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Research Article

Communication in a Group of Semi-Captive Black Rhino (*Diceros Bicornis*). A Reconsideration of their Cognition and Social Organization

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Abstract

Rhinos, like many perissodactyls, are highly threatened species. Since there is no truly wild terrestrial areas left, all rhinos live in some form of controlled environment, where if they are going to survive and breed, they should have a life of quality. In the light of poor reproduction in captive rhino, a closer assessment of their communication and the resulting social organization is necessary. This study analyses 41 behaviours used in communication. Vision was most frequently used but much communication was multi-sensory. The behavior of initiators and recipients was batched into 7 categories of meaning:- Positive messages:-1) approach. 2) Affiliative 3) showing interest. Negative messages:- 4) threat and aggression, 5) avoid or withdraw. Also (6) Behaviors indicating Uncertainty and/or Frustration, and (7) Recipients Ignoring directed behaviour.

Positive interactive behaviors were significantly more frequent than negative ones. Uncertainty, Ignoring directed behaviour and Reciprocating with behaviour in the same meaning category were frequent. The social strategy of these rhinos is more likely to be to cooperate to have a cohesive, stable social structure rather than competition between them. This has implications for the survival of this highly threatened species.

Keywords: Behavior; Captivity; Cognition; Communication; Epistemology of other minds; Frustration and Uncertainty; Positive and Negative Interactions; Rhino; Social Organization; Welfare

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Introduction

Many species of perissodactyls are either extinct or foredoomed [1] Particularly threatened are all 5 species of rhinos, mountain zebra and the four species of tapir. On a positive side, however, the population of Prezwalski horses (*Equus caballus*) extinct in the wild in the mid-20th century, has now increased and two "feral" populations have been re-established, (in Lozere in France, and Mongolia : https://www.fao.org.)

If we know enough about how to provide a life of quality for rhino, we may be able to stem the tide of extinction, recognizing the intrinsic rights of individuals [2] and retain each species' role in the ecological community [3]. Since there are no areas of the world left unaffected by human activities, all large mammals are subject to some human management. Rhinos are known for having high rates of mortality and low breeding scores in captivity [4] even though their life expectancy in zoos can be between 30-55 years, if surviving infancy [5] Black Rhinos (*Diceros bicornis)* number between 3,000 to 5,000, but despite efforts by various organizations (e.g. Save the Rhino International) they are being poached and shot for human gain (South Africa gave licenses for 10 adult black rhinos to be shot in 2022), and their habitat continues to be usurped by humans as numbers decline. Detailed behaviour studies are crucial to improve the breeding of black rhino. For example, in this group of Black Rhino, female infertility was found to be the result of management [6] Separating the the females at night, resulted in all females breeding and 13 young black rhino have been re-introduced to a national park (T*he History of the breeding of black rhino at Imire Safari Park Zimbabwe).*A detailed study of rhino communication is also of evolutionary interest since there have been few comparative behavioural studies in the perissodactyla. Various "folk beliefs" concerning black rhinos sensory abilities are widely held. It is commonly believed by both popular science and serious scientists (e.g. Reed. 2017, How do rhinos communicate? Pets on mom internet, Estes 2012 & rhinosorcecentre.com) that rhinos have poor sight but, there is no physiological evidence for such statements, Pettigrew and Manger (2008) after assessing retinal ganglion cell density, maintain that black rhinos see "at least as well as rabbits and able to define both near and far objects clearly". Little is known about the rhinos ability to smell, taste or communicate by touch. Olfactory communication is complex [7] and often difficult to identify. But, we do know that black rhinos eat a range of shrubs and herbs and are fussy about what they eat, rejecting unfamiliar foodstuffs [8] so taste must be import to them. Generally only explicit behaviors are recorded in communication studies. These are divided into "aggressive" (threat and attack) and "submissive behaviors" (withdraw and particular postures). A few studies include affiliative behaviours. A movement or posture which is highly ritualized (exaggerated, and often performed out of context e.g. Huxley 1960) is performed *primarily* to communicate. However, many non-ritualized movements which are used for non-social functions, may be of communicative value. These include ear or tail movements primarily designed to get rid of flies [9], rubbing, touching, scratching self, movements to protect sense organs and other parts of the body. Head

and tail elevation (the result of contraction of the anti-gravity muscles in preparation for flight [10] sweating (to reducing temperature), and noises made without the larynx, such as coughing or sighing to clear the bronchial tract or lungs [11] all these behaviors, can be of communicative significance.

