Evidence for avian core-Merge is indisputable: A reply to Beckers et al. (2024)

Toshitaka N. Suzuki[1],* and Yui K. Matsumoto[1]

[1]Research Center for Advanced Science and Technology, The University of Tokyo

4-6-1 Komaba, Meguro, Tokyo, 153-8904, Japan

*Corresponding author

Toshitaka N. Suzuki

Email: toshitakasuzuki@g.ecc.u-tokyo.ac.jp

1. Introduction

It has been hypothesized that the generative power of language stems from a cognitive capacity called "Merge," which enables senders to combine two linguistic items (e.g., two words or two phrases) into a sequence and receivers to recognize it as a single unit (Chomsky, 1995, 2001). In an experimental study published in *Nature Communications* (Suzuki and Matsumoto, 2022), we demonstrated that a bird species, the Japanese tit (*Parus minor*), has evolved "core-Merge," the most fundamental form of Merge that combines two words into a single unit (Fujita, 2009, 2014). In their recent publication in *Frontiers in Psychology*, Beckers et al. (2024) raised concerns about the interpretation of our results. However, after careful consideration, we maintain the conclusion that our results provide evidence for core-Merge.

2. Suzuki and Matsumoto (2022)

Japanese tits produce alert calls when warning conspecifics about danger, such as the presence of predators, while they produce acoustically distinct recruitment calls when attracting others to non-dangerous situations, such as food locations or during nest visitations (Suzuki, 2014; Suzuki et al. 2016). They often combine these call types into ordered sequences (alert-recruitment call sequences) when gathering other individuals to approach and harass (i.e., mob) a predator (Suzuki, 2014; Suzuki and Matsumoto, 2022). Previous experiments showed that tits display different behaviours when hearing alert calls (moving their head horizontally as if scanning for danger) and recruitment calls

2

(approaching the sound source) (Suzuki et al. 2016). In response to alert-recruitment call sequences,

tits progressively approach the sound source while continuously scanning the horizon, suggesting that

they detect compound information (i.e., "alert" + "approach") (Suzuki et al. 2016).

There are two possible explanations for the bird's responses to alert-recruitment call sequences.

One possibility is that receiver tits recognize an alert-recruitment call sequence as a single unit (i.e.,

core-Merge) and extract a compound meaning. The other possibility is that tits perceive the two-call

sequence as two individual calls that are arbitrarily produced in close time proximity, not as a single

unit, and then extract both meanings. If tits recognize an alert-recruitment call sequence as a single unit,

then they are expected to exhibit appropriate responses to alert-recruitment calls given by a single

individual; however, they should not perceive the same information when alert calls and recruitment

calls are separately produced by two individuals with the same timing (see Suzuki and Matsumoto,

2022). To test this, we exposed flocks of Japanese tits to a taxidermic specimen of predator (bull-headed

shrike) during playback of (i) alert-recruitment call sequences broadcast from a single speaker (1AR)

or (ii) alert and recruitment calls broadcast from two speakers in turn, following the alert-recruitment

order (2AR) (Figure 1, see also Suzuki and Matsumoto, 2022).

We found that Japanese tits approach and harass a predator specimen when perceiving alert-

recruitment call sequences played from a single source, but not from two sources (Suzuki and

Matsumoto, 2022). Therefore, we concluded that tits perceive an alert-recruitment call sequence as a

single unit, providing evidence for core-Merge.

3. Interpretation

The main criticism raised by Beckers et al. (2024) is that simply recognizing two calls as a single unit does not provide evidence for core-Merge. However, this is due to a misunderstanding of the definition of core-Merge. According to Fujita (2014), core-Merge is "the simple binary combinatorial device that concatenates two syntactic atoms (lexical items) into a set." In other words, core-Merge does not lead to a structure with endocentricity, but does construct a simple concatenation of two meaning-bearing units (e.g., a + dog = {a dog}) (Fujita, 2009, 2014). Thus, for animal studies, core-Merge could be defined as a capacity which allows senders to combine two meaning-bearing calls into a sequence and receivers to recognize it as a single unit (Suzuki and Matsumoto, 2022). If an animal species perceives a two-call sequence produced by a single individual as a single unit (or a single utterance which is both spatially and temporally linked), this should provide evidence for core-Merge. Therefore, according to the definition of core-Merge, Beckers et al. (2024)'s statement that "we agree that the experiment shows that 1AR can be seen as one utterance, contrary to 2AR" supports our conclusion as it is.

