



Universität
Zürich UZH



Vocal Communication in the Banded Mongoose

Complexity of information coding

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PhD committee

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Content

- Introduction
- Study species/site
- Vocal repertoire
- Vocal cues
- Call sequences
- General discussion

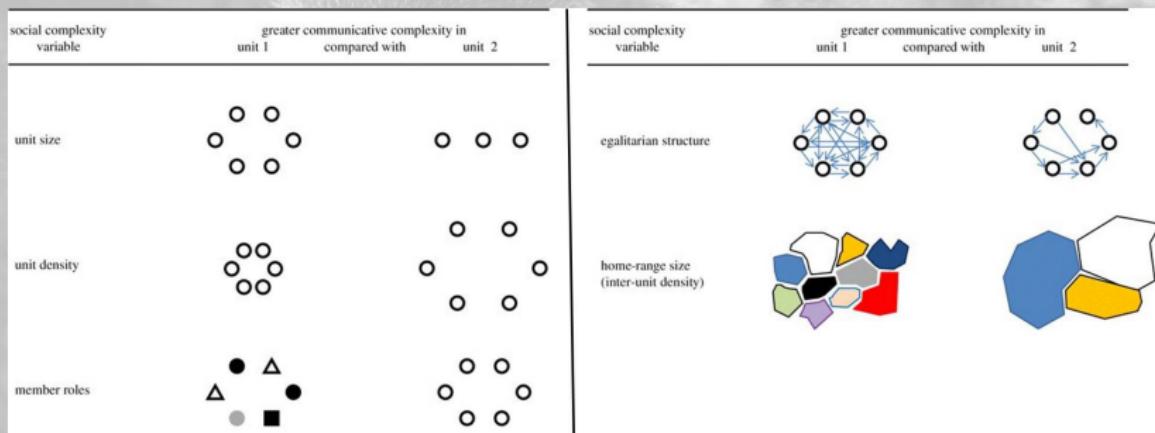
The Expression of the Emotions in Man and Animals.

'With social animals, the power of intercommunication between the members of the same community, and with other species, between the opposite sexes, as well as between the young and the old, is of the highest importance to them. This is generally effected by means of the voice, but it is certain that gestures and expressions are to a certain extent mutually intelligible.'

Darwin 1872, p. 60

Social complexity

- Social complexity hypothesis
 - Social groups
 - Cognitive skills



(Whitten and Byrne, 1988; McComb and Semple, 2005; Freeberg et al, 2012)

Social complexity and vocal repertoire complexity

The evolution of communication.

'...the richest elaboration of systems of social communication should be expected in intra-specific relationships, especially where trends towards increasing inter-individual cooperation converge with the emergence of social groupings consisting of close kin.'

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Social complexity

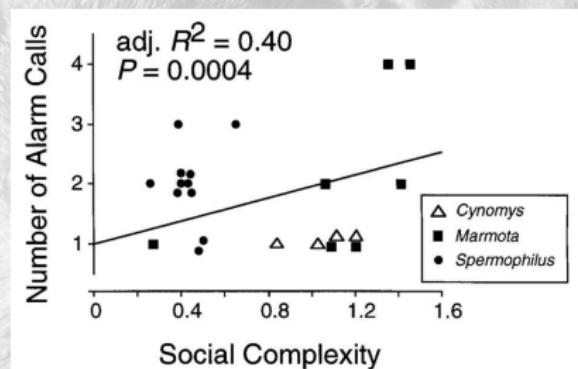
- Social complexity drives the evolution of vocal repertoire size



(Marler, 1977; Hauser, 1996; Blumstein and Armitage, 1997; McComb and Semple, 2005; Freeberg et al, 2012)

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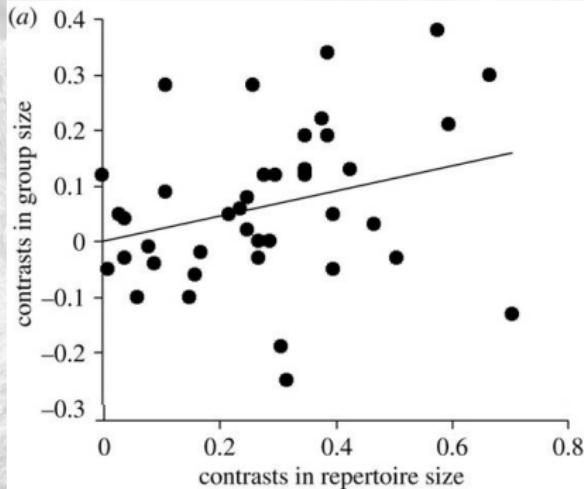


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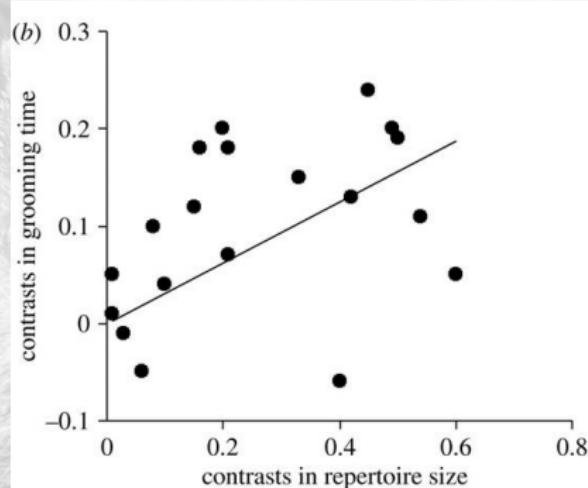
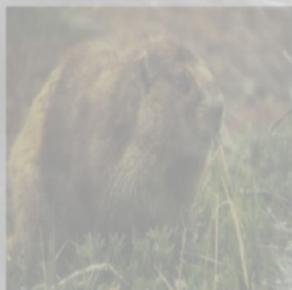
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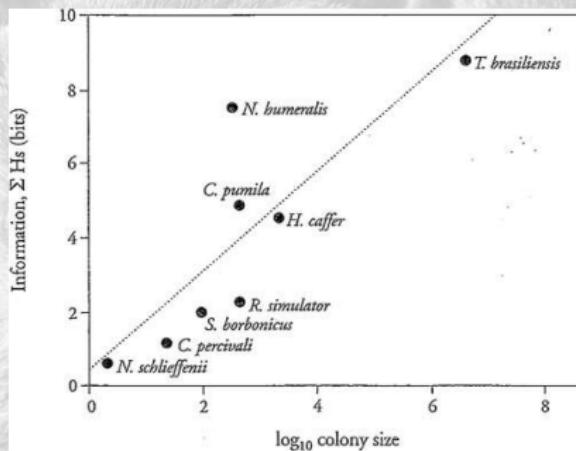
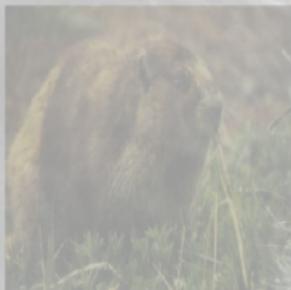
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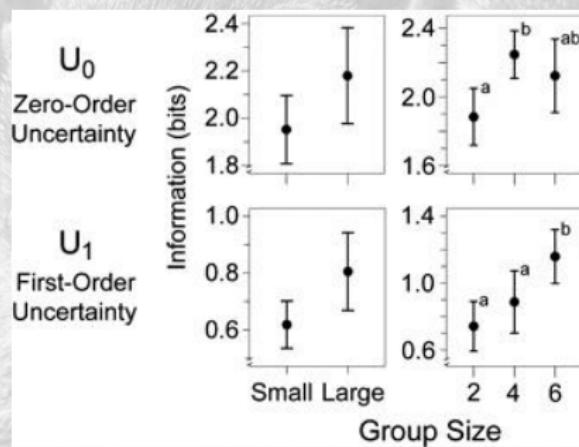
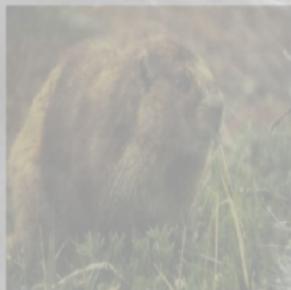
Wilkinson, 2003