The senses used to communicate vary, and are often multi-sensory, thus visual messages may also have olfactory, tactile or gustatory messages. For example "head resting" or "horn to horn" pushing, where the performer and the recipient can see but also touch, smell and possibly taste each other [12] Auditory communication using the larynx is of particular interest because, unlike other sensory modalities, it has no other function but for communication. It has been known for some decades that the meaning of many, (but not all) calls made by ungulates, canids, and felids are context dependent (Kiley 1972), that is they indicate a general level of excitement, but the specific meaning (what emotion is being felt with other information) is gathered from the context. Although some of the sounds made by black rhino have been recorded, neither their hearing nor the frequency or complexity of their calls have been investigate in any detail [13] Today although there is much equipment and many techniques for investigating audition [14] this study only records sounds heard by the observing humans.The frequency of interactions would be expected to be higher in larger groups, so black rhino who are often found alone or with their previous offspring, are considered "less social" than white rhino (*Diceros bicornis*), but the degree of sociality is also influence by the size of the population. It is believed that black rhino (*Diceros bicornis*) evolved to be predominantly browsers since they eat a large range of tree and bushes leaves and twigs [15] and because their browse is erratically distributed, they live in small groups. Whereas white rhino (*Ceratotherium simum*), with their large flat top lip, are believed to be predominantly grazers and consequently can live in larger groups. But, the etho-ecology of any species is also the result of individual experiences, we now know that both species can adapt to a wide range of habitats and types of social living. For example, black rhino, can live in open Savannah as well as the Namibian deserts (e.g. https://www.savetherhino.org/programmes/ministry-of-environment-and-tourism/), and have been filmed in groups of up to 50 (BBC 2005) and have long been known to come together in groups of 10 or more [16] The degree of sociality is the result of the environment, population density and individual experiences rather than just species typical.

Since resources (e.g.food, water, shelter, resting sites etc.) are equally available to all in many large grazing herbivores, they do not need to compete constantly for resources as do some birds and primates where resources are batched and restricted. There may be no need for a "dominance hierarchy" to reduce injuries [17] rather the great advantage of social living is *to gather ecological and social information.* As a result, their social networking may be based on cooperation accompanied by knowledge of others' roles and skills rather than competitive. This has been shown in buffalo [18,19] This study assessed:-

1. The use of the different sensory modalities in communication.
2. The meaning of different behaviors in communication (their message-meaning)
3. Their overall social organization (without giving individual personality profiles).

In a study of this group of black rhino in their night time accommodation where only 1 female was breeding, a change of management resulted in all 4 females breed and 13 black rhino raised and re-introduced to a National Park (Randle & Kiley-Worthington 1996 and Imire Safari Park: The History of the Black Rhino 2022). This indicates that communication studies may be crucial for survival.

Many of the behaviors recorded have not previously been recorded or their meaning assessed, but this has led to a re-construct of their social contract, emphasizing cooperation (see e.g Rubenstein et Kealey 2010).

Methods

Zimbabwe National Parks Authority captured seven black rhino as infants (4 females and 3 male aged 1- 6 months old) when their mothers were poached during the 1990's . They were given to Imire Wildlife Park to rear. They were bottle reared and lived in a group under guard ranging over the 1,000 h nature reserve during the day. At night they were herded into an enclosure fortified against poachers, the females into individual stables, the males kept in a group as show-in in (Table 1).

