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Research Article

Communication in a Small Herd of Semi-Domestic Elephants another Interpretation of their Social Organization, Social Contract and World View

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Summary

The communication between 6 individually identified free ranging young elephants were observed for over 200 hours (1278 elephant hours) in a nature reserve in Zimbabwe. 97 different behaviours, some explicit (whose meaning is clear) and some implicit (whose meaning is hidden), were recorded. Visual signals were the most common. The meaning of the 22 most common behaviours was assessed from recipient responses. Two surprising results were that (i) many behaviours were ignored by the recipients, and (ii) reciprocity was common. Correlations between the rank orders in the 4 different behavioural categories (aggression, affiliation, avoidance and interest) did not indicate an overall "dominance order". Rather it indicated that behaviour encouraging group cohesion (showing interest and affiliation) was much more common than any related to competition in the group (that is aggression, avoiding and withdrawing). It is argued that the large number of implicit behaviours which indicate slight arousal also indicate "uncertainty". Many behaviours 'meanings were context dependent (i.e. the same behaviour used in a variety of contexts with its particular meaning only assessable from the context). To interpret the meaning of messages in this way, elephants must be aware of others intentions and desires, as well as others' knowledge and roles in the society. The implication of these results for a different understanding of elephant's social organization and mental aptitudes are discussed.

Abstract

2140 interactions were recorded in 213 hours of observation (1278 elephant hours) in a group of 6 individually identifiable free ranging orphan elephants between 10 and 19 years old on a nature reserve in Zimbabwe. 97 defined behaviours were recorded, performed by the initiator or as responses. Visual signals, often associated with other sensory modalities (smell, taste, touch), were the most common. Vocalizations, audible to the human ear accounted for 0.5%, although infra-sound and seismic vibrations were not measured. The explicit and implicit meanings of the 22 most common behaviours were assessed from (i) recipient's responses, (ii) ethological theory & (iii) folk knowledge. Many behaviours were frequently ignored by the recipient, (14 of the 22 most common behaviours) and the recipient responded reciprocally more often than expected ($p<0.05$). In addition, 'interest' in the performer, and 'affiliation' were more common than behaviours associated with conflict or any "dominance order" ($p<0.01$). Behaviours typically produced in approach/avoidance and frustration situations were common and carried a message that the communicant was "uncertain" what to do. The rank orders in the 4 categories of batched behaviours related to their normative meanings were correlated. This indicated that individual had different roles in the society, but no evidence of any overall" dominance order". The meanings of many messages were context dependent, conveying information concerning the general level of excitement/arousal with the particular emotional state read from the context. The implication of these findings for further understanding elephants' social contract, theory of mind, epistemology and evolutionary behaviour are discussed.

Keywords: Cognition; Elephant communication; Imitation; Social ontology theory of mind

Introduction

The elephant has the largest brain of any terrestrial mammal [1]. Since species with large brains are generally reputed to possess considerable mental development [2,3], it is likely that the brain of elephants with its large olfactory lobe, hypothalamus and cerebral cortex [4,5], possesses the hardware necessary for complex cognitive functions-including sophisticated communication, social knowledge [6], social networking or "eavesdropping" [7-12] and the development of cultures, all of which influence "intelligence" [13]. A detailed study of visual communication in particular, could further elucidate their social relations and accompanying mental attributes.

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It has been widely believed that human language has an over powering influence on cognitive [14-17]. As a result, many studies have either focused on assessing whether species can learn to use an artificial human-type, context-independent language [18-22]. Anderson [23], or testing if these species have human mental characteristics such as manipulating and deceiving [6].

Communication in elephants, like that of almost all behaviours of mammals, is flexible and adaptable [24,25]. The specific meaning of the message conveyed by a particular behaviour may be independent of the context in which it occurs, that is "context independent", similar to much of human language. But it may be "context dependent", where the meaning conveys the state of arousal of the communicant, but the detailed meaning is read from the context [26,27].

Another feature of elephant's communication is that it often multi-sensory. A summary of how the different senses are used in communication follows.

Vocal communication has received most attention in a range of species including elephants (e.g. birds, whales, see forthcoming review on audition in mammals. Their auditory sensitivity ranges from infra sound to higher frequencies than humans [28]. Their vocalisations have been studied since the 1960's [24,25, 27,29,30-32] and a number of studies have focused on the use of ultra-sound by elephants to communicate over several kilometers [33-37] identification of individuals by their vocalizations [33,38,39] and communication by sensitivity to seismic movements has also been demonstrated [40-42].

Olfactory and gustatory communication are often linked but have received less attention in elephants, although they have a very large olfactory sensitive area in the trunk, taste buds on the tongue and around the mouth, and a relatively large olfactory bulb in the brain [1,6,43], mentions that they receive and analyze a great deal of olfactory information which is important to them. The vomeronasal organ attached to the base of the brain is considered to be for the careful investigation of strong, pertinent or unfamiliar smells [44]. It is uniquely large in the elephant and has paired palatal ducts, a folded epithelium and a dorso-medial position of the neuro-epithelium indicating its complexity and links to the cerebral cortex [45], and elephants perform flehmen which is associated with the vomeronasal gland [46]. They have cutaneous glands around the temple and inter-digital glands that produce steroids as well as other secretions and have been found to secrete pheromones related to sexual status. Olfactory research has concentrated on sexual pheromones [45,47-50], but elephants have sweat glands well distributed over the body [51,52], which may produce individual smells. The multi-sensory trunk acts as a hand, a nose and a mouth thus multi-sensory information is inevitably acquired. Taste plays a major role in the choice of diets of course, and frequent tasting another (see below), is likely to be important in communication, but has been little investigated to date.

Some tactile communication has been studied with the salience of the trunk demonstrated [53-55]. Elephants are capable of extraordinarily complex manipulations with the trunk; within the blind area (see below), by touching and presumably smelling, they can sort beans that they wish to eat from those that they do not (personal video), or find rings in piles of hay with their trunks (Circus Knie). Communication by touching different parts of each other's bodies also are important [53], but such movements also always have visual communicative cue.

Visual Communication has not been very carefully investigated in detail, although explicit trunk movements have been recorded. The first step is to study what they can see. First, they have dichromatic vision, like some colour blind humans [56], but further research is required. Due to the position of the eyes on either side of the large head, elephants have two large simultaneously observed monocular visual fields which enable him/her to acquire visual cues from a large area (300º). But they have a relatively small binocular visual field, approximately 25-60˚, compared to the 100-120˚ of humans. The breadth of the head with the trunk protruding directly in front of the laterally placed eyes ensures that s/he has a blind spot of approximately 2m directly in front of the head [57,58]. Both the placing of the eyes, and the two simultaneous monocular visual field, presents a different visual appreciation of the world from humans' relatively small monocular, but large binocular visual field.

It has been maintained that elephants have poor vision [51,59,60], although visual signals, such as some trunk movements [24,25,60,61] and head, tail and ear movements [24-26,29,57], have been described. Some visual displays associated with must [62] and female reproduction has also been described although these visual cues may have a biochemical foundation [63].

It is well known that elephant as well as other domestic animals react to slight visual cues indicating intentions that are emotional states. They also show an ability to imitate others [58,64], indicating perhaps emotional contagion [65,66]. These abilities have been used for centuries [67], by their handlers. Thus, such critically assessed information or "folk knowledge" must be part of any good scientific investigations, if we wish to progress in our understanding [68-71], rather than just "discovering" what is already known.

