Chimpanzee Religious Behaviors: An Answer to Jane Goodall

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Supplementary File 1. Background: Chimpanzee culture, communicative behaviors, mind and intelligence

The following provides more detailed summaries of chimpanzee culture, communicative behaviors, mind and intelligence that are briefly cited in the Background section of this study.

1. Chimpanzee intelligence.
   Developmental studies of great ape (orangutan, gorilla, chimpanzee, bonobo) intelligence indicate that they can achieve the stage of 'rudimentary (first-order) symbolic-level structures' and 'limited hierarchization and combination/recombination' abilities, which human children typically achieve from about 2 to 3.5 years of age. Great apes have a rudimentary symbolic level cognition of causality among dynamic relations between objects affected by external forces and of spatial relations, spatial knowledge and reasoning. They also have a rudimentary symbolic cognition of classification of objects including analogical reasoning, hierarchical part-whole relations, and use of abstract codes; and also of seriation (organizing object sets with respect to originality and transitivity) (Russon 2004: Table 6.2; 92-93).

2. Chimpanzee communicative behaviors.

- Goodall (1986: 127) identifies 32 distinctive chimpanzee communicative calls, which express emotions or feelings, in addition to a repertoire of communicative facial expressions, gestures and postures, and all of these can be modulated by combination and context, in single channel or multi-channel 'displays'.
- First systematic analysis of gesture in wild chimpanzees, Sonso community, Budongo, Uganda, found 66 distinct gesture types, repertoire varied between individuals and age classes; no idiosyncratic usages (by one individual only); 24 gestures overlap reported gestures in gorilla and orangutan gestures; gestures used flexibly across range of contexts, adjusted to audience (Hobaiter and Byrne 2011a); and chimpanzees regularly gesture in series, including 'bouts' of gesturing at include response waiting (Hobaiter and Byrne 2011b). Morphological analysis based on 29 features identified 30 distinctive manual gesture types, and indicates they are graded rather than discrete signals (Roberts, Vick et al 2012).
- Modulation of posture-signals ('signal-emblem'). Depending on behavioral context, 'branch-shaking' can signal (a) desire for other to approach; (b) if resting, 'Come and groom me'; (c) if traveling and other lingering, emphatic 'Follow me!'; (d) male toward female during initiation of consortship, 'Follow me!'; (e) combined with bristling, splayed thighs and penile erection, 'Come and copulate'; (f) if at snake or monitor lizard, 'Go away' (Goodall 1986: 139, 141). A Gombe juvenile Fifi invented a new communicative signal, 'wrist-shaking' to threaten an older female, which spread to others who used it in a variety of contexts for over a year until it faded away (Goodall 1986: 145).
- Modification of gesture-signals ('deictic-iconic'). Chimpanzees use pointing and iconic movement gestures to indicate how they want to be groomed (Pika and Mitani 2006).

- Modification of multi-channel 'display sequencing'. One or more chimpanzees sometimes innovate new components to modify the functional sequences of traditional courtship display, e.g., adding 'leaf-clipping' at Mahale and Bossou, but never at Gombe; a juvenile Shadow, at Gombe, dropped unproductive aggressive components of courtship display for an 'everted lip flip', which was successful (Goodall 1986: 144-145).
- Iconic (symbol displacement). At some sites but not others—thus characterizable as 'cultural'—chimpanzees 'leaf-groom', a 'signal that a male without much social status may use it to let more dominant males know that he would like to groom. The signal avoids social blunders that might draw the wrath of others in their group' (Wrangham, in Cromie 1999).
- Modulation of calls to differentiate semantic categories ('mental representation'). Chimpanzees acoustically modify rough grunts to specify particular types of preferred foods, which indicates they use mental representations (categories) (Slocombe and Zuberbühler 2005, 2006). Using a lexigram keyboard Sherman and Austin, two captive chimpanzees, acquired the ability to name objects and comprehend symbols as referents of objects. Later they could attend to one another; coordinate their communication; exchange roles of tool-requester and tool-provider; comprehend the function and intentionality of their communication; and share their access to tools and food obtained through tool use (Savage-Rumbaugh and Lewin 1994: 67, 81).
- Signal combination ('syntax') to modulate semantic intent. Taï Forest chimpanzee alpha males pant-hoot and then drum on tree buttresses to communicate location to group and direction in which drummer is progressing, which is evidence of 'symbolic communication'. They modify the drumming pattern in order to deliver at least three distinct messages: change direction of travel; take group resting period of about an hour; and—by combination of both messages—change direction and then take an hour's rest (Boesch & Boesch-Achermann 2000: 235-237).
- Shared neural substrates of communication. Taglialatela et al (2008) have discovered that portions of Broca's area in chimpanzees are active during the production of communicative signals. "Significant activation in the left IFG in conjunction with other cortical and subcortical brain areas during the production of communicative signals in chimpanzees suggests that the neurological substrates underlying language production in the human brain may have been present in the common ancestor of humans and chimpanzees."

