

What do Monkey Calls Mean?¹

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Abstract. An emerging field of 'primate semantics' offers articulated analyses of the 'literal meaning' of monkey calls, and of additional mechanisms of 'pragmatic enrichment'. We show that comparative studies across species may validate this program, and may in some cases help reconstruct the evolution of monkey communication over millions of years.

Keywords: primate semantics, primate call evolution, primate implicatures, primate linguistics, evolution of meaning, evolution of communication

1198 words

1 Data and problems

Since the 1980's, numerous field experiments have yielded rich generalizations about the use (henceforth, 'meaning') of monkey calls ([11][12]). But only recently did a field of 'primate semantics' emerge ([7][8][9][10]), combining methods from linguistics and primatology. It offers quasi-grammatical analyses of the meaning of monkey calls, and may help trace their development over millions of years.

We introduce two theoretical problems raised by four case studies.

- First, what is the *meaning of individual calls*? A rich example is afforded by Campbell's monkeys of the Tai Forest (Box1a). Male adults use a call *krak* to raise leopard alerts, and *hok* for raptor alerts. But they also have suffixed calls: *krak-oo* for unspecific alerts, and *hok-oo* for non-ground disturbances. The challenge is to assign the meaning to *krak*, *hok*, and *-oo*. Further complexity is added by Campbell's call use on Tiwai Island, where leopards haven't been seen for decades: the Tai calls are used, but *krak* raises unspecific alerts (as does *krak-oo*), rather than leopard alerts. Should we conclude that meaning is subject to 'dialectal' variation – like it is for *pants* in American vs. British English?
- Second, how are the *meanings of individual calls combined*? An expression is 'compositional' if its meaning is derived from that of its parts. Several monkey cases challenge compositionality ([1][10]). –In Putty-nosed monkeys (Box1b), *pyows* alone are used for unspecific alerts, while *hacks* alone are associated with raptors (or possibly high arousal). But sequences containing a few *pyows* followed by

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a few *hacks* trigger group movement, rather than predator-appropriate reactions. Is the meaning of these '*pyow-hack* sequences' derived from the meaning of their parts, or should they be treated as a non-compositional idiom, such as *kick the bucket*?

–A radical compositionality problem arises in Titi monkeys (Box1c). With two calls (A and B) rearranged in various ways, their sequences encode information about both predator type (cat, raptor) and predator location (ground, canopy). Are these sequences very long idioms?

–A similar issue arises in less complete data from Black-and-White Colobus monkeys: *snorts* given singly are usually indicative of ground predators, *roars* are usually indicative of non-ground alerts, but *snort-roar* sequences are apparently used in all contexts.

2 Possible Theories

We argue that in almost all cases concatenated calls each contribute their meaning independently from the others, hence a sequence is interpreted as the conjunction of its calls; furthermore, no 'dialectal' variation in call meaning is needed. But a key ingredient of this simple theory is that *the interpretation of a call or call sequence can be pragmatically enriched by competition with others*. Notably, calls are subject to an 'Informativity Principle': if a call *C1* is less informative than a call *C2*, then whenever possible *C2* should be preferred (whether this preference is intentional or automatic is left open). Thus if a raptor shows up, and a raptor call is available, then it should be preferred over an unspecific call; for this reason, the unspecific call may signify the *absence* of a raptor. Strikingly, this Informativity Principle is pervasive in human language and explains why, e.g., "I'll invite John or Bill" suggests that "I will invite John AND Bill" is false ([7][10]). The potential presence of an Informativity Principle in monkey languages thus raises interesting questions about their (joint or separate) evolutionary origin.

- Using Informativity, a uniform analysis of Campbell's calls can be developed (Box1a). *Krak* triggers unspecific alerts, and *hok* non-ground alerts. If *R* is *krak* or *hok*, *R-oo* indicates a *weak* alert of the R-type. Thus *hok-oo* indicates a weak (-oo) non-ground (*hok*) alert – which is more informative than *hok*. The Informativity Principle then kicks in, and *hok* is enriched to *hok but not hok-oo*: it only applies to aerial (*hok*) non-weak (*not hok-oo*) alerts – hence the raptor uses. Similarly, the unspecific alert *krak* competes with *krak-oo*, but also *hok*. In the end, *krak* can only be used for *serious (not krak-oo) ground (not hok) disturbances* – hence the leopard uses in Tai. On Tiwai Island, the Informativity Principle would yield a useless meaning due to the absence of serious ground predators. This may explain why *krak* retains its 'literal' meaning.