(Marler, 1977; Hauser, 1996; Blumstein and Armitage, 1997; McComb and Semple, 2005; Freeberg et al, 2012)

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Vocal repertoire

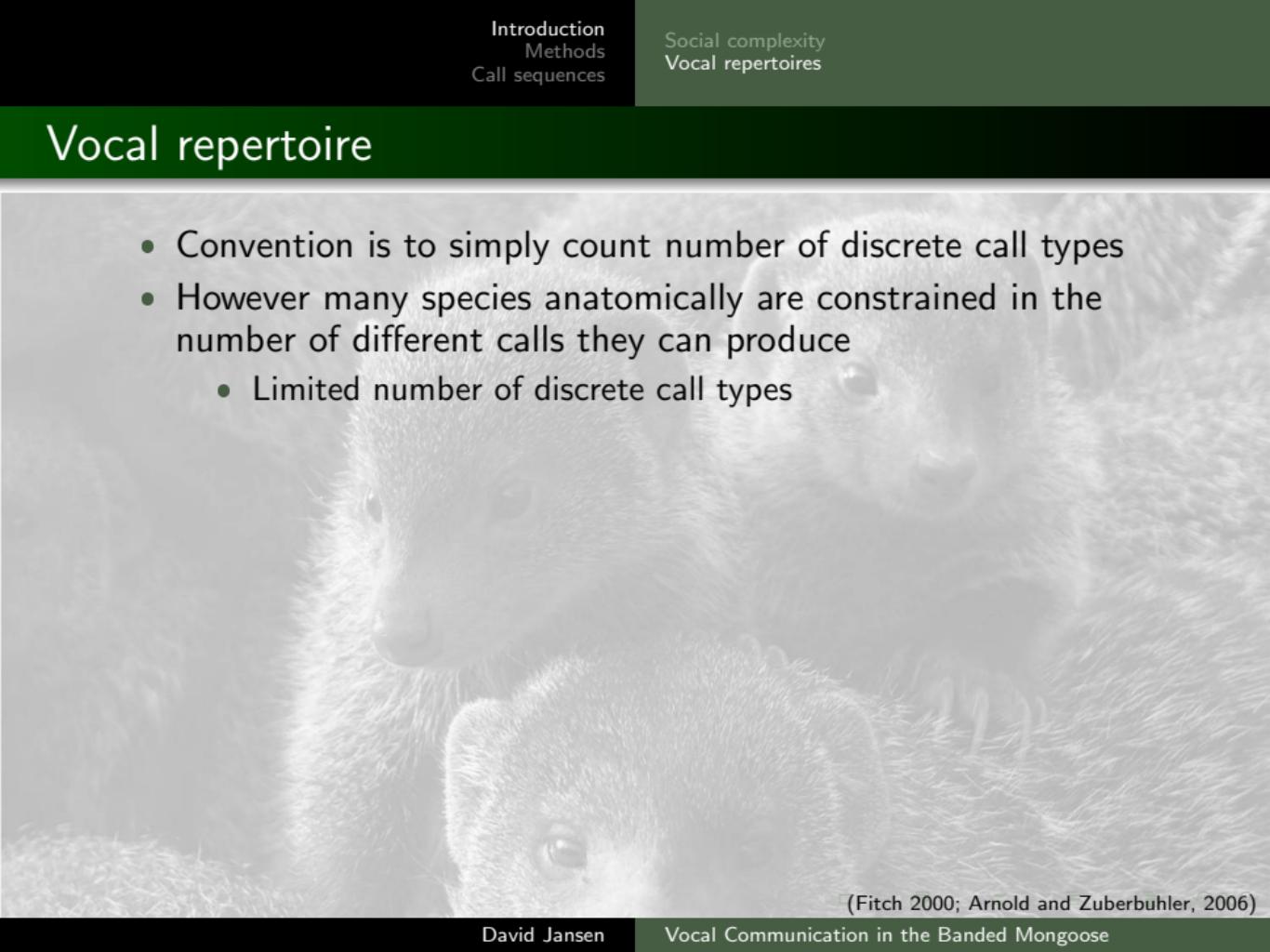
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(Fitch 2000; Arnold and Zuberbuhler, 2006)