Beckers et al. (2024) also argue that the results of Suzuki and Matsumoto (2022) are inconsistent with those of Suzuki et al. (2017), which demonstrated that Japanese tits respond to novel call sequences comprising conspecific alert calls and heterospecific recruitment calls (synonymous calls as their own recruitment calls, produced by the members of mixed-species flocks to maintain flock cohesion) only when these calls are combined into alert-recruitment ordering. However, their

claim is based on an unfounded assumption that Japanese tits should recognize two calls from different

species as two separate utterances even if the two calls are spatially and temporally linked (see also

Schlenker et al., 2023). No study has tested this assumption. Therefore, it might be possible that tits

recognize sequences of conspecific and heterospecific calls as a single unit produced by the same

individual when the two calls are produced from the same spatial location in a temporally linked

manner. Future experiments are required to test these two possibilities; however, regardless of the

outcomes, the Suzuki and Matsumoto (2022)'s conclusion that receivers recognize 1AR (a sequence

of conspecific calls) as a single unit should be unchanged.

4. Discussion

In our paper, we introduced the existence of two conflicting theories for the origins of language's

productivity (Suzuki and Matsumoto, 2022). One theory holds that Merge is an atomic and primitive

capacity, enabling us to produce and comprehend any kind of word combinations, including complex

expressions with hierarchical structure (e.g., a + dog + barks = {a dog} + barks = {{a dog} barks})

(Bolhuis et al. 2014; Berwick and Chomsky, 2019). The second theory holds that such complex

expressions require at least two capacities: a capacity for combining words (core-Merge or Merge: $(\alpha,$

$\beta) \Rightarrow \{\alpha, \beta\})$ and another capacity for its recursive application (Fujita, 2009, 2014; Boeckx, 2009;

Horstein, 2009; Fukui, 2011; Rizzi, 2016; Suzuki et al. 2019). Although the terminology for such a

recursive applicability has not been settled (e.g., "Copy" (Boeckx, 2009), "Label" (Horstein, 2009),

"Embed" (Fukui, 2009)), it envisages taking an already merged unit and one of its members, combining them to form a set union, and turning it into another unit to which the core-Merge can apply again ($\{\alpha, \beta\} \Rightarrow \{\gamma, \{\alpha, \beta\}\}$, where $\gamma = \alpha$ or β) (Fujita, 2009; Fujita, 2014). In this theory, it is expected that without recursion, Merge (or core-Merge) merely serves to combine two linguistic items into a set.

Our findings support this second theory, since Japanese tits combine two call types into a single unit, but there is so far no evidence that they produce sequences with more than two meaning-bearing calls. However, absence of evidence is not evidence of absence. Future research is necessary to determine if tits can create hierarchically structured sequences. Therefore, we introduced the two theories in our paper without insisting on a specific trajectory of language evolution (Suzuki and Matsumoto, 2022).

While Beckers et al. (2024) stated "we do not agree, therefore, with their claim that core-Merge explains the increase in the repertoire of vocalizations, or with their suggestion that such call combinations could be the first step toward hierarchically structured expressions," we never made such claims in our paper (see Suzuki and Matsumoto, 2022). Instead, we concluded that "determining how widely Merge is involved in animal signals and what specific mechanisms provide the basis for the emergence of hierarchical structure remains a key challenge in animal communication research" (Suzuki and Matsumoto, 2022). Thus, we believe that Beckers et al. (2024)'s claim overlooks the focus of our paper which tests whether birds have a capacity to recognize a two-call sequence as a single unit (i.e., core-Merge).