- Turning to Putty-nosed *pyow-hack* sequences, they may be treated as (non-compositional) idioms, but this is unsatisfying as these are slow and non-stereotyped sequences. Alternatively, these sequences might have a weak literal meaning, but pragmatically enriched by a Principle of Urgency, which mandates that *within a sentence calls that convey information about the location of a threat come before those that don't* (Box1b). Specifically, we take *pyows* to trigger unspecific alerts, and *hacks* to warn of (serious) non-ground, movement-related events. Semantically, then, a *pyow-hack* sequence warns of a non-ground, movement-related event, e.g. the impending movement of an attacking raptor, or of the (arboreal) monkeys themselves. But if a raptor were present, *hacks* would convey information about the location of the threat and hence should come before *pyows*. This explains why *pyow-hack* sequences are indicative of group movement; no idioms are posited, but competition principles are crucial.²

² For brevity, we simplify various aspects of the analysis. (i) In [8], *hack*-sequences are enriched by the Informativity Principle, which compares them with *pyow-hack* sequences *as already enriched* by the Urgency Principle (hence indicative of group movement). As a result, pure *hack*-sequences come to warn of serious non-ground movement-related events *other* than group movement. On the assumption that eagles attack by flying, this explains the raptor uses of pure *hack*-sequences. (ii) Our analysis only pertains to what [8] calls 'sentences', i.e. sequences preceded and followed by longer-than-normal pauses. In eagle contexts, there are longer *discourses* made of *hack*-sequences followed by *pyow*-sequences. The latter are explained by the fact that after a while an eagle alarm becomes less serious, hence the 'serious' component of *hack* isn't licensed any more.

- Due to their length and slow time course, it's unlikely that Titi sequences are interpreted as idioms, hence our proposal to take each call to contribute its meaning independently (Box1c). The B-call is used in predatory and non-predatory situations alike and thus seems to trigger an unspecific alert. In field experiments, the A-call triggers a 'looking up' behavior; we posit that it is indicative of *serious non-ground alerts*. These assumptions explain why we find B⁺-sequences (=series of B-calls) in 'cat on the ground' situations, and A⁺-sequences in 'raptor in the canopy' situations. But why A⁺B⁺ in 'raptor on the ground' situations? A remark about hunting techniques might help: raptors on the ground usually attack by *flying*, hence the serious non-ground alerts A⁺. Still, being on the ground isn't a typical hunting position, and after a while the alert stops being serious, which only leaves B as a possibility. In 'cat in the canopy' situations, we find AB⁺ sequences, possibly because a serious non-ground danger is indicated, which then transitions to a weaker danger (a cat becomes less dangerous after detection).

- The situation is different with Colobus *snort-roar* sequences. First, unlike *pyow-hack* sequences, they are produced without pause and could form an acoustic unit. Second, they appear in all contexts, hence they are entirely unspecific. Since a conjunction is always *more* specific than its component parts, this presents a challenge to any conjunctive analysis, and *snort-roar* sequences might have to be analyzed as being non-compositional.

3 Perspectives

A comparative study of monkey calls may help reconstruct their evolutionary history. Acoustic similarities among calls have long been used to reconstruct phylogenies, with results that often converge with DNA methods. ([3][10]). But one can turn the problem on its head and start from established phylogenies to reconstruct call evolution. Initial results are striking. *Booms* are non-predation-related calls present in many subspecies of cercopithecines, including Campbell's and Putty-nosed monkeys (Figure2). Inspection of their distribution is strongly indicative of their presence in the most recent common ancestor of entire subgroups: *booms* probably existed several million years ago ([10][4]). While comparative monkey semantics might not directly illuminate the evolution of human language, it could help understand meaning evolution in simpler systems.