Name of Rhino	Age	Sex
Cuckoo	9 years	Female (only female to breed)
Amber	8 years	Female
Mvu	8 years	Female (no ears)
DJ	7 years	Female
Noddy	8 years	Male
Sprinter	9 years	Male
Fumbi	7 years	Male

Table 1: The observed rhinos ages and sex.

All the rhino were continuously observed during the day in the nature reserve from a distance between 5 m and 50 m for 257 hours per rhino (1800 rhino hours) by 7 observers. Each observer observed one rhino and rotated between rhinos each day. The observers were their keepers and guards, and had spend at least 2 years daily with the rhino. Each rhino was easily identify at over 100m and could be approach to within 2m without moving. The observers were supplied with binoculars and given 15 hours training before the data was used. The observations were recorded either verbally onto a tape recorder, or onto a psion event recorder and transferred to a computer for analyzes. At all times the observations were monitored by two experienced observational ethologists.

Forty one behaviors were recorded. Every behaviour was defined, their definitions given in (Table 2).

The performance (P) and the responses (RR) to each behavior was recorded. The response was only recorded if it occurred within 5 seconds of the performer's directed behaviour, thus communication dyads —performer and recipient response—were recorded, not chains. Should the recipients response initiate another behaviour from the initial performer, after a further 5 seconds; it was recorded as a separate interaction.

If the recipient to which the behaviour was clearly directed, showed no response within 10secs, the response (RR) was recorded as "ignore". Several behaviors were often performed and recorded simultaneously.

Category of meaning based on explicit and implicit information.	Behavour	Definition
APPROACH	Approach	Walk or run at least 5 paces directly towards another individual, from up to 10m
	Stand up:	Raise forehand first from lying down
		Move front of body towards another
	Turn body towards	
	Follow	Following another for >5m
	Turn head towards	Turn head >30o towards another
POSITIVE INTERACTION	Head extended to another	Head extended forwards chin first an investigative posture.
	Nose twitch	Twitching movement of external nares, indicting smelling
INTEREST	Nostrils Enlarge	Contracting muscles around the nares so that they project
AFFILIATIVE	Blow	Pressure build up in trachea which is suddenly released with a short audible noise.
	Flehmen	Inversion of the top lip with head lift, a response to strong unfamiliar tastes or smells
	Watch	Watch another often with head turn towards another and with Ears pricked forwards
	Both hears pricked forwards	Ears orientated, not flattened back
	Both ears back One ear orientated to a stimulus	Ear following stimulus
	Raising head	Raising head above the back
	Raising tail	Raising tail above its insertion at the root (not with defaecating or unrinating).
	Contact walk	Walk >5m within 1 m of each other
	Contact Stand	Stand >3minutes within 1 m of another
	Head rest on another	Resting head on back of another
	Rubbing another	Rubbing with the head any part of another
	Smelling another	Nose close to any part of another's body for >1min
	Lick another	Lick any part of another's body
	Nose to nose touch	2 rhinos touching noses for >5 secs.
	Growl	Low frequency vibrating call involving larynx, often when greeting within 5 m of another.
	Grunt	Low frequency non-vibrating noise no involving larynx <3 sec long.
	Squeak	High frequency call, often repeated up to 2 sec long used in greeting.
	Lying together	Lying on sternum or flat, touching another
AGGRESSION AND THREAT	Ears flattened back	Ears flattened back and rotated inwards , a ritualized threat.
	Chase	Running after another for >5m
AVOID & WITHDRAW	Horn to Horn push	Heads down and pushing horn of each, continuing for at least 10secs, often with head twisting
	Horn to body of another	Pushing the horn into any part of another's body
	Head lowered	Head lowered with chin in pointing horns at another (threat).
	Contact Break& Walk away	Walk away for >5m from another when within 2 m
	Turn head away	Turn head by 30o+ from another who is within 2 m
		Front , or all 4 feet off the ground as leap further away from another within 2 m
	Leap away	Lateral tail movement >5 times
	Tail swish	