One of the objects of this paper is to report the explicit behaviours in communication (the behaviours whose meanings are clear) and to investigate the responses they cause. The implicit behaviours which have often been ignored in scientific reports, (although their meaning is often known by those who deal with elephants) have also been recorded. First, both the explicit and the implicit behaviours must be defined, their meanings critically evaluated and their involvement with other senses recognized.

Studies of explicit behaviours related to competition between individuals and this often comes with a commitment to outlining a "dominance hierarchies" [72-74]. The inclusion of both afflictive and implicit behaviours in communication might suggest different interpretations of elephant's social contract.

Non vocal signals are unlike vocalization in their communicative value because vocalizations are only made to communicate [29]. But, visual, olfactory, taste and tactile messages may have other functions and be performed without intent to communicate, even though a message concerning their emotional state may be transferred to others watching. For example when one elephant sees another putting his trunk out to smell a strange object, he receives the message that "there is something interesting there", even though the behavior was probably performed from curiosity, rather than with intent to communicate. Thus, the communicative meaning of many messages can be complex.

For many movements and vocalizations, the meaning may act as an analogue system indicating the general level of arousal of the animal so the same behavior may occur in a variety of contexts [26,27,75]. The behavior itself does not convey why s/he is in this state. For example, the elephant shakes his/her head when s/he (i) has an irritation on the head, (ii) is scared, (iii) about to attack, (iv) excited, (v) anticipating something (vi) cannot obtain a desire goal. In essence, the animal indicates that it is aroused, but "uncertain" what to do next. This has been demonstrated for many vocalisations, including the elephant rumble [27], head and tail movements in ungulates, elephants and carnivores [26,29,30]. The cause of the arousal can be traced to frustration or approach avoidance conflict [26,30,54,76-80].

Whether the individual is interested, aggressive, and friendly or is experiencing other emotions such as curiosity, fear or embarrassment [81], will be read from the context. Thus, a better understanding of visual signals and the consequent mental aptitudes could further illuminate the elephants' social contract.

Undeniably, such a study is difficult. It requires experienced observers who attend to details, are inter-observer reliable, familiar with the species and can recognize individuals. Different combinations of behaviours may be performed simultaneously so some behaviour may be missed. Although not all the olfactory messages, seismic vibrations or infra-sounds can be perceived by the human observer without special equipment, if information has been transferred it is likely that there will be some visual cues.

To date, there has been no quantitative analysis of the meaning of many of the visual messages conveyed by elephants, and the importance of their trunk for manipulation and multi-sensory communication needs further study although see Kiley-Worthington and Plotnick et al., [61,82]. As Langbauer et al., mention "more work needs to be done to elucidate the specific role of many signals".

Aims of the Study

These are:-

1. To assess the importance and multi-sensory role of visual signals in elephant communication
2. To ascertain which behaviours are most common, both from the initiators (performers) and as responses.
3. To help derive the meaning of different behaviours from the analysis of responses
4. To suggest meanings for implicit visual messages
5. To correlate the rank orders between the different behaviours and outline the implications of these results founder standing elephant social ontology, their social contract and mental aptitudes
6. To consider the evolutionary importance of this.

Elephant communication shown in figure 1

Methods

Subjects

A group of six semi-domestic African elephants (*Loxodonta africana*), five males (aged 12-19 years, all pre-musth) and one female (aged 13 years) were studied. All individuals were orphaned between 4 and 8 years old due to their mothers being shot in parts of Zimbabwe over a period of 6 years. The orphans had been captured and transported to Imire Game Ranch, Wedza. On arrival they were handled by humans and often bottle fed. After 6 months to 1 year, each was gradually introduced to the growing social group.

Figure 1: Visual gestures as three elephants begin to walk down a path.

Husbandry and daily routine

From 6pm-7am, the elephants were kept shackled by one hind leg approximately 5m apart so they could see and smell but not touch each other in a designated area, close to human accommodation (this was to protect them from poachers and to prevent them from plundering crops). Each was given 15-20kg of hay and generous bedding. None of the elephants were observed performing stereo types or other signs of prolonged distress during this study. At 6am each elephant was mucked out by a handler. The handler then spent up to 30 minutes interacting with that elephant using a restricted vocabulary of 100 words, teaching them the names for part of their bodies and to perform simple tasks to a word command with positive reinforcement of food and verbal praise, and non-violent negative reinforcement (voice & gestures). The handlers did not have an ankus, so there could be no prodding or hurting the elephant during this process. These exercises were designed to improve the handling and teaching in an interactive and co-operative way [58]. Each elephant was fed 3kg of 'game nuts' after the training session had ended. At 7am the elephants were unshackled and walked to a nearby area where the handler and tourists would mount them. They would be ridden for up to 30 minutes on different paths through the reserve. Not all elephants were ridden every day - those that were not, were left to wander around and browse until the others returned. The entire group of elephants was then released into the 500ha wild life park with indigenous vegetation & other wild and domestic herbivores. They remained under surveillance by the handlers who kept between 30 and 200m from them for the rest of the day. Surveillance was necessary to prevent the elephants plundering the commercial crops (tobacco and maize), wandering outside the park or being killed by poachers. At midday they were moved to a meeting point together with 7 black rhino (*Diceros bicornis)* who had also been orphaned and were being kept to establish a breeding group [83]. At the luncheon site, there was a lake and they could be observed by tourists from 30 to 200m distant. From approximately 2pm-5pm, the elephant again moved around freely within the park grazing or browsing and at 5pm they were herded or ridden back to their night-time accommodation, fed hay and bedded down for the night at around 6 pm. The group typically remained relatively close by choice (average distance of nearest neighbor was 30m. [64].

Observations, training of observers & inter-observer reliability

Observations of the social interactions between all the elephants were conducted between January 6th and February 28th 1996 during the day when they were free to wander around and feed in the nature reserve (between approximately 7.30am-5pm).The observations were conducted by the author, her assistant and four of the experienced handlers who had been with the elephants for more than 6 months. No behaviours were recorded when the handlers were nearer than 3m, or the elephants attention was directed at humans rather than other elephants. The observers were given 5 days training, the ethogram shown in table 1 with the definitions of each activity, a stop watch and a tape recorder. The handlers only recorded observations once the author was confident that they were able to do so comprehensively and with parity. Each observer was checked during each session to ensure that all were clear about the definitions for each activity, used only this, and was careful to observe all the behaviours of the performer and responder. Since the elephants were accustomed to the continual presence of the human handlers between 30-200m, it was unlikely that the observer's presence had a significant influence on the elephants' interactive behaviour during the observational periods.