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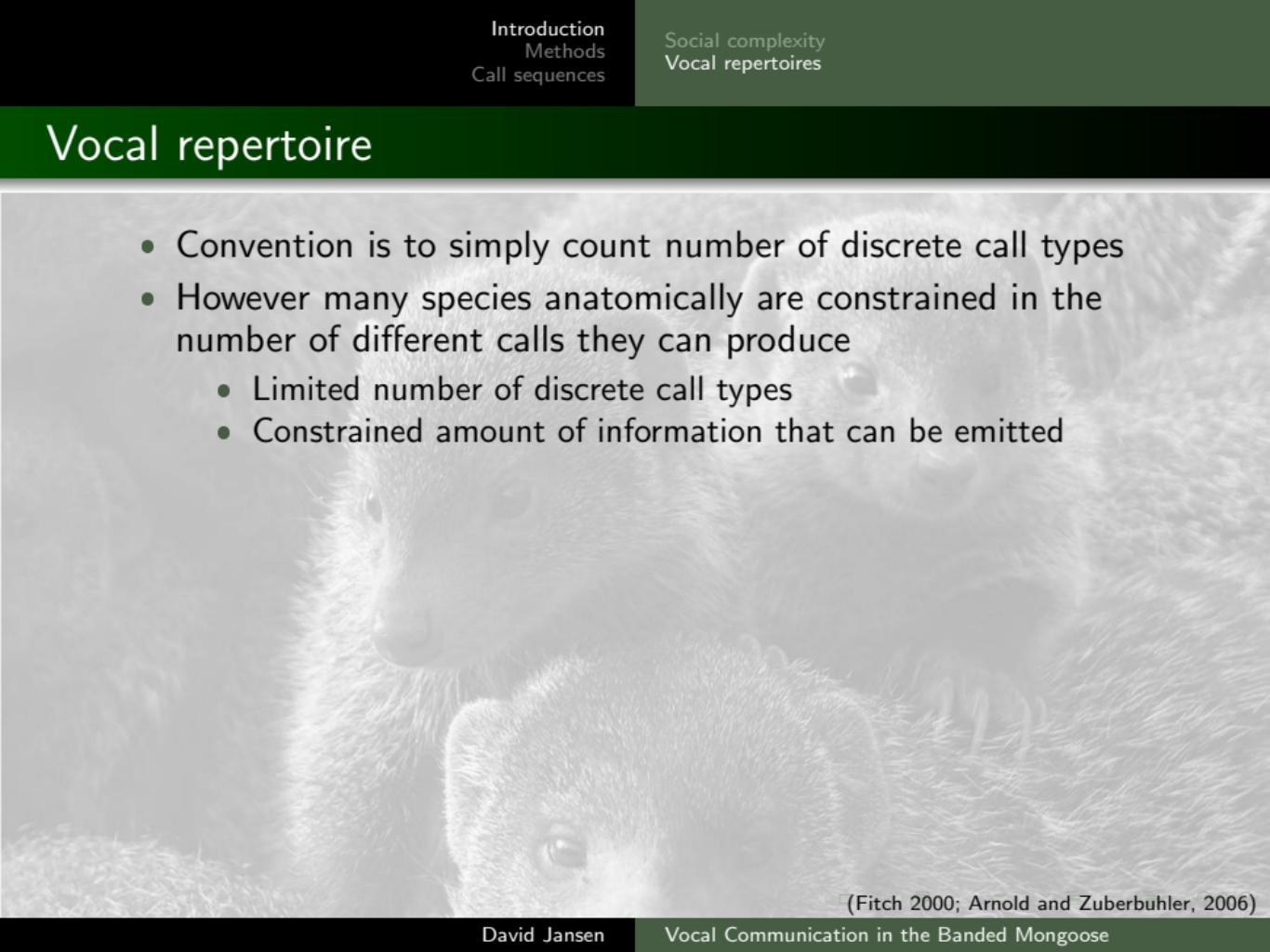
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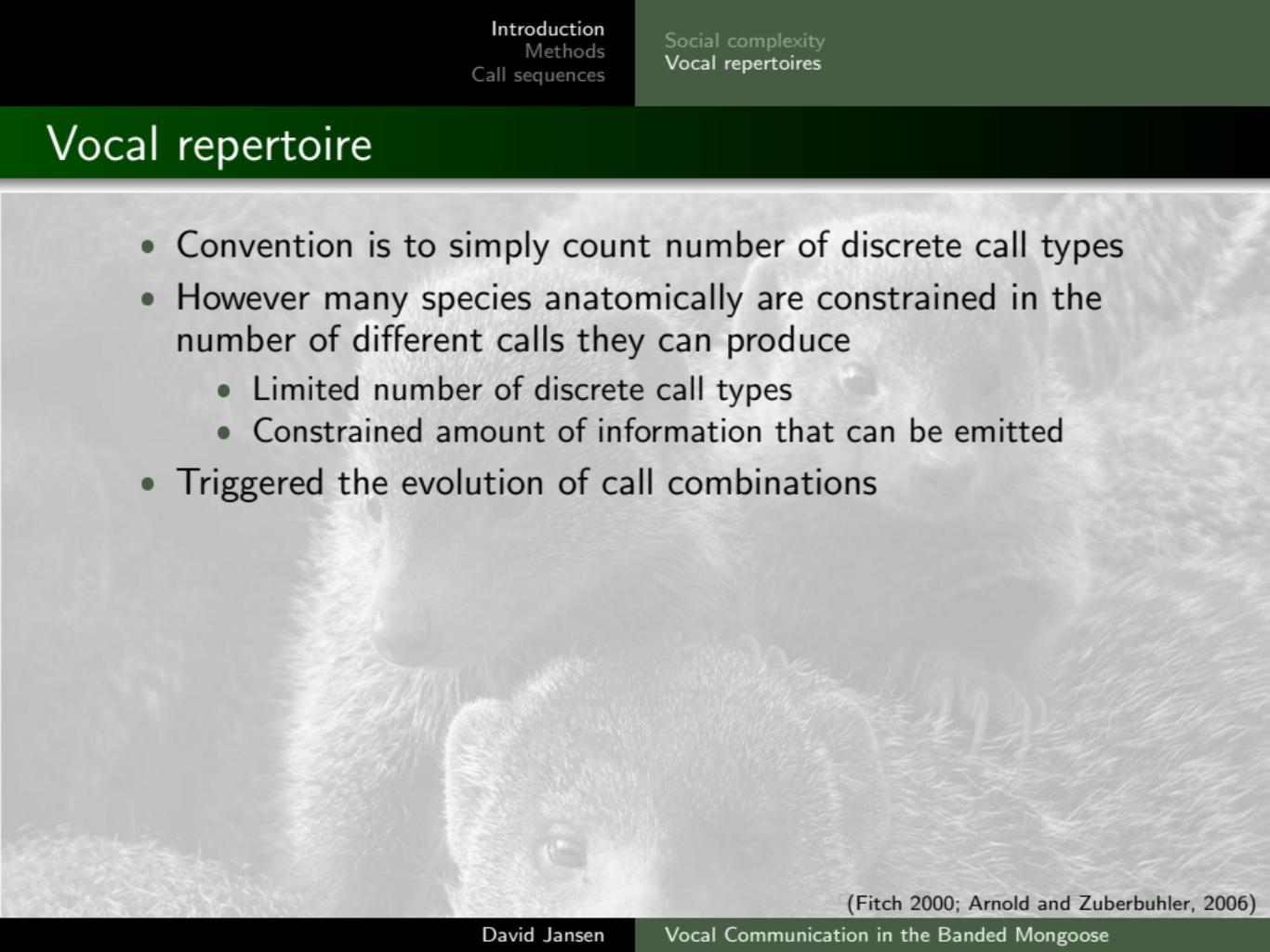
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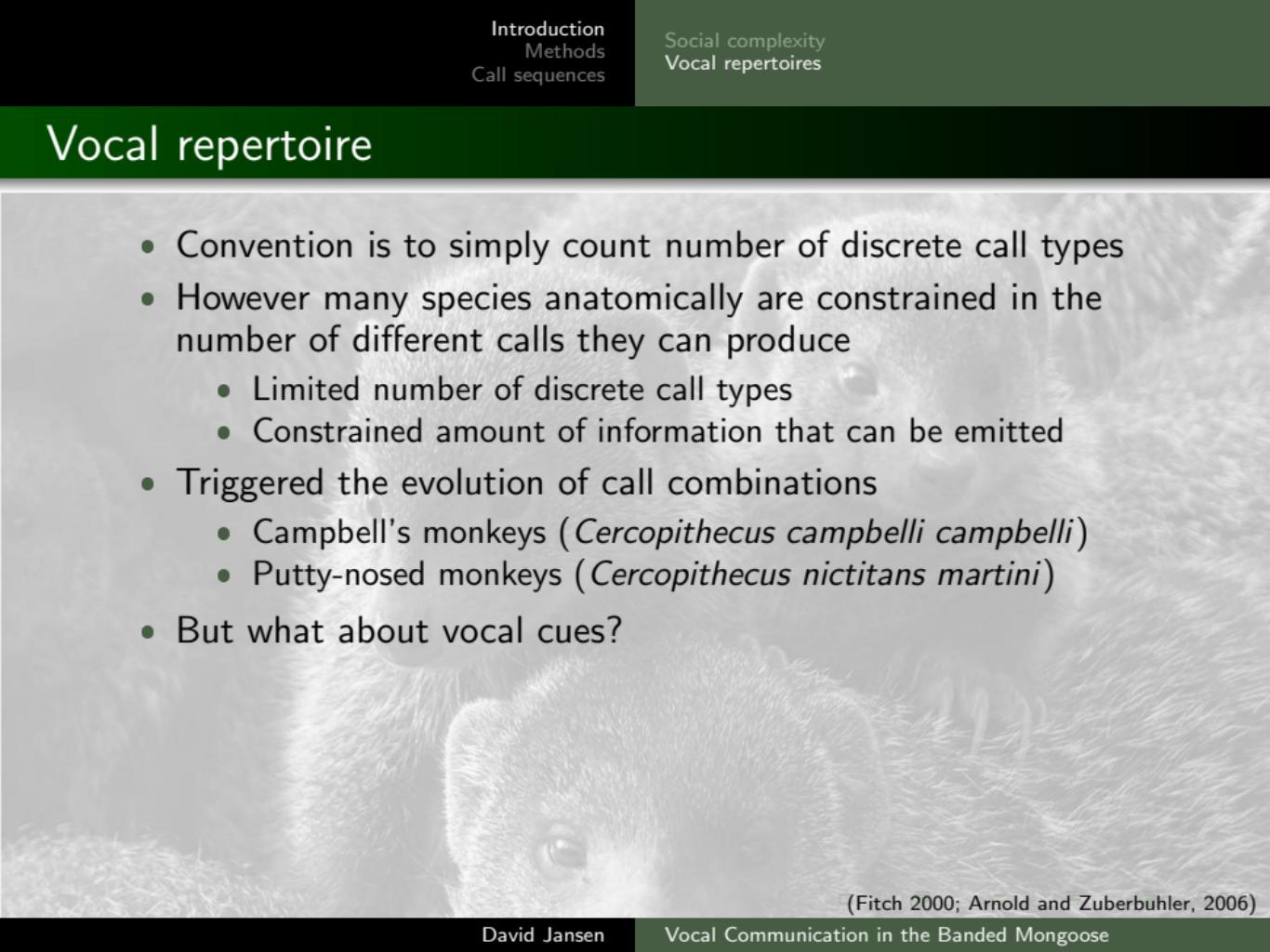
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- But what about vocal cues?



