The Cognitive Animal

Empirical and Theoretical Perspectives on Animal Cognition

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22 Consort Turnovers as Distributed Cognition in Olive Baboons: A Systems Approach to Mind

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In a section on psychological components of tactics used by males in competition for mates, Smuts provides the following anecdote from her field observations of olive baboons (*Papio anubis*):

> Early in the morning, Dante is in consort with Andromeda. Three older males, Alex, Sherlock, and Zim, are following and harassing Dante. Their movements are so perfectly synchronized that they take on an almost dance-like quality. Sherlock and Zim stand side by side facing Dante and, in unison, they rapidly and repeatedly threaten Dante with raised brows and then glance at Alex, 20 m away, soliciting his aid. Alex lopes over to them, places one arm around Sherlock's shoulder, and all three pant-grunt at Dante in an antiphonal chorus. In one smooth motion Zim lipsmacks, touches Alex's rear, looks at him, grunts at Sherlock, and then circles around to the other side of Dante. When he is opposite Alex and Sherlock, he resumes threatening Dante and, at precisely the same instant, they do the same. Alex embraces Sherlock and, together, they circle Dante and join Zim. All three stand in contact and swivel as a unit to face Dante, who avoids them. Dante appears increasingly tense. He repeatedly interposes his body between Andromeda and the other males and then herds her away by shoving her from behind. Each time he pushes her, Andromeda squeaks in protest. She too seems tense, glancing back and forth between Dante and the other three males. A few minutes later, a fifth male, Boz, appears on the hillside above the consort pair. Alex, Sherlock, and Zim immediately solicit Boz's aid against Dante. Boz runs towards them, and at the same time the other three once again move toward Dante. Dante and Andromeda break away from each other and run in opposite directions. Zim and Sherlock chase Dante while Boz and Alex run after Andromeda. Alex reaches her first, and she stops running and lets him copulate with her. A new consortship is formed (focal consorts sample, 2 July 1983). (Smuts 1985, 153–154)

The dynamics leading to a new consortship (referred to as a consort turnover, or CTO, event) serve Smuts as the backdrop for a discussion of individual baboons as psychological beings motivated by sophisticated goals and emotions. The complex dance of activity is transformed into an argument about confidence, tension, frustration, and the ability (of a male baboon) to manipulate the emotion of others (Smuts 1985). In this essay I revisit such social dynamics and propose that alternative links between patterns of activity and their cognitive implications are possible, perhaps even necessary if we are to resolve current issues regarding the nature, development, and evolution of cognition in primates. The general framework of distributed cognition (DCog) I present here was developed by Hutchins (1995) in a human setting. Later, in collaboration with Strum and Hutchins, I adapted this framework to the study of nonhuman primates (Forster et al. 1995; Strum et al. 1997; Strum and Forster 2001).

Research Questions and the Big Picture

Students of animal behavior are, most broadly, interested in the constraints and underlying mechanisms that organize the behavioral patterns we observe. Animal cognition researchers are, more specifically, concerned with the role cognition plays in organizing and controlling behavior, with an understanding that not all behavior is necessarily cognitive and not all cognitive processes necessarily produce observable behavior. There is a more or less common ground in cognitive science, which states that the "stuff" of cognition is representational in nature, intimately related to the brain, and is (or should be) amenable to computational models (for a general review see Gardner 1983; alternatively, see Varela et al. 1991). The popular stance among cognitive scientists studying behavior is that cognition mediates between "experience" (a gloss here for "things" that happen to organisms) and behavior (certain kinds of activities that certain organisms produce; see chapters 7 and 8 in Millikan 1993). Cognitive scientists argue that trying to explain the relationship between experience and behavior without addressing cognitive (i.e., representational) structures and processes will ultimately prove inadequate.

At the core of most controversies in cognitive science are the interpretive variations on the term *representation*. Articulating the arguments is beyond the scope of this essay, yet the DCog theory presented here turns on the notion of cognition as a process of propagating and transforming representational states across representational media (Hutchins 1995). I resist making claims about representational states and media in the world of olive baboons in the wild at this point and instead count on a conceptual link between representational and informational processes (Hutchins 1995).

The outcome of cognitive research is (wistfully) expected to reveal something about the internal psychological states of animals. Moreover, the explicit assumption in much of the literature is that cognition is restricted to what goes on inside the head of individuals; thick boundaries are drawn around the cognitive unit of analysis at the surface of the skull. Historically, the notions of a mind–brain identity and of the brain as an input/output device (''black box'') for information processing got reinvigorated with the advent of computers and their mechanical and functional appeal as a model of the mind (for critiques, see Gardner 1983; Hutchins 1995; and Varela et al. 1991).