Behaviour	Definition
1. Ignore	Make no response to behaviour directed at the recipient for 20 secs afterwards.
2. Approach /make contact	Walk directed towards another for >5steps to within 5m
3. Contact activity	Stay within 1m for at least10sec while walking/running
4. Contact break	Walk away from another for at least 10m
5. Turn body towards	Whole body and head turned towards another and take at least 3 steps.
6. Follow	Follow an individual for at least 10m
7. Turn head towards another	Turn head only towards another
8. Trunk extend towards another	Trunk held out towards another for at least 5 secs.
9. Tail wag	Slower sideways movement of tail when no obvious flies were around
10. Tail swish	Rapid move of the tail sideways at least 5 times
11. Tail up	Tail raised up above the horizontal and held for at least 5sec
12. Tail withdraw	Tail pulled tight over anus
13. Flap both ears forwards & back	Move ears back and forth at least 3 times.
14. Both ears back	Ears compressed against the head with visible muscle contraction
15. Ears pricked	Both ears forward, attention directed at something held for at least 10sec
16. Swing trunk	The hanging trunk is swung back & forth or right & left at least 5 times.
17. Trunk up	Trunk raised above head
18. Trunk down & relaxed	Trunk hanging usually on ground
19. Trunk forward investigating object	Trunk held forward to smell the object of attention better
20. Puff	Air released from trunk with a puffy noise, less abrupt & loud than "blow"
21. Blow	Sudden blast of air from trunk giving rise to sudden abrupt noise.
22. Rumble	Low amplitude and pitch rumbling vocalisation
23. Trumpet	Loud higher amplitude vocalisation with changing pitch
24. Head shake	Lateral shaking of the head at least 3 times.
25. Head nod	Up and down movement of the head at least 3 times
26. Head throw	Trunk and head thrown up and sideways at least 1 time
27. Head up	Head held up high above temple for at least 5 sec
28. Walk	Lateral 4 time walk of at least 5 paces
29. Run	Diagonal or 4x fast walk for at least 5 paces
30. Lie on sternum	Four feet spread back and forwards with weight on sternum
31. Lie flat	Lying on side with legs laterally on the ground
32. Getting up	Front feet out and heave self up
33. Wallow	Lye down and move around in water or mud
34. Urinate	Eliminating urine for at least 10sec
35. Defecate	Eliminating faeces from the anus
36. Fart	Air released through the anus making a noise
37. Sigh	Slower than normal large breathe taken in and slowly released
38. Chew	Moving lower jaw up and down at least 5 times
39. Paw	Moving front leg backwards and forwards touching the ground
40. Swing leg	Lifting a front or hind leg and swinging it back and forward in the air at least 3x
41. Raise leg front	Holding a leg in the air for at least 5 secs
42. Raise or rest hind leg	Resting one leg with weight on the other hind
43. Stamp front or hind leg	Lift leg up and down hard and faster than normal
44. Increase postural tonus	Head, tail up stand erect
45. Decrease postural tonus	Head tail and whole body relaxed
46. Tusks pushing into ground	Kneeling and pushing tusks into earth, moving head
Touch/scratch/ smell self	
47. Rub head on object	Head against object and rubbing up and down at least 3 times
48. Trunk to own mouth	
49. Trunk to own penis	
50. Trunk to own foot	
51. Scratch or rub self with trunk head & eyes	Trunk twisted to rub the different area
52. Trunk on shoulder or ears,	
53. Trunk between legs	
54. Trunk to feet or legs rubbing/investigating	
55. Any other area of body	
56. Cross legs	Stand with front or hind legs crossed
57. Erection of penis	
Scratch/smell/touch other	Recorded if trunk or parts of their bodies touch
58. Trunk into others mouth	Trunk enters open mouth of other and remains in for more than 5sc
59. Touch neck of other with trunk	
60. Touch head of other with body or trunk	
61. Touch trunk of other	
62. Entwine trunks	Twist trunks around each other
63. Nibble other's body with trunk	Trunk touching and nibbling with prehensile lips any part of another 5sc<
64. Touch leg	
65. Touch quarters of other	
66. Touch other's penis	
67. Touch between legs other	
68. Rest chin on another	Chin rested with trunk often over body

69. Trunk smelling other	Not closer than 10cm smelling particular area
70. Trunk pushing at another's face or thrown forward	Either trunk pushing or thrown at face of other
71. Smell/taste urine of other	Trunk either in urine or smelling urine on ground
72. Rub body on another	Rubbing body against any part of another's body
73. Touch tail of other with trunk	
74. Smell vulva of other with trunk	
75. Smell penis of other with trunk	
76. Mount another	
Other behaviour to another	
77. Tasting others urine	Trunk to own mouth after being in others urine.
78. Stand over another	Standing over another lying down for at least 10 sec
79. Push another with head or tusks	Head or tusks pushing another's quarters or side
80. Flehmen	Raising trunk and testing urine probably with vomero-nasal gland
81. Turning back on other	Turning face away from the other
82. Grab tail of another	Trunk holds the tail of another
83. Circle	Walk around another in a semi circle
84. Barge another	Walk fast or run at and push another
85. Watch other	Watching another carefully either with one eye or both for at least 10 secs.
86. Social Play	Touching, pushing, sparing, chasing each other without intention to hurt.
87. Object Play	Lifting/throwing/ pushing etc object
88. Push another's head	With head or tusks
89. Tusks to tusks	Pushing twisting tusks to tusks
90. Tusks to another part of body	Tusking any other part of body of other
91. Tusk to legs of other	
Avoid or withdraw from another	
92. Turn away	Turn away from another for at least 5 sec
93. Turn and walk away	Turn and walk at least 5m
94. Back off	Back away from another at least 5m
Aggressive acts	
95. Chase	Run towards another head up at least 5 m
96. Push tusks into another's body	Anywhere on the body other than to tusks
97. Tusk to tusk pushing	

Table 1: The behaviours recorded and their definitions.

Statistical method

Simple descriptive analysis was conducted using Mini-Tab v13.2 statistical package. A Continuous Recording, Instantaneous Time Sampling method [84], was used. All of the elephants were observed for the entire observation period with an observer for each elephant. Thus there was continual observation of all six elephants and their interactions. 97 different defined behaviours were recorded (Table 1). Some behaviours were not frequent enough to be quantitatively analysed, so much of the detailed analysis was confined to the 22 most common behaviours (Table 2).

For each social interaction the identities of the initiator/performer and the recipient were recorded and all of the behaviours exhibited by both (up to 5 behaviours might be simultaneously performed). The behaviours were recorded either on dicta phones and then transferred directly into the Mini-Tab statistical package for analysis, or a psion event recorder. Additional observations of maintenance behaviour and proximity relations exhibited by the elephants were also noted every 15 minutes using a focal, scan sampling method which are reported elsewhere [64].

The behaviours recorded and their definitions are shown in table 1.

Results

A total of 2410 interactions between the 6 elephants were observed over 213 hours, (that is 1278 elephant hours). This represents 1.89 interactions/elephant/hour.

The analysis of the meaning of the messages were restricted to the 22 most frequent behaviours, selected on the total number of times performed regardless if by an initiator or a recipient. These behaviours accounted for 73% of the recorded behaviours. Table 2 lists them and their frequencies.

The use of the different sensory modalities in the interactions

The frequency of the use of the different sensory modalities is shown in table 3, followed by further details for each sensory modality.

Olfactory communication

The visual evidence of smelling included frequent movements of the trunk searching and investigating strange or interesting smells and possibly tastes 39% of all of the behaviours recorded in this study had an olfactory component: (18% visual, tactile, gustatory and olfactory, and 21% visual and olfactory). There may have been other olfactory messages without visual cues which the observers could not pick up.

Gustatory communication

It was not possible to completely separate taste from olfactory or tactile cues, but, there was a taste component in 18% of the interactive behaviours (Table 3).

Tactile communication

Tactile and gustatory cues could not be separated visually either as when touching, the trunk may also be tasting and smelling. The elephants also touched each other with other parts of the body. There was a tactile component in 18% of all the behaviours performed.

Auditory communication

This was used very little in this group (0.5% of observations). It is possible that during the study, the elephants were using infra sound or seismic vibrations, but, visual signs would be likely to have been seen.