UNCERTAINTY	Chew	Lateral movement of the jaw chewing, either with full mouth or as a displacement activity
	Lick , rub, scratch own body	Touch any part of own body to lick, scratch, smell when within 2 m of another (usually a displacement activity)
	Cough	Release of pressure in the respiratory tracked, often to clear it.
	Yawning	Opening of mouth wide with head usually up for up to 5secs, often as displacement behaviour.
	Shake head	
		Shaking of the head laterally >5 times
		Vertical up and down movement of the head > 5 times.
	Nodding head	

Table 2: The behaviors recorded , their definitions and the categories into which they were placed (see below for explanation of the categories).

Since the population was small and behavioural variation high, an assessment of averages and percentages are preferred to detailed statistical analysis as the intention is to outline the methodology and trends, although some excel, Chi squared.

Results

1206 interactions recorded between the 7 rhino continuously observed with more than one behaviour recorded in many interactions.

1. The use of the different sensory modalities in communication.

The frequency the different sensory modalities were use is in (table 3).

Sensory Modality	Total number	The percentage of all interactive behaviors in each sensory modality
All messages with visual content & possibly olfactory	1345	83.2%
Visual message with possible tactile & taste content	150	11.1%
All Auditory messages within human hearing range	85	5.7%

Table 3: The frequency the different sensory modalities were used in interactions by both by the performer and by the response of the recipient.

Of the 83.2% visual messages, an unknown percentage were combined with olfaction, and a further 11% of the visual messages could have a touch and taste content, thus the total percentage of the messages with a visual content was 95%. Only 5.7% of the messages were auditory. Auditory messages using the larynx (vocalizations) consisted of growl, grunt and squeak were rare (table 4). Non-vocalized noises were more common (e.g. blow, cough, snort, and sigh). It is possible that there were also ultra or infra sounds given.

The two most frequent noises were "cough" given with an open mouth, and "blow", made by pressure changes in the buccal and nasal cavities with the mouth shut.

2. The meaning of the messages.

The meaning of many messages is "explicit", that is self-evident. For example: "running away" indicates the recipient wants to get away from the initiator. Touching or licking another indicates is affiliative. But, the meaning of some behaviors is "implicit ", that is it

Noise made	As a peformer	As a response	Total
Blow	5	27	32
Cough	10	24	34
Snort	4	3	7
Sigh	0	1	1
Growl with larynx	5	4	9
Squeal use of larynx	0	1	1
Grunt use of larynx	0	1	1
Total	21	58	85

Table 4: The frequency the different auditory messages were used (see table 2 for definitions).

does not have self-evident motivational state such as "tail wagging" or "head shaking" often related to indecision/ uncertainty whether to approach or avoid [20] or frustration (an inability to obtain a desired goal [21-25] When given in social situations, they are called "displacement activities" . They are:- tail wag, flap both ears, ear twitching, head or body shake or nodding, head toss, head extended forwards, scratch or rubbing self, chewing (table 2 for definitions). Displacement activities may be exaggerated when ritualized and occur out of the normal context in communication (for example preening in courtship in birds [35] or head shaking, scratching & tail swishing in ungulates and canids [9] where higher priority behaviors are blocked so behaviors of less importance in the repertoire become "disinhibited", implying that the individual is "uncertain" what to do. "Uncertain" behaviors were recorded 202 times; 13.7% of all the behaviors in interactions, considerably more than aggression or threat.

The frequency of the different behaviours in each of the 7 category of meaning, either performed (P) or as a response,(RR) are shown in (table 5). The overall frequency for each behavioural category (P+RR) in column 4, and its percentage of the total in column 5, and each discussed below.

Approach

(walking or running for at least 4 meters towards another), before negative (aggressive) or positive (affiliative) interaction. The negative responses to approach where infrequent (withdrawal + aggression 27 =6.7% of all : (Table 6).