The reformulation of the cognitive science mission as the search for internal psychological states technically leaves open, not only the straightforward possibility of internal nonpsychological states, but also the possibility of external/interpersonal/supraindividual psychological states. The latter points to the realm of phenomena we are more interested in pursuing in our own research. In other words, we subscribe to the notion that although a lot of cognition happens inside the head of individuals, representational states have a tendency to ''leak'' across the internal–external boundary and the permeability of this boundary has much to do with, and much to teach us about, the nature, development, and evolution of cognition. On a continuum from cognition being only inside the head to cognition being only in the external world (e.g., Gibson 1979), distributed cognition of the Hutchins (1995) variety sits somewhere in the middle, with representational structures and processes that span the internal–external boundaries organizing behavior.

Cognition research on social behavior remains strikingly fixated on internal psychological states. The social function of intellect (Humphrey 1976), or SFI, hypothesis, more recognizable as Machiavellian intelligence (Byrne and Whiten 1988, but see Strum et al. 1997), links social behavior and cognition and has its contemporary roots in field observations of nonhuman primates (e.g., Jolly 1966; Humphrey 1976; review in Byrne and Whiten 1997), although historically the ''discovery'' of social complexity in primates was distinct from, and slightly preceded, the ''rediscovery'' of the nonhuman animal mind (Strum and Forster 2001; Strum and Fedigan 1999). SFI is an evolutionary argument stating that an increase in social complexity acted as a driving force in the evolution of higher cognition in primates. It thus encompasses the cognitive abilities of individuals as well as the evolution of cognition in primates, levels often confounded in behavioral explanations.

Social complexity was pursued during a period in which the behaviorist tradition and its moratorium on invoking mental states still haunted field researchers, finding its way into the scientific literature through behavioral ecology. This move supported the sociobiological (i.e., selfish gene) approach to explaining behavior, which inadvertently allowed a profusion of cognitive metaphors (tactics, strategies, goals, etc.) into evolutionary explanations (natural selection itself could be talked about metaphorically in intentional terms). Authors added disclaimers to texts to avoid accusations of attributing any real mentality to their subjects (e.g., Dunbar 1988), but by the time cognitive ethology (Griffin 1976; Ristau 1991) gained recognition, an easy slippage between metaphorical and real cognition permeated the literature.

Social complexity remains largely an intuitive concept and only rarely receives operational treatments (Strum et al. 1997). Indeed, the impact of SFI to date has been mainly in determining the presence or absence of specific behavioral patterns (tactical deception, imitation, cultural traditions, teaching, etc.) which supposedly indicate the presence or absence of particular in-the-head abilities (such as symbolic reference, theory of mind, order of intentionality). Moreover, these patterns and abilities are usually defined in very human-centric terms (Caro and Hauser 1992; King 1994). The evidence then fuels speculative arguments about the extent of primate social complexity, the depth of primate understanding, and of domain specificity (Byrne and Whiten 1997; Tomasello and Call 1997), among others. Even though the (social) environment presents the context for these behavioral patterns (i.e., the problem space), the locus of cognitive resources for behavioral organization and control (the solution space?) is still "seen" and sought after mostly inside the head (but see Tomasello 1999).

Our orientation remains linked in spirit to the SFI hypothesis and explores the relation of social complexity to the nature, development, and evolution of cognition. We believe this requires a more thorough examination of how social complexity plays out in these contexts (see discussion in Strum et al. 1997). Since social complexity is a relational concept, we direct our search toward relational aspects of cognitive phenomena, and are drawn to relational perspectives on cognition (e.g., Vygotsky 1978; Rogoff 1990; Lave and Wenger 1991; Fogel 1993; Cole 1996; Nunez 1996). We study socially distributed behavioral phenomena that have cognitive properties: joint decision making, distributed information processing, polyadic conflict resolution, etc.—phenomena that by their temporal pace, variability of execution, and developmental paths rule out the possibility that they are organized and controlled merely by genetic and/or maturational processes.