There are also a variety of non-vocal noises made by elephants without the larynx. These include blows, sighing, sniffing and puffs, stamping, breaking sticks and so on. Blow and puff accounted for 1% of the behaviours used in social interactions. Environmental noises made by individuals were not recorded.

Behaviour	No. Times Exhibited by Performer. P	No. Times Exhibited by a Recipient as a Response. R	Total Number of Times Exhibited	% of Total
Approach/contact make	677	59	736	9.9
Ignore	0	712	712	9.6
Tail wag	220	309	529	7.1
Contact activity (walk, stand or lie)	335	148	483	6.5
Flap ears	210	216	426	5.7
Contact break (general)	150	256	406	5.4
Swing trunk	182	108	290	3.9
Turn body towards	111	92	203	2.7
Tusk - to- tusk	103	96	199	2.7
Trunk up	103	78	181	2.4
Trunk to mouth	121	54	175	2.3
Follow	145	28	173	2.3
Turn head towards	75	46	121	1.6
Trunk extend	74	47	121	1.6
Head shake	61	51	112	1.5
Tusk to body	77	10	87	1.2
Both ears back	23	62	85	1.1
Entwine trunks	37	41	78	1.0
Head nod	39	36	75	1.0
Ears pricked	38	33	71	1.0
Blow	30	39	69	1.0
Tail up	27	39	66	1.0

Table 2: The 22 most common performed behaviours.

Sensory Modality	Number of Different Behaviours	Frequency	% of Total (7542) Different Behaviours Observed
Visual only, as far as could be assessed	36	4307	58%
Visual, tactile/gustatory and olfactory	29	1314	18%
Visual & olfactory	7	1553	21%
Auditory - vocal Auditory - non vocal	3 2 Total = 77	37 111 Total = 7344	0.5% 1.5% Total = 99%
Other behaviours whose sensory modality was not clear	27	143	1%

Table 3: The frequency of the use of the different sensory modalities.

Visual communication

There was a visual component in 97% of the behaviours recorded (Table 3: 58%+21%+18%). Even though other sensory cues were sometimes attached, over half (58%) had only visual cues as far as we could ascertain.

The use of the trunk

Sixteen different trunk movements were distinguished that were not related to feeding, although some of these were relatively rare (Table 4). These trunk movements accounted for 18.1% of all the interactive behaviours.

Further discussion on the use of the trunk is below.

Analysis of the meanings of different behaviours

When studying communication, as a rule, only behaviours with an explicit message are recorded, such as aggressive (e.g. fighting with the tusks, barging and tusking another, trunk pushing) and withdrawal and avoiding. Affinitive behaviour such as touching or rubbing another, are explicit, but have less frequently been recorded. Showing interest in another is explicit, but has rarely been recorded. There are much other behaviour used in interactions which have an "implicit" or hidden meaning which we will unravel. Meanings can be accessed from an analysis of the recipient's responses, but this is not always clear, as the responses vary. Nevertheless, it can be the first step. Table 5 shows the three most common responses to the 22 most frequently performed behaviours.

Approach, the most commonly exhibited behavior (690 times), caused 76 different behavioural responses (Table 5). All the behaviours had a number of different responses (column 3).

Trunk Movement	No. Times Exhibited by Performer, P	No. Times Exhibited by Recipient, R	Total Number of Times Exhibited, P+R	% of 7542 Behaviours
Swing trunk	182	108	290	3.9
Trunk up	103	78	181	2.4
Trunk to another's mouth	121	54	175	2.3
Trunk extend to another	74	47	121	1.6
Trunk to vulva	72	15	87	1.2
Trunk to penis of other	56	29	85	1.1
Entwine trunks	37	41	78	1.0
Trunk to body of other	52	12	64	0.9
Trunk to face of other	34	29	63	0.8
Trunk to anus of other	17	43	60	0.8
Trunk to head/shoulder of other	35	23	58	0.7
Trunk to tail of other	36	6	42	0.5
Trunk to own mouth	19	19	38	0.5
Trunk to rear of another	12	1	13	0.2
Trunk down	4	4	8	0.1
Trunk to neck of other	7	1	8	0.1
Total	861	510	1371	18.1%

Table 4: The Use of the Trunk in communication. The different movements, their frequencies and the percentage of all the behaviours recorded.

Behaviour Performed	Number of Times Recorded	Number of Different Types of Responses	Most Common Response	Second Most Common Response	Third Most Common Response
Approach/contact make	690	76	**Ignore310**	Contact break106.	Tail wag69
Tail wag	359	68	**Ignore73**	*Tail wag 66***	Contact31
Contact activity (walk, stand or lie)	339	56	**Ignore137**	*Contact 117***	Tail wag49
Flap ears	335	59	**Ignore73**	*Flap ears 66***	Tail wag54
Contact break (general)	80	39	**Ignore 60**	Tail wag11	Follow7
Swing trunk	217	50	**Ignore88**	Tail wag34	*Swing Trunk 29***.
Turn body towards	161	52	**Ignore 40**	Tail wag27	Flap ears18
Tusk - to- tusk	198	35	*Tusk-to-tusk 84***	Entwine trunks18	Ignore10
Trunk up	169	57	**Ignore29**	*Trunk up 14***	Tail wag11
Trunk to own mouth	141	44	**Ignore41**	Contact break20	*Trunk to own mouth 13***
Trunk extend	104	40	**Ignore19**	Flap ears12	Tail wag12
Entwine trunks	79	21	*Entwine trunks 28***	Tusk-to-tusk17	Contact break4
Tusk to body	55	37	Contact break24	Ignore14	Leap away13
Both ears back	45	28	Tail wag6	Flap ears4	Contact break 3
Head nod	56	26	**Ignore 17**	Tail wag10	*Head nod 8***
Ears pricked	58	25	**Ignore 14**	*Prick ears 8***	Tail wag8
Blow	74	35	Tail wag8	Flap ears5	Trunk to mouth5
Tail up	59	26	**Ignore 28**	Tail wag 5	Ears back 4
TOTAL number Responses in category.	3467	826	1051	554	348

Table 5: The number of times each of the 22 most common behaviours were performed, the number of different behaviours elicited, and the 3 most common responses.

Note: Bold=Behavior ignored by recipient. Dyadic movements by definition, excluded from analysis. Italic: Are reciprocal **=t test significant at P<0.01

The implicit behaviour, tail wagging or swishing, was the second most common response. It was often performed with other behaviours (33.2%). See below for discussion.

Ignore as a response

Curiously, the most common response was to ignore the directed behavior, defined as "no observable change of behaviour exhibited by the recipient within one minute of the performer's directed behaviour" (see Table 1). All the behaviours that were not of their nature dyadic (e.g. tusk to tusk, trunk entwine) were ignored at some point, a total of 712 times (20.5%). Table 6 shows the most and least commonly ignored behaviours.

Performed Behaviour	Number of Times Ignored	Total Number of Times this Behaviour is Performed	Percentage Each Behaviour is Ignored
Most often ignored (more than 20% of occasions performed)			
Contact break (general)	310	677	60%
Follow	73	220	50.3%
Approach/contact make	137	335	45.8%
Head nod	73	210	43.6%
Contact activity (walk, stand or lie)	102	150	40.9%
Flap ears	88	182	37.6%
Ears pricked	40	111	36.8%
Turn body towards	10	103	36%
Swing trunk	29	103	35.7%
Turn head towards	23	121	34.7%
Tail wag	73	145	33.2%
Head shake	26	75	32.8%
Tail up	8	27	29.6%
Trunk up	19	74	28.2%
Trunk extend	20	61	25.7%
Least commonly ignored (less than 20% of occasions when performed)			
Trunk to own mouth	14	77	19%
Tusk to body of other	3	23	18%
Blow	4	37	16.7%
Both ears back	17	39	13%

Table 6: The most and least commonly 'ignored' of the 22 most frequent behaviours.

