after interruptions. Social activities were resumed more frequently than solitary activities, suggesting that bonobos feel some sense of commitment. Further, Heesen *et al.* [76] coded the presence and duration of potential opening and closing phases in play and grooming interactions in chimpanzees and bonobos. These phases were defined as exchanges of signals or behaviour before the main action starts (e.g. the first grooming move). Opening phases thus defined occurred in 90% of bonobo interactions and 69% of chimpanzee interactions. Openings in both species, lasted around 12 s on average. Closing phases thus defined occurred in 92% of

bonobo interactions and 86% of chimpanzee interactions, lasting around 14–17 s on average. Moreover, bonobos with closer relationships were less likely to produce openings and closings than those with more distant relationships.

In this framework (figure 1), the question remains to what extent different species use specific signals to solve these coordination problems, e.g. specific signals to open joint actions or close them. Of course, language allows expressing subtle information about the particular circumstances of an opening, closing or other phase. Many animal species have greeting signals [108], but not signals more specific to each phase, and leave-taking signals may be less frequent [109]. Mutual gaze is widespread as a potential signal of mutual orientation and commitment in humans [54,94,99] and many primate species [110]. While it is often difficult to determine its precise function, some results are suggestive of joint commitment. Miss & Burkart [111] found that marmosets engaged in a joint Simon task engage in mutual gaze significantly more often before performing a joint version of the task than a control version.

(c) Specific joint commitments

(i) In humans

It should be clear from the generic joint action processes described previously that promising and accepting is not the beginning of the joint commitment process. Although participants may try to establish explicit agreements early on, the coordination problems that must be solved in the opening phase before they can do so may take any time from seconds (one person approaching another on the street; [96]) to hours (two caravans sighting each other in the desert; [59]). Before explicitly soliciting commitments, participants often engage in pre-sequences [112] to indirectly ascertain if an invitation or offer is likely to be accepted. Moreover, even when an explicit commitment has been established (Aaliyah: *Want to go to the concert tomorrow?* Bashir: *Great idea, I'm in!*), much uncertainty remains as to how it is to be honoured, and participants need to create further more specific joint commitments. In impromptu joint actions, these are created piecemeal [27]. Thus, the next coordination problem Aaliyah and Bashir need to solve is buying tickets. Aaliyah might suggest they each buy tickets separately, or she might ask Bashir to get tickets for both of them. And so on. Going to a concert together involves the creation of multiple joint commitments following on the initial agreement.

Clark [27] proposed that joint commitments have two key properties: stacking and persistence. First, commitments *stack up* hierarchically in the course of an interaction. That is, initial commitments serve as the foundation for subsequent, more specific commitments. Second, these commitments *persist*. If Aaliyah suggests that Bashir buys tickets for both of them, and he demurs, he still remains committed to going to the concert with her. Moreover, specific commitments can be entailed by lower-level (e.g. perceptual or motor) processes once initial commitments are established [18]. Once we agree to play tennis, and I serve you the ball, you are committed to hit it back, and you will do so without so much as a fleeting thought, and so on, until one of us scores a point.

According to Clark [27], stacking and persistence explain the risky nature of joint commitments. Indeed, the more participants advance in a joint action, the more commitments they accumulate. These make it increasingly difficult to back out of the joint action and expose participants to risks

of exploitation and overcommitment. In the famous Milgram experiment, each subsequent dose of electric shocks delivered to the student by the participant constitutes an additional barrier to the participant's ability to quit (indeed, participants who did end up quitting tended to start resisting early on; [113]). The Milgram experiment is a dramatic example of how the accumulation of commitments can subtly and progressively change the nature of the original commitment. This principle is of course the foundation of many persuasion techniques like the foot-in-the-door technique, used by salespersons and con artists alike [114].

(ii) In animals

Joint action in humans is much more complex and thus requires much more specific commitments than in nonhuman animals. However, many animal species may engage incrementally in specific commitments in joint actions like play [115], where in the course of a bout, transitions between types of play or role switches (in chase play, chaser becomes chasee) are signalled by specific signals [105]. Also in coalitions formed for intergroup conflict, chimpanzees who encounter pant-hoot calls of extragroup males engage in a loud chorus of vocalizations [116], which may serve as an activity-specific commitment signal.

5. Conclusion

Joint commitment is a crucial enabling condition of joint action [17]. There is much to gain from enriching its current conceptualization, not least the potential for a better understanding of how highly mentalized joint commitments in adult humans may have emerged from earlier forms of proto-commitments in other species. We explored several potential enrichments, moving from explicit to implicit commitments and to the insight that the sense of mutual obligation at the heart of joint commitment is graded and not binary [52]. We also suggested that the processes by which joint commitments are established are as important as its product. Indeed, product and process interact: the flavour and strength of a particular sense of commitment is affected by the coordination processes by which it was brought about.

Joint commitment processes are affected by prior joint actions, which create precedents and conventions that can be embodied in material arrangements of institutions. Joint commitment processes also arise as solutions to generic coordination problems related to opening up, maintaining and closing down joint actions. Finally, in the course of joint actions, additional commitments are made piecemeal. These stack up over time and persist, making it difficult for participants to unilaterally disengage from joint actions [27]. The standard account of the joint commitment process as participants' reciprocal expressions of readiness to perform a joint action (aka agreements) is thus revealed to be a very special case.

Philosophy has made an important contribution to explicating the meanings of 'joint' or 'collective' forms of intentionality and action. However, the enriched understanding of joint commitment processes in the real world sketched out here has been enabled by several decades of empirical research on human social interaction [8]. Productive inquiry into the evolution of joint action phenomena guided by concepts and findings from interactional research [78,106] is already under way. Joint commitment is next in line.

Data accessibility. This article has no additional data.

Authors' contributions. A.B.: conceptualization, funding acquisition, writing—original draft, writing—review and editing; E.G.: conceptualization, writing—original draft, writing—review and editing; R.H.: conceptualization, writing—review and editing; F.R.: conceptualization, writing—review and editing; K.Z.: conceptualization, funding acquisition.

All authors gave final approval for publication and agreed to be held accountable for the work performed therein.

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