The exploration of these issues through research on sexual consort dynamics in baboons was undertaken for reasons that go beyond the fit to the criteria just mentioned. Historically, data on consort dynamics were also central to earlier formulations in behavioral ecology and cognitive ethology (exemplified by the opening anecdote), as well as discussions of tactical deception and other aspects of Machiavellian intelligence. Here I present research organized around dynamics like those described in Smuts's anecdote (see also Forster and Strum 1994; Strum et al. 1997). Briefly, in a female baboon, sexual consortships form in the days prior to ovulation, during which a male partner tries to monopolize access to the receptive female. Male followers and other troop members may actively participate in these efforts, especially in the dynamics that lead up to a switch in male consort partners, the consort turnover event. Here I revisit CTO events as the choice system or unit of cognitive analysis.

Theoretical and Empirical Methods

Although the current perspective is made possible only by standing on the shoulders of (a long line of) giants (see discussions and references in Strum et al. 1997; Strum and Forster 2001), I merely point here to the convergence of two "trailheads" that guide us most directly on our journey to linking social complexity and cognition: Hinde's (1983, 1987) relationship perspective on social structure and Hutchins' (1995) distributed perspective on cognition. While they do not directly overlap, both paradigms have in common an emphasis on development, dialectical relations between levels of organization in complex systems, and the employment of nonreductionist explanatory frameworks. Also, both emphasize the sociocultural context of behavior.

Hinde (1987) describes levels of social complexity (individuals ↔ interactions ↔ relationships ↔ social structure ↔ sociocultural environment) and shows how each level has properties that are not relevant to the ones below it. For example, properties of interactions, such as the level of coordination or synchronicity, are not relevant to descriptions of individual activity; the frequency of interactions over time is relevant to descriptions of relationships; and so on. Hinde's relationship perspective on social structure and its cumulative buildup from interactional data is directly relevant to our questions about social complexity. By taking the CTO event as a focal type of interaction in the context of sexual consorts, we begin to see patterns that lead to revisiting other levels of social complexity as well.

Hutchins' (1995) DCog theory suggests treating the CTO event as the unit of cognitive analysis. A cognitive system is defined by a regularly produced outcome, its boundaries flexibly dependent on an ability to identify meaningful regularities in the activity of the system as a whole. The outcome in this case is a switch in male consort partners (to the question, "What does the cognitive system do?" the answer is that the system decides who will be the next male consort partner). This is a profound analytic step since it allows us to proceed without having to first attribute goals or plans to individual participants. Identification of the switch in male consort partners as the defining outcome of a CTO event guides criteria for where to draw the boundaries of the unit of analysis, making sure that no element that is necessary to explain the outcome is left out. Although the focus here is on socially distributed processes, clearly other elements in the environment are relevant and at times are the defining factors (see a pattern of CTO events labeled "sleeping near the enemy," or SNE, in Forster and Strum 1994; Strum et al. 1997). In sexual consorts in general, the consort pair can be considered the nucleus of the system, yet a consort party may include other participants (see introductory anecdote). The system is not dependent solely on the identity of the participants and will maintain its character in the face of changing "personnel"; in this sense the description of it resembles a script with slots for prescribed roles.

While a system and its boundaries are defined by a clearly produced outcome, it is probed and studied as a process. An examination of the regularities of CTO events (Forster, in preparation) suggests a system that moves between four easily recognizable states: stable configuration (SCN), disruption (DSR), negotiation (NGT), and new configuration (NCN). All CTO events move between the four states, although the order and frequency of their expression in any given case may vary. There is a finite set of possible "flavors" for each transition to a system state; for example, there are nine ways to initiate disruption of an SCN. Significantly, these states are properties of the system and may differ from the properties of any individual participant or even of any dyad. A system state is achieved by a variety of individual activities and configurations, and conversely, an individual or dyadic activity such as grooming can "serve" a variety of system states, a many-to-many mapping, making it impossible to simply reduce system states to the activity of the elements from which they emerge. This redescription of CTO events has implications for explaining the cognitive behavior of individuals. Rather than relying on the outcome to characterize an individual (e.g., winner, loser), we can explore regularities in the way participants move through the various states, obtaining a richer cognitive profile.

This notion of process (of things changing continuously) is pursued over multiple time scales and tracked on several levels of behavioral organization: the system as a whole, the activity of individual participants, and changes in smaller behavioral units in the system (e.g., head movements). The heart of a DCog analysis is in tracking the transformation of and coordination among bits of structure on the various levels throughout the process. However, arriving at this form of description is no easy feat. It requires capturing the various levels simultaneously while preserving the ability to track each level and element separately (so that the relations between them can be empirically examined rather than assumed or extrapolated). Through repeated viewing at variable speeds, video footage of CTO events allows independent tracking of multiple agents over multiple time scales.