(Fitch 2000; Arnold and Zuberbuhler, 2006)

Vocal cues

- Individual identity signature is the most commonly shown vocal cue,
but also vocal cues for:



Vocal cues

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 - Parent-offspring recognition
 - Group
 - Sex
 - Male quality
 - Reproductive state



Vocal cues

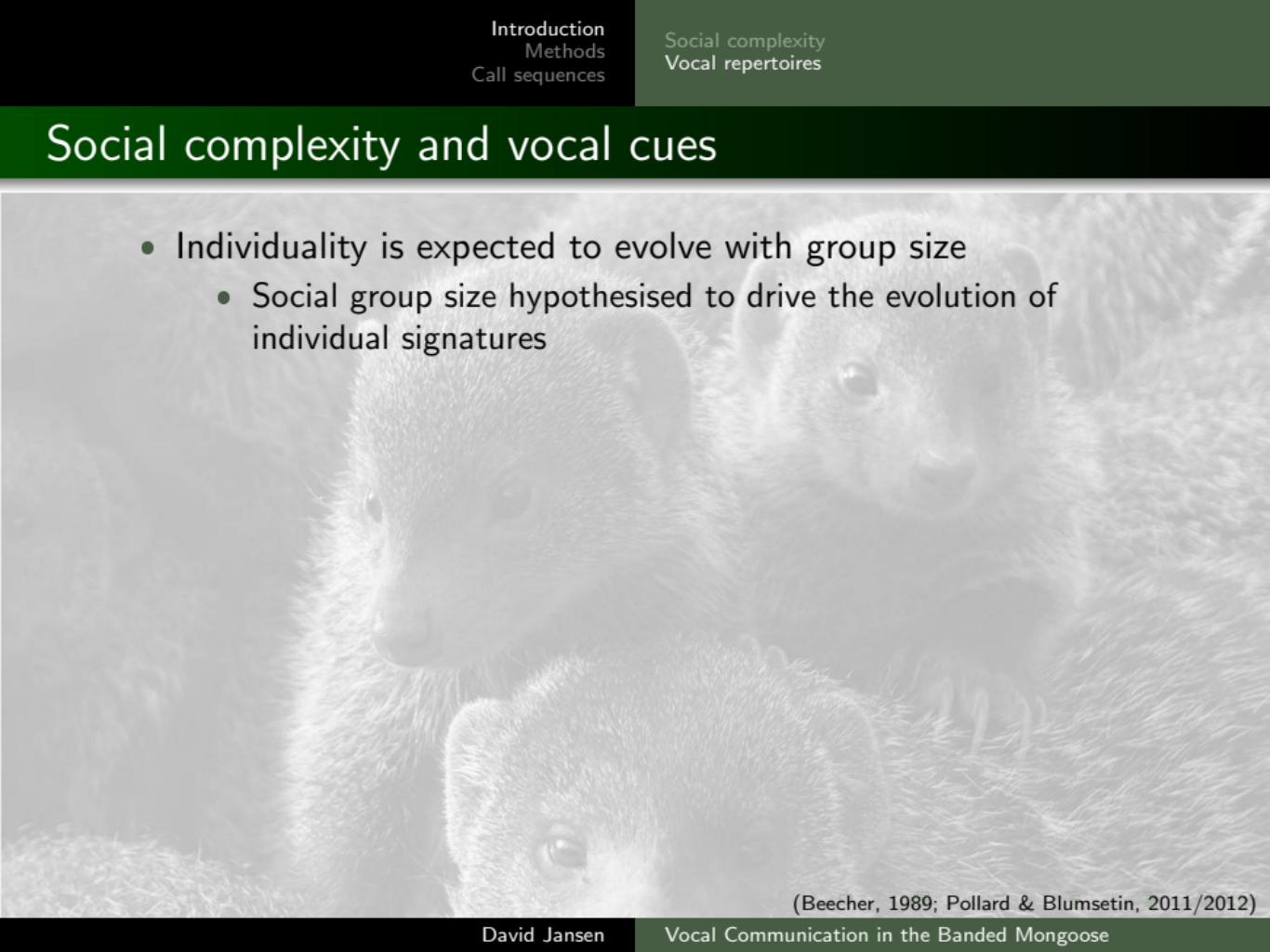
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⇒ These all provide potential additional information to receivers