3. <u>Chimpanzee miming and symbolic play.</u>

- Great apes in general have attained the cognitive level of basic symbolic play, including pretense, re-enacting actions (events, scripts) outside their usual context and without their usual objectives; symbolic object use, role play; miming requests (Russon 2004: Table 6.2).
- Pretend play. Chimpanzees Vickie, Austin and Sherman have exhibited pretend (symbolic) play with miming of actions, which is a stage of play typical of human children during toddler and early childhood and which is instrumental in gaining sense of self and theory of mind (Savage-Rumbaugh and Lewin 1994: 276-278). Wild chimpanzees at Bossou have been observed capturing, playing, sleeping with, and grooming hyraxes as if they were pets (Hirata et al 2001).

- 'Pan-morphism'. Just as humans may engage in anthropomorphism, projecting human-like capacities into inanimate or animate objects, chimpanzees may engage in their own form of 'morphism'. A young female chimpanzee, Gaia, carried, cradled and groomed rocks and sticks as she held them in her lap in mimicry of nurturing behavior, much as human children care for dolls, and a young female baboon is reported to have similarly groomed rocks (Wallauer 2002).
- In two captive groups (Stanford Outdoor Primate Facility; Lion Couhntry Safaris, Florida), adolescent and adult chimpanzees frequently used the bipedal swagger component of aggression displays as invitation to play (Gale and Cool 1971 cited in Goodall 1986: 144).

4. Chimpanzees sense of self or self-consciousness.

Great apes in general have developmentally achieve a rudimentary symbolic level of sense of self-awareness and self-understanding, including mirror self-recognition, indirect self-recognition in picture or shadow, self-evaluative emotions (shame, guilt, pride), self label, self conscious behavior, self-concept as causal agent, understand see-know in self ('know if you know, based on what you saw') (Russon 2004: Table 6.2).

- Sense of self. Chimpanzees modify their own pant-hoots to signal their identity to others and status of caller (level of arousal, locomotion/resting, arrival at food source) (Notman & Rendell 2005) and in addition they can change the modulation to develop a new personal signature, which may be an imitation of the pant-hoot of a deceased or other chimp. This resembles their ability to recognize themselves in mirror reflection (Boesch & Boesch-Achermann 2000: 234-235).
- A brain scan study shows that both chimpanzees and humans have high levels of activity within resting default mode brain networks (associated with ToM) in medial prefrontal and parietal cortex, but chimpanzees show higher activity in ventromedial pFC and lower activity in left-sided areas, suggesting chimpanzee resting state involves emotionally laden episodic memory retrieval and some level of mental self-projection into the past, the future, or another's individual perspective albeit in the absence of language and conceptual processing (Rilling et al 2007).

5. Theory of Mind (ToM).

- Chimpanzees more or less show one or more components of 'theory of mind' with a capacity somewhere between monkeys and humans (Tomasello et al 2003; Whiten 1994). In terms of the Baron-Cohen and Ring (1994) four-component developmental ToM model, it appears that chimpanzees can form dyadic representations of the Intentionality Detector and Eye Direction Detector but not the Shared Attention Mechanism nor the full-blown Theory of Mind Mechanism, with some dispute whether they even possess the EDD module (Baron-Cohen 2005; Scott 2001).
- Numerous studies have begun to clarify the in-between status of chimpanzee capacities. Chimpanzees like humans have a limited 'theory of mind', operationally defined as ability to 'follow a gaze to a target' and 'understanding what an actor intends to do (unsuccessfully)', although they differ in that they do not process such states with human-like language or concepts and have a lesser level of skill than humans with respect to 'theory of mind' as well as social learning and communication (Herrmann et al 2007).