Affiliation was (72 of 429) 16% of total, but, 31% of the total approaches were ignored.

Behavioural Meaning Category	Number Performed by initiator): P.	Number Performed as a response to any behaviour : RR	Total: P + RR	Percentage of the total in that category
1) Approach	429	126	555	36.4
2) Uncertain	84	118	202	13.7
3) Interest	111	43	154	10.1
4) Affiliative	280	64	344	22.4
5) Aggression & Threat	27	29	56	3.6
6) Withdraw or avoid	62	149	211	13.8
Total:	1080	442	1522	100
7) No response: ignored	0	638	638	41.9% of all behaviors in interactions were ignored

Table 5: The frequency of the behaviors in the 7 categories.

	Uncertain	Interest Positive	Affiliation Positive	Aggression Negative	Withdraw Negative	Ignored as response.	TOTAL & % of total responses
Approach	83	108	72 16%	5	22 6.7%	139 31%	429

Table 6: Responses to approach.

Uncertain

Table 5 shows that uncertain behaviors are more frequent as a recipient response than performed by the initiator (Table 5, RR=118 to P=85).

But, they are one of the least ignored of categories of behaviour (see table 7 below) indicating their importance in carrying a message.

Positive interaction

Interest

Interest is shown by explicit orientating and showing curiosity towards the other such as pricking both ears, turning the head towards, or watching/ looking at the other. When the attention was directed behind, one or both ears rotated back, or when the head or tail were raised indicating slight arousal [26-29] are included here. This category is 10.1% of all the behaviors in interactions. More "interest" is performed by the performer than the recipient.

Affiliation

Affiliation **is** another explicit behaviour indicating that the individual wants / likes to be close to the other shown by touching, smelling, licking or rub another, contact walking, stand together, following, resting head/chin/neck on the other, nose to nose smelling, or standing over another when s/he is lying. It was 22% of the total behaviors recorded, and more frequently performed by the performer than as a response [30,31].

The the total positive/ cooperative communicative behaviors is 32 % of all behaviors (10.1 interest +22.4 affiliation).

Negative interactions

Aggression and threat

Aggressive acts were horn to horn or horn to body push. Ritualized threat was both ears rotated flat back , or the lowering of the head with chin withdrawn which pointed the horns at the other. Chasing another, kicking, or turning the quarters towards another or showing intention to kick, were included Aggression or threat occurred in 3.6% of the behaviors recorded in interactions with little difference between the frequency shown by initiator or responder (table 5).

Avoid another or withdrawing as a response

These accounted for 13.8% of the total behaviours, more common as a response (withdrawing rather than avoiding).

The socially negative behaviours are often used to measure "dominance hierarchy". Here they are considerably less frequent than the socially positive behaviors: 17.4%, compare to 32.4%

Ignoring directed behavior

One of the surprising results was that 41.9% of the directed behaviour was ignored. Further analysis in (table 7).

Behavioural Category	Total number directed behaviors ignored in each behavioral category	% of all directed behaviors that were ignored for each category
Approach (+ or -)	139	21.8%
Aggressive	12	1.9%
Avoid or withdraw	196	30.7%
Affiliative	172	26.9%
Uncertain/frustration	39	6.1%
Positive interest	63	9.9%

Table 7: The frequency of the behaviors in the different behavioral categories that were ignored by the recipient.

The most frequently ignored behaviours were: approach, withdraw and affiliative behaviour.

The lease ignored, and the least used were aggression and threat (1.9%).

But, "uncertain" behaviour was *not* frequently ignored… only 6.1%. This confirms that such behaviour has considerable communicative importance.

Reciprocity

Kingsley (1893, anonymous 1993) in his moral children's tale for children called this "do as you would be done by". The overall frequency of the recipients response being in the same category as s/he had received was 17.24% (significant higher than expected at p>0.01).