The less ignored behaviours are likely to be those with the strongest messages. These include: (i) putting the trunk into his own mouth. (ii) Tusking another's body, which caused a leap away, but could also be ignored? The least ignored of all were "blow" and "both the ears back". The most common responses to both were tail wagging, and/or putting the trunk in his own mouth (Table 5).

Why so many behaviours are frequently ignored is discussed below.

Do as done by, imitation or reciprocity (Table 5 italic)

Many responses were reciprocated significantly more than expected (Table 5 in italic). In fact, reciprocal/imitative behaviours were one of the three most frequent responses for 7 of the 19 most common behaviours (Table 5 and details Table 7). All except for "blow" and "tusk to body of the other" were significantly reciprocated (Chi^2, $P<0.01$).

Batching the behaviours according to their meaning

The meaning of explicit behaviours is evident. Here they are batched into 3 categories, 1) those related to aggression and avoidance, 2) affiliation and 3) showing interest in the other.

Much implicit behaviour are originally related to skin irritation, such as tail wagging, head nodding or shaking, scratching, and ear flicking (further discussion below). These behaviours were frequent, but their meaning in social interactions is not obvious. These results indicate that these behaviours show some arousal because of indecision/ uncertainty of what to do (approach or avoid: frustrated). Therefore, they are placed in the 4th category labeled "uncertain" or indecision. Category 5 is behaviours that occurred too in frequently to analyze.

To summarize, the batched categories are:-

Socially positive behaviours: Interest/Attention that is turning the attention to the other and affiliative behaviours. Socially positive behaviours foster group cohesion: "sticking" together. (a) Affiliation, friendly behavior (24.27%), significantly higher than expected (Chi^2, $P<0.01$), and (b) interest (22.94%). These 2 categories accounts for 47.66% of all the behaviours recorded, almost half.

Socially negative behaviours: Aggression and also avoid and withdraw-Socially negative behaviours relate to unpleasantness to another, its avoidance or prediction (such as avoiding and withdrawing). Socially negative behavior promotes group division or "splitting". Socially negative behaviours accounted for 18.4%, significantly less than expected (Chi^2 $p<0.05$).

Uncertainty or indecision: These are frequently performed behaviours that often occur during frustration or approach-avoidance conflict which indicates some arousal, usually caused by indecision. Interestingly, this category was the most common: 29.27%, significantly more than expected (Chi^2, $P<0.01$).

Unclassified behaviours: The communicative meaning of these behaviours remains unknown due to their infrequent performance.

The behaviors in each category are listed in table 8. Table 9 shows the frequency that the different categories were recorded in the interactions.

Performed Behaviour	Total Times Elicited by Performer, Frequency	Same Behaviour Elicited by Recipient, Frequency	Same Behaviour Elicited by Recipient, %	Value of Chi²	P Value
Contact activity (walk, stand or lie)	335	117	34.9	13.96	0.001
Flap ears	210	66	31.4	31.08	0.001
Tail wag	220	66	30.0	29.87	0.001
Ears pricked	38	14	21.1	16.02	0.001
Head nod	56	8	20.5	9.03	0.001
Swing trunk	182	29	15.9	15.16	0.001
Head shake	92	8	8.7	6.61	0.025
Trunk up	169	14	8.3	8.46	0.005
Tail up	27	3	11.1	22.45	0.001
Trunk to mouth	121	13	10.7	10.33	0.001
Both ears back	23	2	8.7	11.08	0.005
Blow	30	2	6.7	1.69	NS
Turn head towards	75	3	4.0	5.01	0.025
Contact break (general)	150	5	3.3	5.82	0.025
Tusk to body	77	2	2.6	1.09	NS
Approach/contact make	677	17	2.5	9.92	0.001

Table 7: "Do-as-done-by", reciprocity or imitation by responder.

Interest	Affiliation	Aggression and Avoidance	Uncertainty	Unclassified
Approach Ears forward pricked Ears back Look at Trunk extend to Tail up Puff Turn body towards Turn head towards Walk faster Trot Circle another Trunk up Smell other from a distance	Rest head/neck on other Rumble Contact make Contact walk Contact stand Stand over Follow Grab others tail Mount with or without erection Rub against another Rub head against other, Smell & touch other Smell penis or vulva, Touch anus, penis, vulva, face, body, neck, nose, shoulder, tail Nibble head, body Playing Entwine trunks Trunk to others mouth	Barge into other Push another's body or tum Tusk to head, rear or body of the other Tusk to tusk Throw trunk at, or smack with trunk	Ears Flap Head nod Head throw Head shake Chew Tail wag & swish Blow Paw & Stamp Raise leg Swing leg Trunk to own mouth Swing own trunk	Rest leg Lie down Urinate Defeacate Graze Dust throw Walk Pull tree & eat leaves.

Table 8: The behaviours batched in the five different categories relating to their meaning.

Batched Behaviour	Total Performed P	% Total Performed	Total Recipient Responses RR (excluding ignore)	% of Recipient Responses Recorded	Total % of P + RR P + RR	
Affiliative	1569	30.51**	1018	21.47	2587	24.27
Interest	1341	26.77	1104	21.24	2445	22.94
Uncertainty	1301	25.3	1818**	34.98	3119	29.27**
Aggression	808	15.1	368 -*	0.7	1176	11.2
Avoid	123*	2.3	648	1.24	771	7.2
Unclassified	403	7.26	136	0.26	539	5.03
TOTAL	5545	100	5092	100	10,637	99.91

Table 9: The frequency of each behavior in the 5 categories either performed by the initiator or as a response.

* = significant at p>0.05 ** = significant at p>0.01

Discussion

Comparative Sociality in mammals measured from the frequency of their interactions

A comparative measure of the "sociability", that is the frequency that a species communicates with its co specifics, has been neglected. This can be represented as the number of interactions per animal per hour observed. There were 1.89 interactions/elephant/hour, which is more than in horses: 1.01/horse/hour when the data was recorded and analyzed in the same way [85]. Whether other elephants are such frequent conversationalist, remains to be explored.

Protective responses

In many canids, felids and ungulates, the origin of some behaviours such as pulling the ears back, appears to be related to protection. This can be ritualized and become a signal indicating defensive threat. Ear withdrawal is particularly obvious and ritualized in species without horns such as canids, felids, equids and camelids. Here, the ears are drawn back and the orifices rotated towards the head [29]. The large aural orifices of elephants are not possible to protect in this way, but the ears themselves can be pulled back and flattened against the side of the head which may protect them from being torn in dangerous situations. Forty five different behaviours were elicited when an initiator put both his/her ears back, and it was often reciprocated (see Table 5) and accompanied by tail wagging, indicating uncertainty. The third most frequent response to ears back was to withdraw. The meaning of ear flattening is suggested below.

The use of the different sensory modalities in communication

The most frequent behaviours recorded in interactions were visual (97%). However many visual cues have inherent tactile, olfactory or gustatory involvement. This is the case for any trunk movements which inevitably involve the possibility of smell (and sometimes touch and taste) as well as visual positional messages. Olfactory and tactile communication is important in elephant communication, but they generally have a visual component and consequently also display a visual message. Vocal messages, audible to the human ear, or with visual indicators (for example trunk vibrations), were relatively rare in this group, although it is possible that seismic or infrasound messages were not picked up.