An examination of relational dynamics would be relevant for any discipline studying complex systems. Yet, from a traditional cognitive perspective, the most desirable aim is to give a representational account of system dynamics, which requires tracking cognitively significant elements. In human settings, the identification of representational structures is a relatively easy (or at least a less controversial) task compared with one using nonhuman primates in observational studies. What counts as representational in the world of olive baboons in the midst of sexual consort dynamics is not a settled issue and perhaps is best tested experimentally. Here I use a conceptual link between informational activities and representational processes. Representational processes are undoubtedly involved in the unfolding of CTO events, yet this early in the analysis I prefer a more conservative assumption, namely, that certain activities such as head movements are indicative of the management of attentional resources. A comparison of head movement patterns to patterns of other elements in the system (e.g., leg movements), suggests that tracking head movement dynamics is indeed relevant to "higher" cognition (on the order of decision making as opposed to that of motor control).

Internal Psychological States from a Systems Perspective

Reframing CTO dynamics in a systems perspective brings into sharp relief the ways social complexity plays out in the context of long-standing cognitive issues such as processing information, making plans and goals, and the development of skill, providing opportunities for alternative interpretations.

Head Movements Relative to Body Orientation as Information Processing

Head movements relative to body orientation (HMBO) in olive baboons were tracked separately for each participant and then represented in continuous fashion relative to two other levels of behavioral organization: activity patterns of (whole) individual participants and overall patterns of systems states and transitions (SCN, DSR, NGT, NCN) (Forster in preparation). I explored these relations across levels of behavioral organization as well as across individuals participating in the overall system, examining the coordination of movements among them. HMBO profiles of individual participants suggest polyadic monitoring and divided attention (showing as frequent side-to-side head movements while traveling in a third direction), especially before and after activity changes and around certain state transitions.

When HMBO profiles of participants are laid out in parallel, it is apparent that the combined patterns match system states and transitions in ways that are not reflected in the patterns of any of the participants individually or even of any dyadic combination. This is an analytic representation of dynamics like those conveyed in the opening anecdote. Video footage of such events makes it possible to detect the subtleties of coordination among participants. These patterns challenge assumptions about communication made in cognitive interpretations, namely, that communication can be described as a sequential exchange of signals between a sender and receiver. They also force us to reconsider the meaning of actions (i.e., their effect on the outcome). Rather than intrinsic to any particular instantiation, meaning is more likely the emergent result of the coordinated interactive unfolding of behavior distributed over the system as a whole.

Plans, Goals, and Situated Action

The discrepancies between individual and system-level properties are not resolved in any straightforward manner. In the SNE pattern of CTOs (Forster and Strum 1994), the regularities that make up a pattern (and make it identifiable as such to human observers) are distributed among the participants and other elements in their environment. This suggests a process that unfolds with equal regularity even if no single individual has an internal representational structure that matches the event as a whole. Individuals may coordinate with the system and may even anticipate the outcome and yet not have the big picture at their mental disposal (Strum et al. 1997). Instead, they may be responding to the constraints of the unfolding situation, hence "situated action" (Suchman 1987). That cognitive work in such a setting seems to get offloaded onto the environment is at times interpreted as a move to take cognition out of the head. It should rather be seen as a move to make more accurate specifications about what *has* to go inside. More significantly, it suggests how new cognitive structures and processes may arise (Hutchins 1995).

Development of Social Skill

A factor that is not necessary yet is often part of CTO systems is the presence of a young subadult male on the periphery of the consort party. Like other follower males, he synchronizes his activity with that of the consort pair, but refrains from interacting with the other participants. Only rarely will a situation unfold (usually during a prolonged NGT state) in which access to the consort female goes unchallenged by other males or is even initiated by the female. It is difficult to explain the presence of this male in terms of the odds of copulating relative to a constant monitoring effort. From a DCog perspective, however, it suggests that the larger system provides the constraints and the structure for young males to safely experience regularities and learn how to coordinate with them. This baboon analog to human legitimate peripheral participation, or LPP (Lave and Wenger 1991), is possible only during a phase in which the subadult is too small and too familiar to present any real challenge to the other males. Therefore the social context can be seen as not only defining the cognitive challenge but also as the location of cognitive resources for learning and problem solving. [For a similar LPP interpretation of agonistic buffering, see Strum and Forster (2001).]