Social complexity and vocal cues

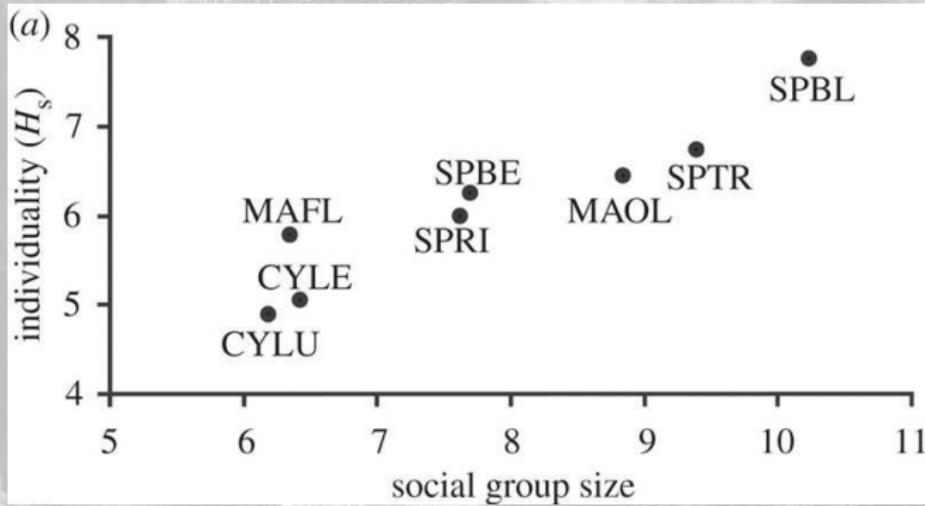
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 - Social group size hypothesised to drive the evolution of individual signatures



(Beecher, 1989; Pollard & Blumstein, 2011/2012)

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Social complexity and vocal repertoire complexity

- Focus of recent research



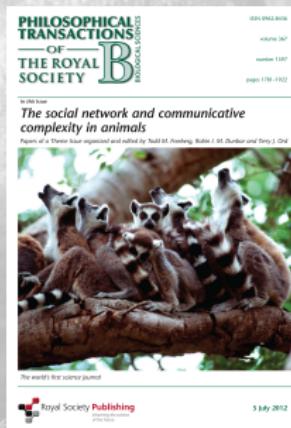
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Social complexity and vocal repertoire complexity

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- Need for more comparisons



Social complexity and vocal repertoire complexity

- Focus of recent research
- Limited or partial evidence
- Need for more comparisons
 - Lemurs
 - Mongooses



Social complexity and vocal repertoire complexity

- Focus of recent research
- Limited or partial evidence
- Need for more comparisons
 - Lemurs
 - Mongooses
 - Solitary
 - Family groups
 - Cooperative breeders



Study species and study site

- Banded mongoose *Mungos mungo*
- Approx. 2kg
- Communally breeding
- Groups of mixed sex with 7 to 45 individuals
- No clear dominance hierarchy



Banded mongoose - Vocalisations

- Vocal repertoire of captive study
 - High degree of variability and graded
 - 9 different vocalisations
 - Two close call types

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Banded mongoose - Vocalisations

- Vocal repertoire of captive study
 - High degree of variability and graded
 - 9 different vocalisations
 - Two close call types
- Previous observations in the field
 - Individual signature in close call
 - Graded recruitment calls
 - Combination of elements

Study site

- Queen Elisabeth National Park, Uganda
- Banded Mongoose Research Station (since 1995)
- 4-6 habituated groups
- Approx. 200 individuals
- All individuals individually marked
- Approx. 30 - 50 habituated to recording microphone at $\leq 2\text{m}$



Methods - field work

- *Ad libitum*
- 5 minutes focal watches
- Record behaviour and associated calls
- Close call variations
- Call sequences

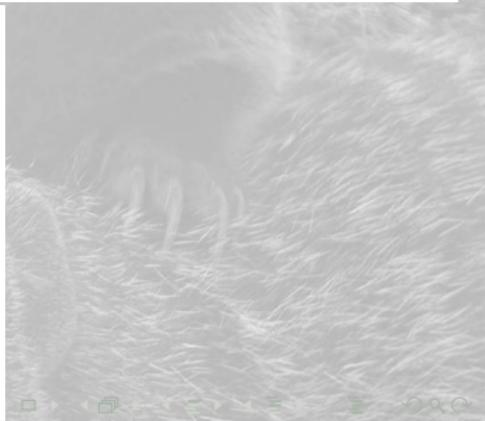
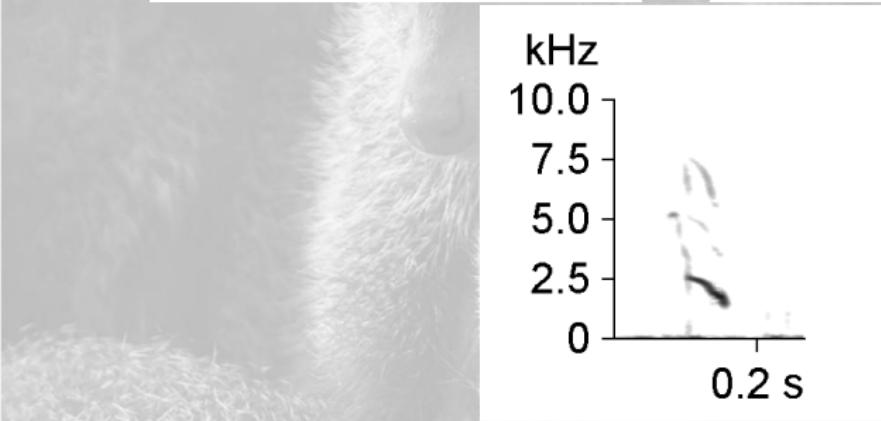
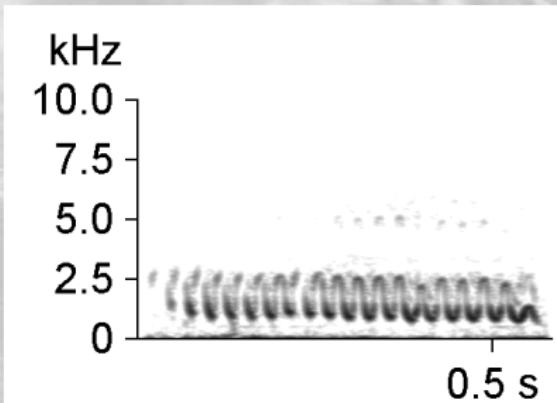
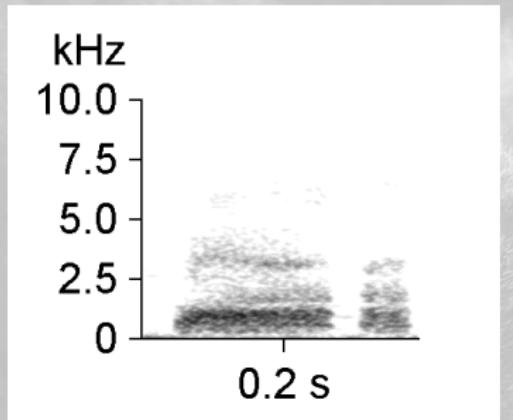