Olfactory communication

Although research attention has been placed on the production of pheromones from particular glands (see introduction) most of elephant's olfaction may be to acquire diverse environmental and/or social information. With their well developed olfactory organs and areas for its analysis in the brain information can probably be gathered from the wind, changes in air humidity, smells of vegetation such as rising sap, potential fruiting or flowering and the recognition of individual plants, buds and leaves.

Information could be acquired in this way about both the past and the future from smells of seasonal changes. For example, Namibian elephants trek around 150km across the desert to baobab trees when they are fruiting, so they must know when this is happening perhaps partly by recognizing smells of seasonal changes. In social contexts, the age and sex of an individual can be recognized from urine or faces and elephants must be able to recognize individual elephants as well as other species by their smells. Indeed, elephants can been taught to discriminate between the smells of familiar and unfamiliar humans, and to track the smell of an individual.

To summarize, smell information will include where another individual has been, what s/he has been eating, who they are, what their sexual status and age is, who they have been with and so on. In effect, for elephants, the olfactory world could be "something like" reading a newspaper for humans, acquiring information about the past (on the wind, in the water, on the earth, from faeces and urine, from tracks and rubs on vegetation), and possible futures (e.g. oncoming oestrus or a possible birth, movements of groups and forth coming musth). Elephants may also be acquiring information concerning other individual elephants' (and other animals') moods (e.g. whether frightened, anxious, or relaxed from body odours such as sweat). Particularly interesting smells are also indicated visually by movements of the trunk.

Gustatory communication

Observations with captive elephants confirm that they have a well developed sense of taste as they taste and smell different or new foodstuffs carefully before eating. One behaviour that was relatively common was placing the trunk in another's mouth, here tactile, olfactory and taste messages as well as visual, and may be, emotional ones, will be acquired (further discussion below).

Tactile communication

Despite the thick skin of elephants (5-15mm), they are extremely sensitive to gentle touch. In teaching experiments [58], gently stroking between the front and hind legs and on the shoulder acted as a positive rein forcer, and helps to calm anxious elephants. The multi-sensory trunk is used to discriminate objects by touch [53] and to gather information and communicate to others using all sensory capacities. But, other parts of the body are also used to touch or feel each other, for example, seismic vibrations are picked up through the feet [40,86,87]. The feet are used to search for and manipulate objects (e.g. branches, pieces of rock etc) and feel others. They are also used in violent interactions: To kick, stamp or squash irritants and frightening objects such as fences or other species, including humans. All other parts of the body can also be used to touch, rub, push or scratch another: The head, shoulders, belly, quarters and the ears; as well as the trunk. Eighteen percent of the behaviours in interactions had a tactile component. The common use of tactile communication in this young and predominantly male group may enhance amicable bonds, but further research in family groups is needed.

Auditory communication, audible to the human ear

This was used very little (0.5%) during the observations. In some vocalisations, such as trumpeting, the trunk is used as a vibratory chamber to increase the amplitude of the sound. Trumpeting has sound characteristics which facilitate dispersal and location over a large distance (high amplitude and alternating frequencies facilitating location using the two ears) and trumpets are individually different and recognizable [29], but there were no trumpets during the study. It is possible that the elephants were using infra sound or seismic vibrations, but visual signs of this would be likely and would have been picked up by the observers. Very little research on the occurrence and communicative significance of non vocal noises has been reported in elephants. In this study, "blow" and "puff" accounted for 1% of the behaviours

used in social interactions; twice as much as vocalisations and "Blow" appears to have an important communicative value, since it was rarely ignored. Elephants moving around make a variety of noises: Breaking sticks, pushing over trees, pulling branches or grass, sighing, farting and so on, but these were not recorded in this study. When and where these noises are made with intent to communicate (e.g. to stay in touch with the rest of the group) requires further research. However, we know that elephants (and other species) can be aware of making such environmental noises because when they do not want to be found (when hunted or searched for) they can move extremely silently, (indicating there awareness of the noises they make), and stop them intentionally.

Visual communication

All the behaviours recorded and analyzed (with the exception of 0.5% vocal noises) were visual (97%), all be it that some also had olfactory, tactile, gustatory or auditory messages attached. Purely visual signals accounted for over half (58%), it is clear that visual signals are numerous and frequently used in close contact. Further discussion on the use of the trunk and the cause and function of the different visual messages follows.

The trunk, a multi-sensory communicative organ

The elephant's unique trunk functions as a nose, hand, mouth/tongue, and vibrating chamber, called "synesthesis" [88], as it is used for conveying and receiving messages in all the sensory modalities (Table 4).

The trunk is also a manipulative organ, like humans, elephants are manipulators, humans with their hands, elephants with their trunks. All of their food is collected using the trunk, which sorts, selects, prepares and processes it [24,25,58] .The trunk has approximately 500 muscles controlling its movement [57]. Consequently, it can perform a great variety of movements such as:- Gripping, pushing, twisting, pulling, grabbing, touching. It can be turned and twisted into small places, used to investigate, to caress, push or slap other elephants and humans [59]. It is particularly used to investigate others' body areas rich in smells, such as the mouth, ears, feet, temporal glands, anus and vulva. It can be used with great skill to lift, pick up, balance, carry, place and stack heavy objects and the tusks, head and trunk working together can act as a fore-loader. Adams [67], personal observations in India with timber elephants). It can also be used to find and lift objects under water (personal observations) and find small hidden objects (such as rings and buckles hidden in hay) and is skilled at sorting objects, even out of sight. It is used for breaking or pushing things over, such as trees or fences (including discriminating between electric and insulated lines, in order to lift posts our of the ground [89]. It is used to make and use tools [89,90] and can be used to manipulate objects in a mirror [91], which humans find difficult. The trunk is used as a resonating cavity for vocalisations, and used to learn to imitate human words [92] and invent new sounds (personal videos elephants in the [93].

The use of the trunk in communication accounted for 18% of all the behaviours in interactions. The 16 different trunk movements had meanings inall 4 of the batched behavioral categories. The trunk is also used of course, for self directed behaviours such as self grooming, smelling, rubbing, scratching, stroking, and essential for drinking, food selection and processing.

The trunk placed in the performer's own mouth was frequent in training experiments [94], occurring when the individual was uncertain what to do, or confused. It occurs in the same situations in which children put their finger or thumb in their mouths which demonstrate uncertainty [95]. On several occasions when teaching elephants with unprotected contact, when they were frustrated or annoyed, they stamped one front leg. This is a similar behavior given in a similar situation by a child stamping a foot. Beating the trunk on the ground is another well known behaviour in captive elephants associated with frustration (e.g. awaiting food or to be unshackle [51], but was not observed during these observations

One of the most interesting movements is the trunk placed in another's mouth, a relatively common behaviour (performed 121x's by an initiator and by a recipient 54x's: Total 175x's). Here the performer acquires information about the recipient and it also demonstrates "trust/confidence/amicability" as biting the other's trunk would be easy. This action has frequently been observed to have a calming influence on the recipient (observations & videos). Some handlers imitate this action by stroking the tongue of an elephant when greeting. The establishment of predictability in behaviour, "trust" or "confidence in each other" has been widely used by good animal handlers for generations [85,96-98] and is now considered to be one of the most important components in establishing good cooperative animal handling and teaching [58].