Future Research Directions

Subcategories and Partial Systems

With systemic descriptions of CTO events, it is possible to identify subtle variations such as the SNE CTO we mentioned earlier. Behavioral patterns that share only some of the characteristics of CTO systems, such as attempt turnovers (ATOs), are also available for scrutiny. ATOs lack the definitive switch in male partners and did not figure in our cognitive analysis of CTOs. Armed with descriptive regularities of system states, we can now compare CTOs and ATOs and gain insight into the factors that influence one outcome over another.

Life Cycle Transitions

Probing CTOs as a process provided us with a richer cognitive profile of individual participation. By the same token, it provides us with the potential for finding richer developmental paths. Rather than characterizing development as a change in some measure of performance, we can explore how individual participation in CTO events changes over life cycle transitions (subadult to adult female, newcomer to long-term resident male, etc.). The transition from a young subadult male who is a legitimate peripheral participant to a fully active consort male partner or follower may address the cognitive transformation from novice to expert.

Other Contexts and Scales

This framework is easily applied to other contexts. We can examine the relational dynamics of other interactions that occur with regularity in baboon social life (e.g., agonistic buffering, Strum and Forster 2001) and adapt the DCog framework to larger-scale situations (e.g., troop movement, intertroop encounters, mobbing). We emphasized polyadic interactions in our research in order to move beyond the restrictions of imposing dyadic sequential descriptions on communicative dynamics, but there is no reason this framework cannot be applied to dyadic interactions (which often occur in greeting and in grooming). A comparison across contexts provides an alternative route for addressing issues of domain specificity and modularity.

Phylogenetic and Methodological Limits

The study of primate cognition, like that of every long-lived social species, leaves phylogenetic arguments largely in the realm of speculation (for our contribution, see Strum and Forster 2001). Population genetics may offer a measure of how distant common ancestors are, so that comparative studies of behavioral patterns across populations, species, and taxa may provide useful landmarks in the speculative landscape. Adding to the ambiguity created by scrutinizing a relatively small number of successive generations is the complexity of the life cycle itself. A comparative approach can do much to set constraints on the range of patterns a phylogenetic story needs to contend with, but a broadening of the horizons of primate-centered cognition research is crucial to its success (Cords 1997; Rowel 2000). The breadth of research described in this volume is a welcome effort.

The observational methods used in our approach leave ambiguous distinctions that a well-designed experimental setting may be able to control for. Experimental settings in which the results of observational studies are further explored have already proven valuable (e.g., Cheney and Seyfarth 1990; Seyfarth and Cheney, chapter 46 in this volume; Tomasello 1999). Nevertheless, the need to deal with context, process, and relational dynamics limits the kinds of systems that can be studied practically. Phenomena in which system-level qualitative changes are easily identified are needed so that the questions of transitions and the relations among levels can be rigorously pursued. Decades of field research on primates, especially baboons, have yielded a rich source of such phenomena that can now be revisited through the lens of systems thinking and dialectical relations.

Conclusion

I have tried to show how choices made at the outset of the cognitive science revolution (Gardner 1983) have influenced and limited the agenda of cognition research in primates. By relaxing the constraints on locating cognitive resources for behavioral organization, and by adopting a relational dynamic view of the nature and development of cognition, we are able to respond more successfully to issues that have stumped us in the past (e.g., how does social complexity affect the individual? how is it linked to cognition?) as well as to ask a whole host of new questions (e.g., how do individuals acquire the functional abilities necessary to establish and maintain coordination with system-level regularities of, say, a CTO event?). The adaptation of DCog theory and other relational perspectives to the study of nonhuman primates opens up new arenas of exploration. These are many advantages in using the primacy of the system as the basis for cognitive analysis:

- The analysis is not completely dependent on the attribution of goal states to one or more individuals.

- Meaning is not intrinsic to behavioral acts, but rather is determined by their distributed and negotiated effect on the system.
- Behavioral patterns of individuals need not get organized solely by internal mental plans.
- Richer descriptions are available for participation profiles in polyadic interactions.
- Systems become not only context and settings for cognitive problems but also resources and learning environments for solving them.
- Alternative scenarios are plausible for how individuals acquire the functional abilities to establish and maintain coordination with system-level dynamics (situated learning by LPP).

Much research is still needed to flesh out the relations between the cognitive processes that emerge in interactive distributed systems and the cognitive work done by individuals. Most significant perhaps is the need to integrate into this picture a developmental perspective that spans the life cycle. No less important though are methodologies that will help reveal representational features in the relational worlds of nonhuman animals.

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