They can follow gaze and 'take the visual perspective of another' (Bräuer et al 2005); distinguish with respect to intentionality 'unable' versus 'unwilling' (Call et al 2004). Flemming (2008) showed that while humans reason analogically, monkeys do not, and chimpanzees are somewhere in between. While not capable of referential (exocentric) pointing, chimpanzees do use egocentric pointing and iconic movement gestures to indicate how they want to be groomed (Pika and Mitani 2006).

- Tai Forest chimpanzee cooperation during hunting; use of feint to deceive mind of colobus monkey during hunt; imitation and teaching of technique of nut-cracking monitoring other and hiding from them; differential behaviors toward the dead, the lightly wounded and the seriously wounded, are all evidence of theory of mind (Boesch & Boesch-Achermann 2000: 242-252). While Povinelli and Povinelli (2001) challenges this account as anecdotal and not proving that chimpanzees are capable of second-order theory of mind, these behaviors appear to be examples of the 'in-between' ToM capacity of chimpanzees.
- Chimpanzees, similarly to humans, 'form abstract categories and representations of the behavior of others and reason about behaviors to make predictions of other's behavior and adjust their behavior accordingly' with respect to deception, gaze-following, hunting, etc. In addition, there is some evidence that chimpanzees like humans attribute to other beings 'first-order mental states' or 'first-order intentional states', such as 'thinking, knowing, wanting, intentions, desires, emotions and so forth', the 'rich complexity of social behavior'. But only humans attribute to other beings 'second-order mental states', such as 'seeing as attention', 'seeing or intention as the private internal experience of others', referential gaze and pointing, or 'signs as conveying information about objects', in other words, 'theory of mind', 'mentalese', or 'representation *to* the mind' as opposed to '*in*' the mind. Only humans form 'concepts about inherently unobservable things, intentions or causes'. (Vonk and Povinelli 2006; Povinelli 2004; Povinelli and Vonk 2003; Povinelli and Bering 2002; Povinelli and Giambrone 2001; Povinelli et al 2000). Compare distinction in Premack and Woodruff (1978): 'inferences about motivation; imputes wants, purposes, or affective attitudes to another individual' but not 'states of knowledge', which have 'contents'.
- Finding an appropriate name for the chimpanzee in-between capacity has varied, e.g., something like 'abstraction from overt behavior for predictions' or 'first order mental states' (Povinelli et al, see above); 'partial components' of a theory of mind (Baron-Cohen 2005; Scott 2001); 'mindreading' (Whiten 1994); ('Machiavellian intelligence' (Byrne and Whitten 1988), 'mental state attribution' (Cheyney and Seyfarth 1992); 'simulation theory' (Cruz and Gordon 2004). Chimpanzees have a 'perception-goal psychology' but do not have false-belief and therefore not 'full-fledged, human-like belief-desire psychology' (Call and Tomasello 2008).
- Neuroscience has shown different neural substrates for an affective and a cognitive ToM network (e.g., cognitive ToM, left dorsomedial PFC versus affective ToM, right ventromedial PFC; Shamay-Tsoory et al 2005; compare Baron-Cohen 2005) and Rilling et al (2007) has shown that chimpanzees have higher activity on the affective side relative to humans, but these findings appear not yet reflected in studies of chimpanzee affective versus cognitive ToM.

6. Chimpanzee culture.

- Chimpanzees have cultural practices. With respect to common chimpanzees, Whiten et al (1999) finds 39 different behavior patterns, which because they are customary or habitual in some communities but absent in others can be called 'cultural' (similarly Boesch and Tomasello 1998). Stanford (2002) adds to the list hunting behaviors as also 'cultural'. Commenting on Whiten et al (1999), de Waal (1999) concurs that it is appropriate to apply to chimpanzees the broad life sciences definition of culture, that is, the passing on of unique suites of behavioral patterns that vary from one community to another by social learning, whether by imitation, teaching or language.
- Whiten et al (1999) classifies that the chimpanzee 'rain dance' behavior as meeting the strict criteria for a 'cultural' form.

Whiten and Erdal (2012) provides an up-to-date review of the above and more recent studies on the human socio-cognitive niche in relation to chimpanzees.

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