The hand/nose/tongue trunk is used in almost every type of situation to manipulate the world, to communicate with others and to read intentions and emotional states of others. Without being aware that his trunk is HIS, the elephant would be unable to do these things, indicating his self awareness of his trunk and his ability to control what, where and when it moves. (Further discussion below).

The indication of parallel experiences between the elephant trunk and human hand underlines the importance of taking a conditional anthropomorphic approach to further comprehend elephant epistemology and mental aptitudes [68,69,71,82].

The meanings of the different behaviours

Communication in elephants, like the rest of their behaviour is flexible and adaptable [24,25,81]. One of the problems is to assess which behaviours (other than vocalisations) are performed with intent to communicate, and which are coincidental and have no communicative significance.

The meanings of many behaviours are self evident; that is, they are "explicit" and can be batched into two categories (i) aggression and avoidance / withdrawing all of which will tend to split the group. (ii) Affiliation and interest in the other, which will encourage group cohesive or sticking. The third category contains behaviours frequently used in communication, which have an "implicit" (inherent, hidden) meaning. Many visual signals are in this category. Further discussion follows.

"Uncertainty". Behaviours indicative of approach avoidance conflict and frustration, convey a message of indecision

Tail wagging, head shaking and ear flapping are widely used in communication throughout large mammals [26,29,30]. They often occur in approach-avoidance conflict or when frustrated: Where the

ability to perform a desired behaviour is inhibited. At such times, often an irrelevant and or less urgent behavior is performed. These have been called "transitional" or "displacement activities" and their original cause related to cutaneous irritation or frustrated movement [26,76,99-101]. Sometimes these behaviours are ritualized for communication (exaggerated and emancipated from their original cause/s) to carry a specific message [76,77,100]. However, highly ritualized displays (which are common in birds), are relatively rare in large herbivores [26], perhaps because the meaning is clearer. For example, behaviours related to skin irritation occur frequently in communication associated with approach-avoidance conflict and frustration [26,78,99,102] and are characterized by some arousal [103]. Behaviours originally associated with cutaneous irritation are tail wagging, ear flapping and head shaking or nodding. Tail wagging was the most frequent; the most common responses were to ignore, or to reciprocate. Ear flapping and head shaking were also frequently ignored or reciprocated. But, since neither head shaking nor ear flapping resulted in aggression, avoidance or withdrawal, they do not indicate any threat, but rather that the communicant is slightly aroused and indecisive/ uncertain what to do.

An interesting behaviour in the same category is placing the trunk in his own mouth. Children may also place their fingers in their moths when in indecisive situations [26,29,58,95], another similarity to humans.

Anselme & Gurturkun [104], in a recent paper shows that "uncertainty" magnifies food searching behavior in birds which then increases exploration and survival. This "uncertainty principle" could equally be applied in communication to reduce potentially emotionally inflammatory situations, encourage group cohesion which in turn will encourage social exploration and curiosity, leading to the acquisition of more environmental and social knowledge.

Ignoring directed behaviours

Ignoring a directed behaviour accounted for 30% of the recipients responses. The reasons for ignoring could be that the directed behaviour had no meaning, or, that the recipient had not seen it. Since all the performed behaviours were responded to on other occasions, ignoring cannot be the result of it having no meaning. Since the initiators behavior was only recorded when it was clearly directed at another, it is unlikely that the recipient was not aware of it as elephants are visual aware as we have shown (Table 2).

Therefore, the most likely explanation is that the recipient chose to ignore that behaviour directed at him/her. Detailed investigation of what behaviours were ignored indicates that some of the most frequently ignored demonstrated "uncertainty" (e.g. tail wag, head nod, flap ears, swing trunk and head shake). The message of "uncertainty" or indecision had been received, but, because there was no threat to social cohesion, there was no need for a response. Ignoring in this situation may help to deflate any emotional conflict.

It is less clear why social behaviours, such as approach and contact make, turn body towards, turn head towards, tail up (indicating a rise in excitement), trunk up, and tusking another's body are so frequently ignored. But this may indicate that ignoring a situation in which conflicts might otherwise arise and grow, will aid group cohesion.

Behaviours that are less ignored will have strong messages. These include putting the trunk in the mouth of another, which shows interest, familiarity, confidence or "trust". "Blow" and trunk extended sniffing were also rarely ignored both indicating something like" take heed, there is something interesting around". Drawing both ears back against the head was also infrequently ignored; which may have a message something like "I am slightly concerned about the situation" and the recipient reciprocating message will mean: "I have seen you and am therefore also slightly concern" .

Do as you have been done by/ reciprocity or imitation

Another puzzle is that reciprocity/ imitative / 'do as you have been done by'/'be done by as you did' [105], is much more frequent than expected overall and for particular behaviours. This is relevant to discussions concerning mirror neurons [106,107], which have now been demonstrated to be widely distributed in different species rather than restricted to humans.

Reciprocity and its role in fostering bonding and cooperation has been discussed in some animals [108], but has not previously been reported in elephants. Sixteen of the most commonly recorded behaviours all of which demonstrated affection/sticking behaviour or uncertainty, were very significantly imitated by the recipient. These were those involving orientation movements and postures (ears prick or turn head towards the other,) investigation (trunk up & smelling), interest in another (approach and contact make). They included those indicating an increase in arousal and preparation for action such "tail up" [26]. Behaviours indicating "uncertainty"/ indecision, were also significantly reciprocated (such as tail wag, head nod, swing trunk, head shake and trunk to own mouth)

It may be that reciprocal behaviour is more common than has been previously reported in many species. Randle & Kiley-Worthington showed that inter-species imitation (the animal imitating a novel action of the human teacher) is frequent in teaching situations and, as in children, can be used as a teaching aid. The function may be to indicate to another; something like "I am also feeling the same way", that is emotional contagion [65,66], which is another way of indicating awareness of others' feelings and intentions. It is interesting that elephants can also be taught to imitate humans speech which is suggested helps them to bond with humans [92].

Kingsley [105], maintains that both "do as you would be done by "that is be nice to each other, and "be done by as you did" (if nasty, it will be returned) are moral rules which children should obey. Following on from this, reciprocating with aggressive behaviours when aggressed would ensure that the social contract is adhered to and those who do not adher can leave the society, so the society can continue. Reciprocity of behaviour (and its accompanying emotions) that might threaten the group stability and the social contract: "Be done by as you did", would then discourage further contravention of the social contract.

Context dependent and context independent meanings

Context dependent meanings for some communication in elephants (and other species) has been demonstrated for many vocalizations [27], and head and tail movements in ungulates and carnivores [26,30].

One of the particularly interesting consequences of context dependent messaging is that, because a particular behaviour acts as an analogue system to convey a message about the general level of

excitement or arousal of the individual, many behaviours are used in a variety of situations. The specific meaning, that is why the elephant is aroused, can only be gathered from the context, thus whether s/he is frightened, worried, feeling slightly aggressive or sexy will only be gathered from the context. As a result, each individual must be acutely aware of the environment and the intent of others or he will not be able to interpret accurately the meaning of the message. Any witness will have to have an understanding of the situation and be aware of others' intentions that are his emotions, desires and needs to interpret the message. Such a reading of intentions of others has been labeled having a "theory of mind": Defined as "attributing perceptual, epistemic, and volitional states to others and themselves" [109-117].