Box 1. Data and possible theories

Typical situations of use

Semantics & Pragmatics

Main results

a. CAMPBELLS MONKEYS

boom boom	non-predation alert
hok	presence of an eagle
krak	<i>Tai</i> : presence of a leopard <i>Tiwai</i> : unspecific alert
hok-oo	alert from above
krak-oo	unspecfic alert

Literal meanings

boom boom	non-predation alert
hok	non-ground alert
krak	alert
<i>R</i> -oo	weak <i>R</i> -alert

Informativity Principle

“Prefer more informative expressions!”

Calls	Competitors	Enriched meanings
hok	hok-oo	serious non-ground alert
krak	krak-oo, hok	<i>Tai</i> : alert, serious, ground <i>Tiwai</i> : useless enrichment, hence literal meaning only

b. PUTTY-NOSED MONKEYS

boom	non-predation alert
hack	presence of an eagle (possibly: high arousal)
pyow	unspecific alert
pyow-hack	group movement

Literal meanings

hack	alert: non-ground movement
pyow	alert

Urgency Principle

“Locate predators early!”

pyow-hack = alert: non-ground movement,
but not a raptor-related alert
(for if so hacks should come first)

c. TITI MONKEYS

B ⁺	non-predation alert
B ⁺	cat on the ground
A B ⁺	cat in the canopy
A ⁺ B ⁺	raptor on the ground
A ⁺	raptor in the canopy

Literal meanings

A	serious non-ground alert
B	alert

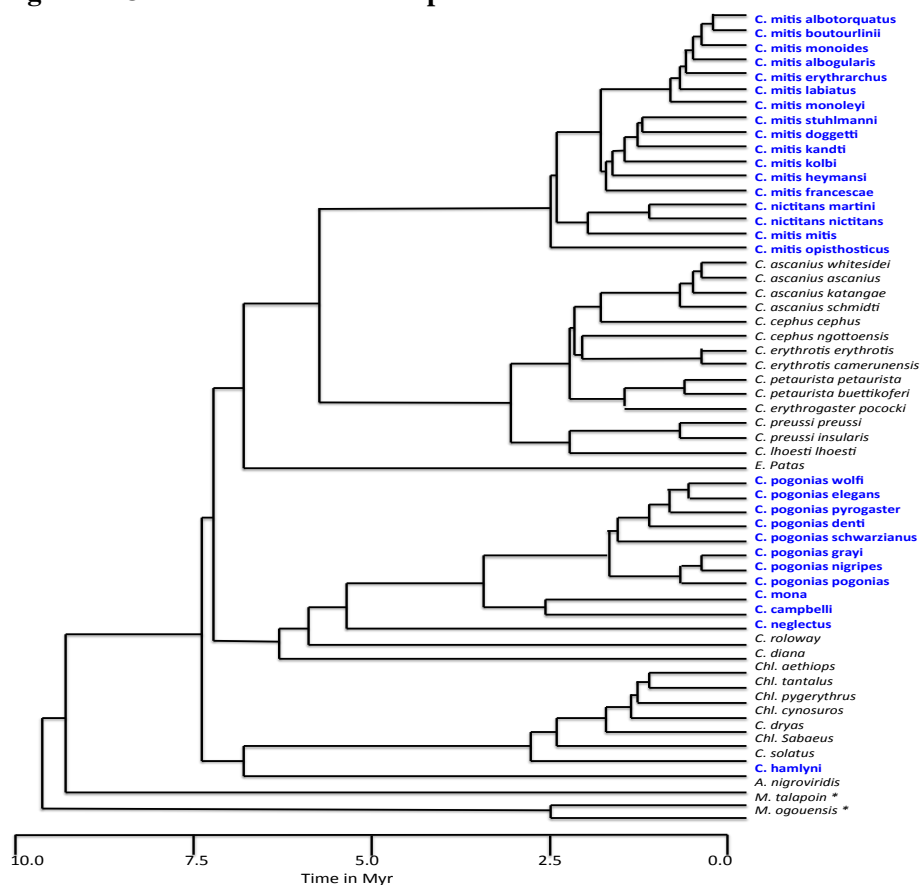
Informativity Principle

“Prefer more informative expressions!”