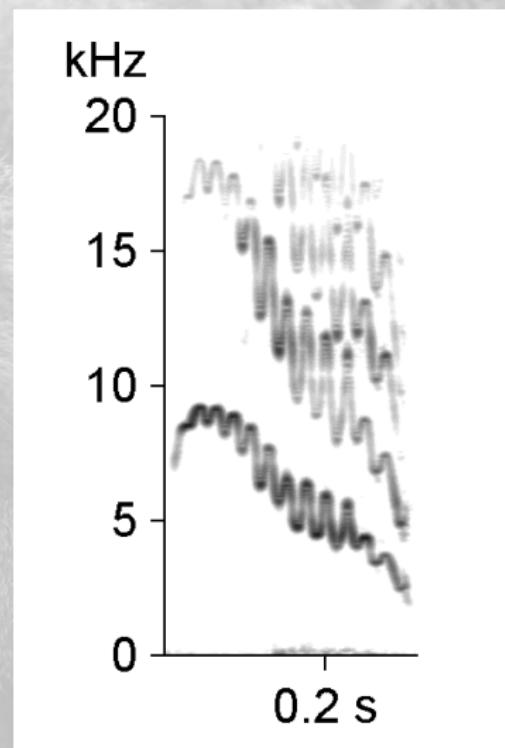
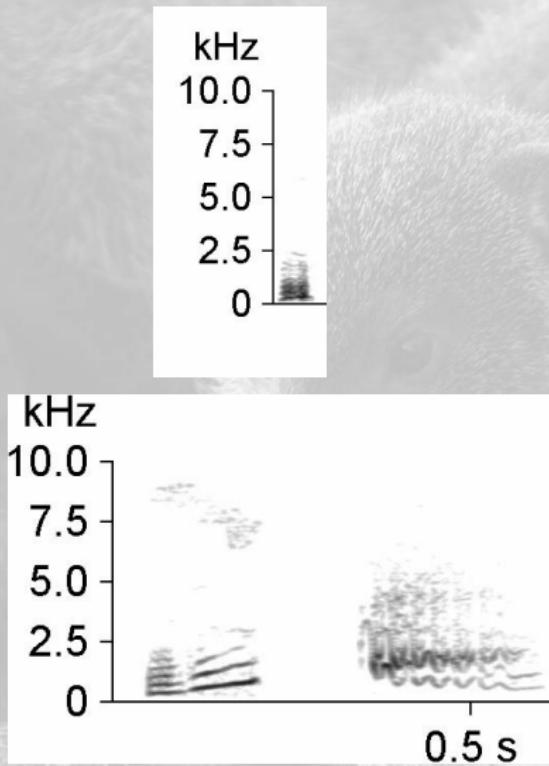
Methods - statistical analysis

- Mixed effect models
- Variance inflation factor
- DFA analyses with stepwise variable selection
- Permuted DFA for nonindependent data
- Bootstrapping analysis to test for significance

Result - Vocal repertoire

- 14 adult call types
- Calls show high degree of variability





Result - Vocal repertoire

- 14 adult call types
- Several new call types
- Calls show high degree of variability
- Calls in 4 different behavioural contexts

Behaviour contexts	Number of call types
Cohesion/movement	3
Resource calls	4
Social calls	4
Calls of context in danger	3

- Additionally 6 pup vocalisations

Discussion - vocal repertoire

- Graded vocal repertoire
- Differences with other social mongooses

Close calls

- Most commonly emitted call type
- Soft short distance vocalisation
- Likely related to maintaining group cohesion
- Individually distinct
- Additional variation

Research questions - Close calls

- What vocal cues are encoded in close calls?

Research questions - Close calls

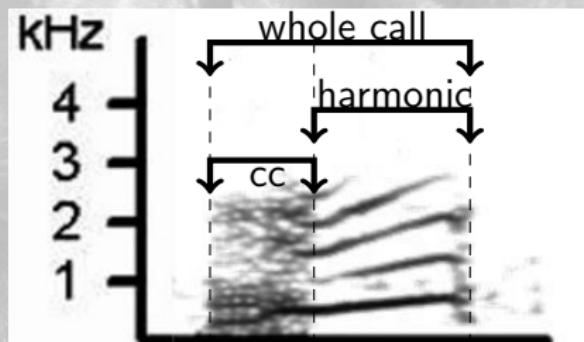
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Research questions - Close calls

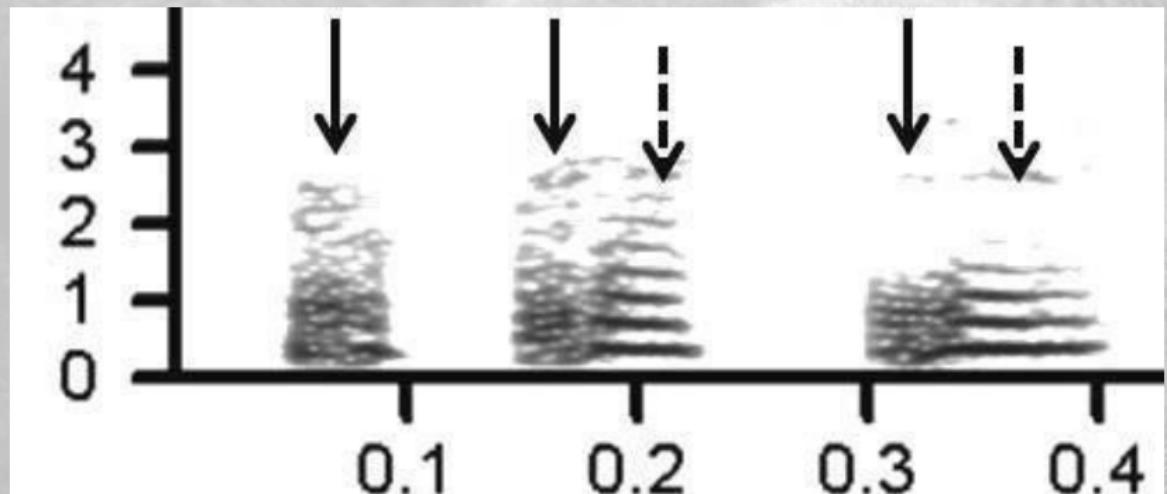
- What vocal cues are encoded in close calls?
- How is the individual signature encoded in a graded call?
- Is the additional variation correlated with behaviour?

Methods - Close calls

- Assigned labels to call parts
 - Whole call
 - Noisy part (cc)
 - Harmonic part (if present)
- 16 parameters
 - Spectral parameters
 - Temporal



Results - Spectrogram



(Jansen et al 2012)

Results - individual signature

Group	#*	Random (%) [†]	CV-values (%)		
			Whole call	Noisy part	Harmonic
1B	8	12.5	48.1***	45.0***	25.0
1H	14	7	26.1*	40.0***	11.4
11	7	14	42.0***	48.0***	22.0
15	7	14	61.5***	61.1***	22.5

* Number of individuals tested

† p -values are derived by bootstrapping (Müller and Manser, 2008); * $p \leq 0.05$, ** $p \leq 0.01$,

*** $p \leq 0.001$

Results - behavioural cue

Part analyzed	Behavior	Individuals	ncce [‡]
Whole call	digging–searching	30	3.340*
	digging–moving	25	40.640***
	searching–moving	20	30.610***
Noisy part	digging–searching	30	1.500
	digging–moving	25	34.850
	searching–moving	20	23.100
Harmonic part	digging–searching	18	78.040***
	digging–moving	30	77.440***
	searching–moving	30	67.600**

[‡] The results of the pDFA is the number of correctly cross-classified elements (ncce).