Therefore, animals that use context dependent communication must have a 'theory of mind' [71,110] or they would not be able to communicate, have a social contract and a social organization.

By contrast, to understand the meaning of context independent messages (such as human language), it is not always necessary to have an awareness of others intentions, desires and needs because the meaning of the message is constant, whatever the situation, emotions and intentions of the communicant which is what allows human language to be understood out of the present context: On the computer or telephone. This is because context independent communication conveys complex, symbolic non-emotional messages entirely divorced from the context and, consequently, can be understood without having any theory of mind of the communicator and his intentions.

Context dependent communication therefore presents a different complex cognitive assessment of the world from context independent language. But, judgments concerning mental development and complexity, are usually made only by comparison to humans, often because of the overruling importance of context independent language in which humans both speak and think most of the time which acts as a cognitive handicap when attempting to understanding the ontology and epistemology of species who use context dependent communication and who, to understand the message clearly, must be acutely aware of the social and physical environment around them and the feelings and intentions of others [66,71]. Without an awareness of others feelings and intentions, such communication will not function and without communications, there could be no social contract, recognition of other individuality, and their knowledge or roles, that is no "social networking" [11].

Rethinking elephants social contract and their epistemology related to these results

It may be that unless there is a need for constant competition within a group, (such as access to food, shelter or other scarce resources to ensure survival), the basis of any social grouping in mammals is emotional attachments [81,118,119], rather than competition for resources. This ontologically starts with the mother/infant attachment [120], controlled initially hormonally but as a result of learning, often reinforced and continuing into adulthood. Thus, it is reasonable to consider that positive emotional bonds become the social cement of some societies [121], rather than socially negative or competitive behaviours which will tend to disperse or split the group and "dominance hierarchies" evolved to reduce competition and injury to group members. The "dominance hierarchy" gives priority of access to resources in all situations to certain individuals. But, the explanation of elephant society in terms of "dominance hierarchies" [73,74,122], has obscured the importance of less melodramatic, non competitive behaviours including those that could help to de flame potentially inflammatory situations and split the group, such as ignoring or indecisive behaviours.

In addition in species such as large herbivours where resources are usually widespread and available for all or none, there is little need for constant competition within the group. Individuals have different personalities and consequently different placings in the different behavioural hierarchies, that is some are more aggressive than others, some more affiliative. Some more submissive, and some more socially involved [85]. But, there is not one individual who is top of the aggressive hierarchy and low in the avoidance hierarchy as there would be if there was a "dominance hierarchy" controlling access to resources. The organization of this society is more complex with individuals having a variety of different roles.

In large free living herbivors since there is no need for constant competition for resources, behaviours and their accompanying emotions which encourage group cohesion would be likely to be common and selected for such as those demonstrating interest and affiliation to keep the group together. Demonstrations of indecision that is "uncertainty", "reciprocity" and ignoring directed behaviour may also help to here the group by reducing negative emotions and possible group splitting.

The question remains why group cohesion is so important. To grow, survive and reproduce, each individual must become a natural botanist, zoologist, ethologist, meteologist, geologist and geographer that is s/he must become a good "natural ecologist" [81,123]. There is an enormous amount of information to acquire by each infant in order to survive, so perhaps, the most important reason for group living is to enable the acquisition of such necessary knowledge by facilitating observational, social learning and imitation, which aid in a rapid and less risky accumulation of knowledge than learning everything by trial and error. However, it is necessary to know who to learn from: To know what knowledge other individual have. Thus an awareness of the age, personality, role [124] and knowledge of each group member will be crucial. Thus, older animal's greater knowledge is recognized so they often become decision makers or "matriarchs" [25,71]. Strong, askilled manipulators will have a role of helping infants out of mud holes [125,126].

If the society is to prosper and reproduce, the society's rules, that is, the social contract must be obeyed. Such rules as "do not attack infants", "recognize others roles" or "do not perform socially negative behavior unless another breaks the rules". If an individual does break the rules, then action must be taken. This would account for the frequency of reciprocal behaviours: "If you are nice to me, I will be nice to you; if you are nasty, I will return it in kind".

There are "other ways of seeing" outlined by Goethe [127], which may be imperative when considering other species epistemology. One idea that is becoming increasingly apparent and may be one of the most significant and important developments for life, is the recognition of how wide spread symbiosis is, both between and within species [128-130]. The importance of symbiosis in the social world of different species [131,132] and different strategies to encourage this in the social contract is another way forward to an understanding of that species epistemology [66,71, 81,82].

The question remains why, what would appear to be a relatively small evolutionary step, that of associating a particular movement posture or call with a particular message, has not always been taken. But, different cognitive maps are held by different individuals and species, for example blind humans become more sensitive to wind, smells and touch than normal humans, and other "handicaps" in humans also point out different cognitive maps. For different species, an emphasis on olfaction may require a different concept of space and time from that of humans [81]. A different world view will be acquired by two simultaneous large monocular visual fields, compared to a large binocular visual field and poor peripheral monocular vision characteristic of humans. The different world view implicated by context dependent communication also illustrates a different world view since when using context dependent communication, the recipient has to be aware of the "perceptual epistemic, volitional states of the other" to receive the correct message and must "socially network".

There is much evidence that non-human mammals do recognize other living "beings"; that is they recognize the body/mind/moods/emotions/intentions/knowledge/roles of others, both inter- and intra-species, and discriminate between the living and the dead [25]. Such communication requires an awareness of others body/mind being that context independent communication does not always need. Thus, awareness that the other has a mind is a necessary attribute for context dependent communication.

Many even naïve/wild mammals have an ability to read others feelings and intentions, including those of other mammals, humans. Even naïve rhinos, horses, dogs, cattle, elephants, lions, tigers respond rapidly to humans moods, although some humans may need experience before they are able to read the intentions of an animal [58]. Having an awareness of others and their intentions is a necessary mental attribute for context dependent language users without which they could not have a social ontology, social organizations or a social network. Whether such animals have "reflective self-knowledge" [133-138], is not the same question.

Conclusion

Studying communication of different species in detail can throw a more distinctive light on another species social contract and consequently their epistemology/ world view. Much of elephant communication is visual, and uses several senses at once, where as vocal communication (audible to the human ear) was relatively uncommon in this group. Much interactive behaviour is ignored, but may also be reciprocated more than expected. There are also behaviours whose meaning is implicit but on examination, these behaviours often indicate "uncertainty" which can de flame a potentially emotionally inflammable situation.

Correlations of the individuals rankings in the different batched behaviours, did not confirm that there is any overall "dominant" individual, but that individuals have different roles in the society and that the prime society parameter is to facilitate it's cohesion: "Sticking behaviour", not competitive or "splitting behaviour" where some priority of access for an individual that is a "dominance hierarchy" might be the most important organizational parameter.

Positive or "sticking" behavior (affiliative and showing interest in another), are much more frequently than expected which indicates that, for this large herbivore, the cohesion of the group is more important than competition within it ("splitting" behavior).Cohesive and symbiotic behavior, may have been selected for to facilitate knowledge transfer by social and observational learning.

The meaning of much of elephant communication is context dependent that is the same behaviours are performed in a variety of situations. To interpret the specific meaning of a message, the recipient must be aware of the situation and the intention of others. Judgments concerning mental attributes only by comparison to humans discourage consideration of different and complex social ontology's and can be a cognitive handicap, we should broaden the search in order to better understand a species epistemology. Animals think, and we can begin to understand what different species think about [139,140].

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