B⁺ correspond to ground or weak alerts
(or alerts that *have become* weak alerts)

(Raptors in the canopy remain serious threats
even after having been signaled by As)

Figure 1. Call evolution: the example of *boom*



Phylogenetic tree of cercopithecines (from [4] and [10]), with boldfaced names in blue for species that have *booms* ([10]). It seems very likely that the most common recent ancestor of the top blue (= *mitis*) group (which lived about 2.5 million years ago) had *booms*, since all of its descendants do; and similarly for the most recent common ancestor of the middle blue group (*C. pogonias*, *C. mona*, *C. campbelli*, *C. neglectus*).

References

- [1] Arnold Kate and Zuberbühler Klaus, 2008. Meaningful call combinations in a non-human primate. *Curr. Biol.* **18** (5): R202–R203.
- [2] Cäsar, Cristiane, Klaus Zuberbühler, Robert J. Young and Richard W. Byrne, 2013. Titi monkey call sequences vary with predator location and type. *Biology letters* 9(5): 20130535.
- [3] Gautier, Jean-Pierre, 1988. Interspecific affinities among guenons as deduced from vocalizations. In Gautier-Hion, A., Bourlière, F., Gautier, J.P. & Kingdon (Eds.), *A Primate Radiation - Evolutionary Radiation of the African Guenons* (pp. 194-226). Cambridge University Press
- [4] Guschanski, Katerina, Johannes Krause, Susanna Sawyer, Luis M. Valente, Sebastian Bailey, Knut Finstermeier, Richard Sabin, Emmanuel Gilissen, Gontran Sonet, Zoltán T. Nagy, Georges Lenglet, Frieder Mayer and Vincent Savolainen, 2013. Next-Generation Museomics Disentangles One of the Largest Primate Radiations. *Systematic Biology* 62(4): 539-554
- [5] Ouattara, Karim, Alban Lemasson and Klaus Zuberbühler, 2009a. Campbell's monkeys use affixation to alter call meaning. *PLoS ONE* 4(11): e7808.
- [6] Ouattara, Karim, Alban Lemasson and Klaus Zuberbühler, 2009b. Campbell's monkeys concatenate vocalizations into context-specific call sequences. *PNAS* 106(51): 22026-22031.
- [7] Schlenker, Philippe, Chemla, Emmanuel, Arnold, Kate, Lemasson, Alban, Ouattara, Karim, Keenan, Sumir, Stephan, Claudia, Ryder, Robin, Zuberbühler, Klaus: 2014, Monkey Semantics: Two 'Dialects' of Campbell's Monkey Alarm Calls. *Linguistics & Philosophy* 37, 6: 439-501. DOI10.1007/s10988-014-9155-7
- [8] Schlenker, Philippe; Chemla, Emmanuel; Arnold, Kate; Zuberbühler, Klaus: 2015, [Pyow-Hack Revisited: Two Analyses of Putty-nosed Monkey Alarm Calls](#). *Lingua*.
- [9] Schlenker, Philippe; Chemla, Emmanuel; Cäsar, Cristiane; Robin Ryder; Zuberbühler, Klaus: to appear, Titi Semantics: Context and Meaning in Titi Monkey Call Sequences. [Natural Language and Linguistic Theory](#)
- [10] Schlenker, Philippe; Chemla, Emmanuel; Schel, Anne; Fuller, James; Gautier, Jean-Pierre; Kuhn, Jeremy; Veselinovic, Dunja; Arnold, Kate; Cäsar, Cristiane; Keenan, Sumir; Lemasson, Alban; Ouattara, Karim; Ryder, Robin; Zuberbühler, Klaus: to appear, Formal Monkey Linguistics. To appear as a target article in [Theoretical Linguistics](#).
- [11] Seyfarth, Robert M., and Dorothy L. Cheney, 1980. The ontogeny of vervet monkey alarm calling behavior: a preliminary report. *Zeitschrift für Tierpsychologie* 54(1): 37-56.
- [12] Zuberbühler, Klaus, 2009. Survivor signals: the biology and psychology of animal alarm calling. *Advances in the Study of Behavior* 40: 277-322.