

OPEN COMPOSITIONALITY IN PIED BABBLER CALL COMBINATIONS

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Human language's generative power rests largely on its compositional nature: words can be assembled into novel, perfectly intelligible, higher-order structures with derived meaning (Hurford, 2012). The generativity of such a compositional system depends on how "open" it is to modifications, namely whether compositional structures can be modified (e.g. changes to word order) but still remain comprehensible to listeners. For example, if one understands the compositional meaning of "*Danger ahead!*", one can also interpret the uncommon form "*Ahead danger!*" (see Goldberg (1995) for related examples). Whilst "open compositionality" is ubiquitous in human language, whether animals show any precursor to such a capacity is controversial, yet key to understanding the evolution of language's generativity (Bolhuis, Beckers, Huybregts, Berwick, & Everaert, 2018; Townsend, Engesser, Stoll, Zuberbühler, & Bickel, 2018).

Here we provide evidence that a non-human animal is capable of deriving the meaning of a structurally modified, species-own compositional structure. Pied babblers (*Turdoides bicolor*), a highly social bird species from Southern Africa, produce alert-recruitment call combinations (Fig. 1) when encountering predators, eliciting mobbing behaviour with prolonged alertness and instantaneous recruitment of conspecifics to the threat (Engesser, Ridley, &

Townsend, 2016). Previous research indicated this call complex to be compositional, with the meaning of the whole being related to, yet going beyond, the meanings of its component calls (*s. l.* “approach to/because of a threat”, as opposed to “be alert and approach”). Through conducting behavioural observations and predator presentation experiments we here show that the combination is highly conserved in its structure with the alert call always preceding the recruitment call component when combined. Despite this stereotyped structure, however, we demonstrate that modifications to the call combination can nonetheless be comprehended by receivers. Specifically, playback experiments exposing pied babblers to an unnatural, reversed call order of their alert-recruitment combination (i.e. recruitment-alert combination, Fig. 1) revealed that adult birds responded in identical ways to natural and reversed-ordered variants. These data suggest that the alert-recruitment call combination represents a compositionally open structure that can tolerate modifications, likely through babblers’ ability to relate the meaning of the whole to its comprising, individually meaningful calls. Furthermore, we found that younger individuals responded less to the reversed-ordered variant, suggesting that a “compositional sensitivity” might be experience-based and acquired during ontogeny, with call combinations initially being perceived holistically as unsegmented chunks.

To conclude, we provide evidence for open compositionality in the communication system of a non-human animal species: despite being stereotyped in production, the babbler combinatorial system is compositionally open in perception enabling the processing of novel call combinations. Such compositional sensitivity might therefore represent a key prerequisite for generativity and a key stepping-stone on the evolutionary path to language’s full blown infinite compositional productivity.

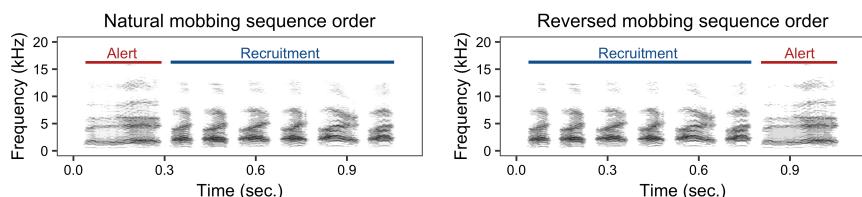


Figure 1. Spectrograms of a natural (alert-recruitment) and a reversed-ordered (recruitment-alert) call combination. Alert calls are typically composed of 1-2 call elements, recruitment calls of 4-7 call elements.

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