Since 17 incidences of aggression was horn to horn pushing which by definition is reciprocal, aggression is more than 50% reciprocated. The next highest percentage of the responses that were reciprocated in the same category was "uncertain", another indication that these behaviors have a message value (table 8).

	Withdraw/avoid	Affiliative	Uncertain/Frustration	Approach	General interest	Aggression	Total
Total number of responses in that category	149	422,	84	429	111	29	1195
Number reciprocated in same category	9	75	21	83	20	17	208
Reciprocity % for each category	6% of withdraw NS	17.8% of affiliative NS	25%** of uncertain Significant p>0.01	19%of approach NS	18% of interest NS	58.6% of aggression	17.24% of total. p>0.01

Table 8: "Do as Done By" or Reciprocity. The frequent of the response in the same behavioural category as received.

Discussion and Conclusion

The use of the different sensory modalities in communication between black rhino

Since all movements and postures potentially carry messages when individuals can be seen, it is not surprising that visual signals were most common, [23,24] over over 90% having a visual component, although some of these also carried olfactory or tactile messages. Some visual signals were ritualized such as "head extending forwards", (indicating curiosity and non-aggression in many large ungulates) and "ear flattening", exaggerated in species without temporal horns where the ears are more conspicuous [9]. Although a considerable number of signals were purely visual, many messages were multi-sensory [32-36] Auditory communication within the range of human hearing was less common (5%). Noises made without the larynx, characteristic of some arousal, were more common [10].The use of infra- or ultra- sound in black rhino awaits investigation.

It is concluded that visual communication is used mostly when black rhino are in a group and consequently, they must be able to see quite well.

The meaning of messages; a re-consideration of the rhinos' social contract Positive communication, that is the performance of behaviors leading to group cohesion were categorized into "showing interest" and "affiliation" and were twice as frequent as socially negative communication such as aggression, threatening, avoiding and withdrawing.

Behaviour which has been shown to indicate "uncertainty" and / or frustration, was common in interactions. Uncertainty can aid the cohesion of the group by reducing potential conflict. This illustrates that rhino make conscious decisions being aware of the other individual and uncertain whether to avoid or approach [37,38]The situation also allows for the continuation of the *status quo, by* messages being ignored by the recipient which was common (41.9% of behaviors), another mechanism to decrease conflict and encourage group cohesion.

Reciprocity with a behaviour in the same meaning category as that received, has not been recorded previously. It was high :17.24%, for the 6 behavioural categories p<0.01).This indicates that (a) socially positive reciprocity help cement bonds, and (b) the importance of obeying the social contract [39-42]. Where resources are widely dispersed, social cohesive behaviors, and behaviors likely to reduce conflict or encourage a continuation of the status quo are likely to be more important than conflicts [43-45] although this will vary with the environment Having a stable cohesive group is encouraged by bonded individuals. Socially cohesive behaviors such as affiliation, reciprocity and ignoring behaviors likely to give rise to conflict, have not been previously considered in large herbivores although central to the accumulation of ecological knowledge (e.g. knowing what to eat and where to find it, where to shelter, drink, the geography of the home area etc). It is important for the individual to learn who to learn from, that is to "know what another knows", thus, learning and following youngsters who have less knowledge is not reliable .Further studies on positive behaviors, uncertainty, reciprocity and ignoring directed behaviors in interactions could lead to a more thorough understanding of group organization and cognition in large herbivores but, time is running out for the black rhino who may become extinct before this is done.

Addendum

All these rhino were shot by poachers in 2007 .However they had, by that time, produced 13 offspring many of whom have been re-introduced to the wild, although it is not known how many of them have survived. The remaining 3 black rhino descendants have bred, and recently have been joined by a pair of breeding white rhino at Imire Wildlife Reserve. It must be emphasized that this is one of the few remaining small populations of black rhino who are successfully reproducing in semi-captivity.

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Declarations

There was no external funding, no competing interests, and no animal was caused to suffer as a result of the study.

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