* $p \leq 0.1$, * $p \leq 0.05$, ** $p \leq 0.01$, *** $p \leq 0.001$

Temporal segregation of vocal cues

- Banded mongoose close calls first quantification in a animal vocalisations for:

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 - Temporally separated behavioural cue
 - 'Vowel-like' segmentation with a animal vocalisation

Call sequences

- Predominately shown in predation contexts
- Hypothesised to be prevalent in affiliative and social contexts
- Mainly be shown in primates
- Predominately investigated for the possible link to evolution of language

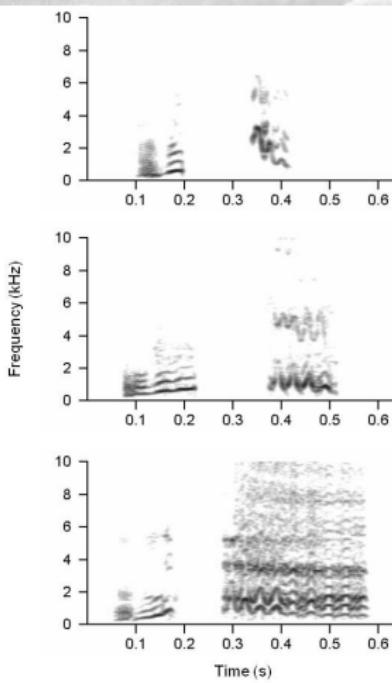
(Lemasson and Hausberger, 2011; Candiotti et al, 2012)

Research questions - Call sequences

- Are close calls used in call sequences?
- Is the individual cue in the close call maintained?
- In which behavioural contexts are the call sequences used?

Call sequences - Spectrogram

Excitement -



Lead -

Lost -



Results - Call sequences

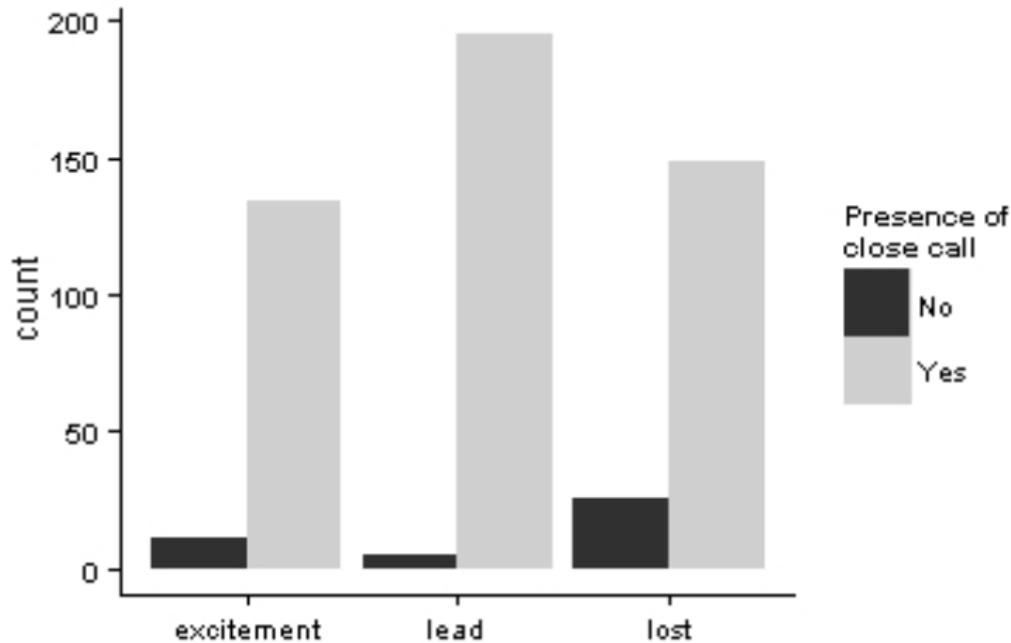
Call type	Context
Excitement	Emitted when encountering wet ground/onset of rain
Lead	Initiation and coordination of group movement
Lost	Emitted when separated from their group

Results - DFA call sequences

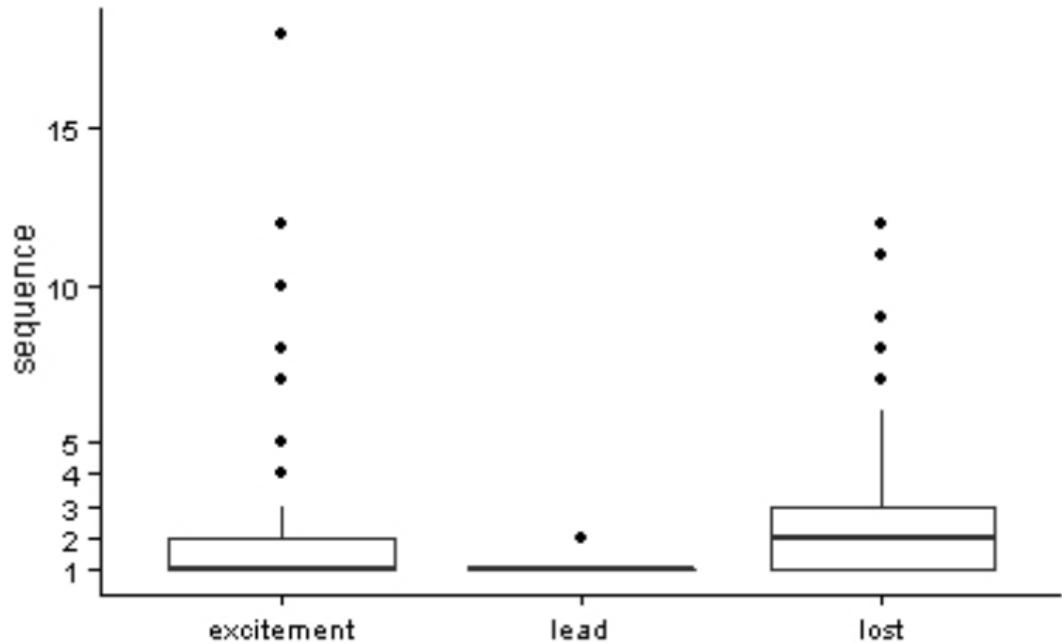
Call types	Predicted membership			Total
	Excitement	Lead	Lost	
Excitement	72.7	27.3	0	100
Lead	3.7	81.5	14.8	100
Lost	8.7	21.7	69.6	100

Call types	Observed behavioural context						Total
	Excitement	Leading	Lost	Foraging	Other		
Close call	-	-	-	21	-		21
Excitement	9	1	-	-	1		11
Lead	-	26	1	4	-		31
Lost	-	3	17	2	3		25

Results - call sequences



Results - call sequences



Discussion - Call sequences

- Close calls used in combination with other elements
- Call sequences used in various behavioural contexts
- Call sequences in affiliative contexts
- Need of playback studies to test exact function

General discussion

- Banded mongoose show vocal flexibility
 - Production
 - Usage



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- Banded mongoose show vocal flexibility
- First quantification for segmental concatenation in mammal



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- Importance of vocal cues



General discussion

- Banded mongoose show vocal flexibility
- First quantification for segmental concatenation in mammal
- Importance of vocal cues
- Considerable complexity may lie within a single 'simple' calls



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...provides an additional dimension to the complexity of information in animal vocal communications.

Is human language complex?



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- Number of discrete 'sounds'
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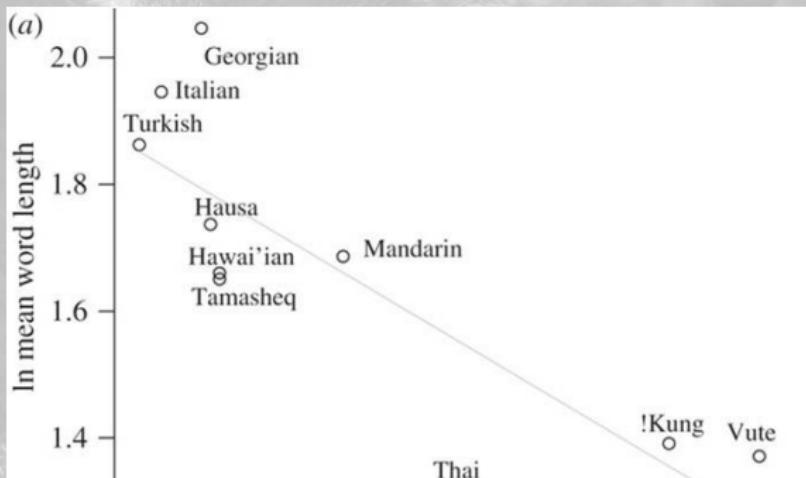
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Is human language complex?

- Number of discrete ‘sounds’
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But clearly this does not represent the complexity of human language

- $\approx \frac{1}{4}$ to $\frac{3}{4}$ million words in English language



(Nettle, 2012)

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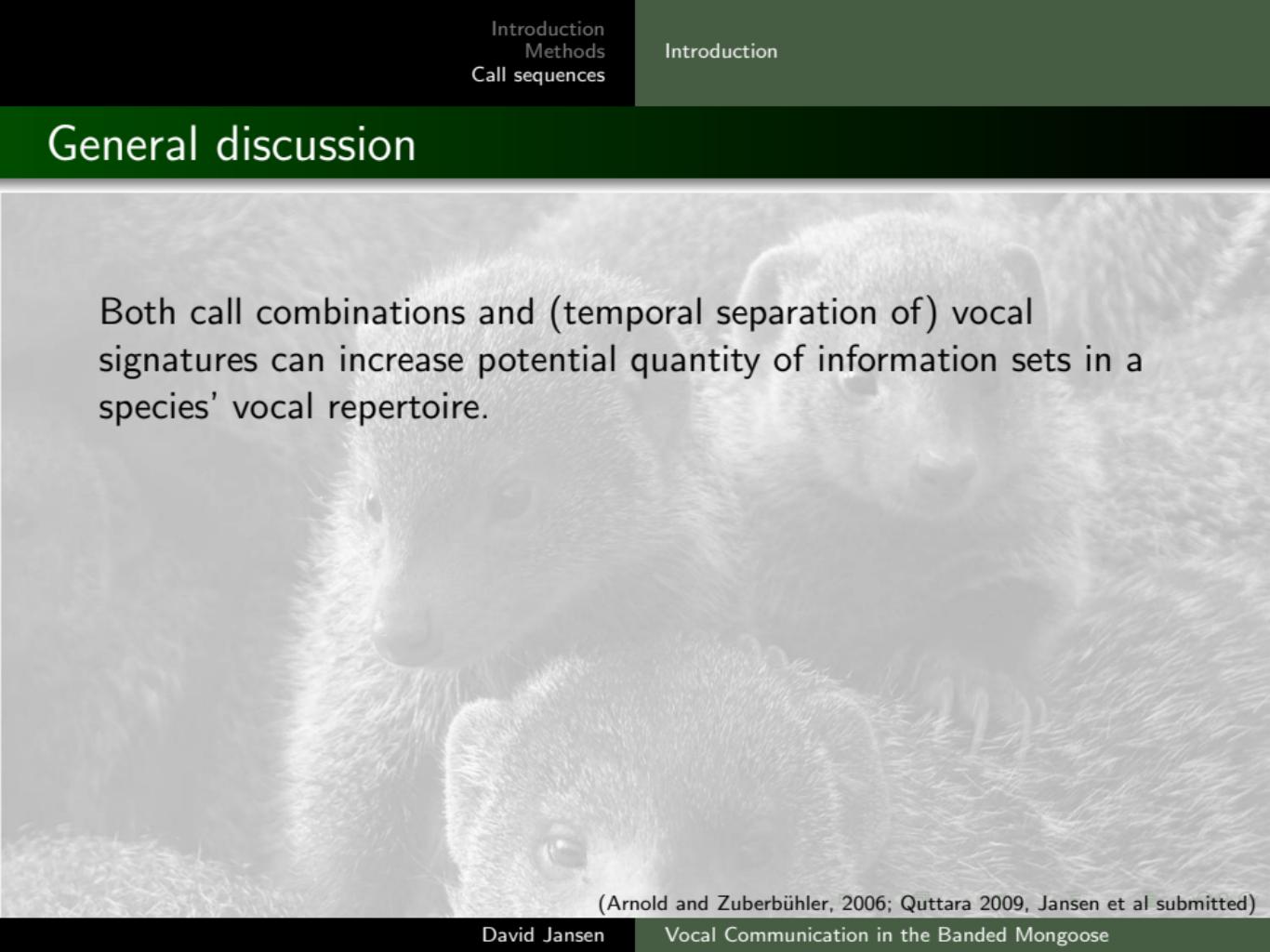
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General discussion



Both call combinations and (temporal separation of) vocal signatures can increase potential quantity of information sets in a species' vocal repertoire.

(Arnold and Zuberbühler, 2006; Quttara 2009, Jansen et al submitted)

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Both call combinations and (temporal separation of) vocal signatures can increase potential quantity of information sets in a species' vocal repertoire.

⇒ These, and other forms of vocal flexibility, therefore should be considered when comparing species.

Acknowledgements

- Marta Manser
- Mike Cant
- Simon Townsend
- Carel van Schaik
- Funding:
 - University of Zurich (PhD)
 - NERC (long term field site)
- Banded mongoose research project (Exeter University)
- The irreplaceable project field assistants
Francis, Solomon and Kenneth



Questions ???