In conclusion, Beckers et al. (2024)'s criticisms do not change interpretations or conclusion of Suzuki and Matsumoto (2022) in any way. Their argument appears to be heavily influenced by their own perspective on "no half-Merge." Even the title "No evidence for language syntax in songbird vocalizations" appears unsuitable as a counterargument to our previous study (Suzuki and Matsumoto, 2022); we strictly defined the term "core-Merge" in our paper and never used or defined the term "language syntax" or even "syntax." In linguistic literature, "core-Merge" (or "Merge") and "syntax" are used with distinct meanings. We believe that explicitly defining terms is essential for advancing interdisciplinary research.

Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Author Contributions

T.N.S.: Conceptualization, Writing – original draft, Writing – review & editing

Y.K.M.: Conceptualization, Writing – review & editing

Funding

References

Beckers, G. J. L., Huybregts, M. A. C., Everaert, M. B. H. and Bolhuis, J. J. (2024). No evidence for language syntax in songbird vocalizations. *Front. Psychol.* 15, 1393895.

Berwick, R. C. and Chomsky, N. (2019). All or nothing: No half-Merge and the evolution of syntax. *PLoS Biol.* 17, e3000539.

Boeckx, C. (2009). "The Nature of Merge: Consequences for Language, Mind, and Biology," in *Of Minds & Language: A Dialogue with Noam Chomsky in the Basque Country*, eds. M Piattelli-Palmarini, M., J Uriagereka, J. and P Salaburu (Oxford, Oxford University Press) 44–57.

Bolhuis, J. J., Tattersall, I., Chomsky, N. and Berwick, R. C. (2014). How could language have evolved? *PLoS Biol.* 12, e1001934.

Chomsky, N. (1995). *The Minimalist Program.* (Cambridge: MIT Press).

Chomsky, N. (2001). "Derivation by Phase," in *Ken Hale: A Life in Language*, ed. M Kenstowicz, (Cambridge, MA MIT Press), 1-52

Fujita, K. (2009). A prospect for evolutionary adequacy: Merge and the evolution and development of human language. *Biolinguistics*, 3, 128–153 (2009).

Fujita, K. (2014). "Recursive Merge and Human Language Evolution," in *Recursion: Complexity in Cognition*, eds. T Roeper and M Speas, (New York, Springer), 243–264.

Fukui, N. (2011). "Merge and Bare Phrase Structure," in *The Oxford handbook of linguistic minimalism*,

147   ed. C Boeckx, (Oxford, Oxford University Press), 73–95

148   Hornstein, N. (2009). *A Theory of Syntax: Minimal Operations and Universal Grammar.* (Cambridge,

149   Cambridge University Press).

150   Rizzi, L. (2016). Monkey morpho-syntax and merge-based systems. *Theor. Linguist.* 42, 139–145.

151   Schlenker, P., Coye, C., Leroux, M., and Chemla, E. (2023). The ABC-D of animal linguistics: Are

152   syntax and compositionality for real? *Biol. Rev.* 98, 1142–1159.

153   Suzuki, T. N. (2014). Communication about predator type by a bird using discrete, graded and

154   combinatorial variation in alarm calls. *Anim. Behav.* 87, 59–65.

155   Suzuki, T. N., Wheatcroft, D. and Griesser, M. (2016). Experimental evidence for compositional syntax

156   in bird calls. *Nat. Commun.* 7, 10986.

157   Suzuki, T. N., Wheatcroft, D., and Griesser, M. (2017). Wild birds use an ordering rule to decode novel

158   call sequences. *Curr. Biol.* 27, 2331-2336.

159   Suzuki, T. N., Wheatcroft, D. and Griesser, M. (2019). The syntax-semantics interface in animal vocal

160   communication. *Philos. Trans. R. Soc. B* 375, 20180405.

161   Suzuki, T. N. and Matsumoto, Y. K. (2022). Experimental evidence for core-Merge in the vocal

162   communication system of a wild passerine. *Nat. Commun.* 13, 5605.

Figure Legend:

A   **B**

Set-up

5m   5m   5m

Sound file (90-s)

Mono — A R   A R

3-s

Stereo — A   A / R   R

3-s
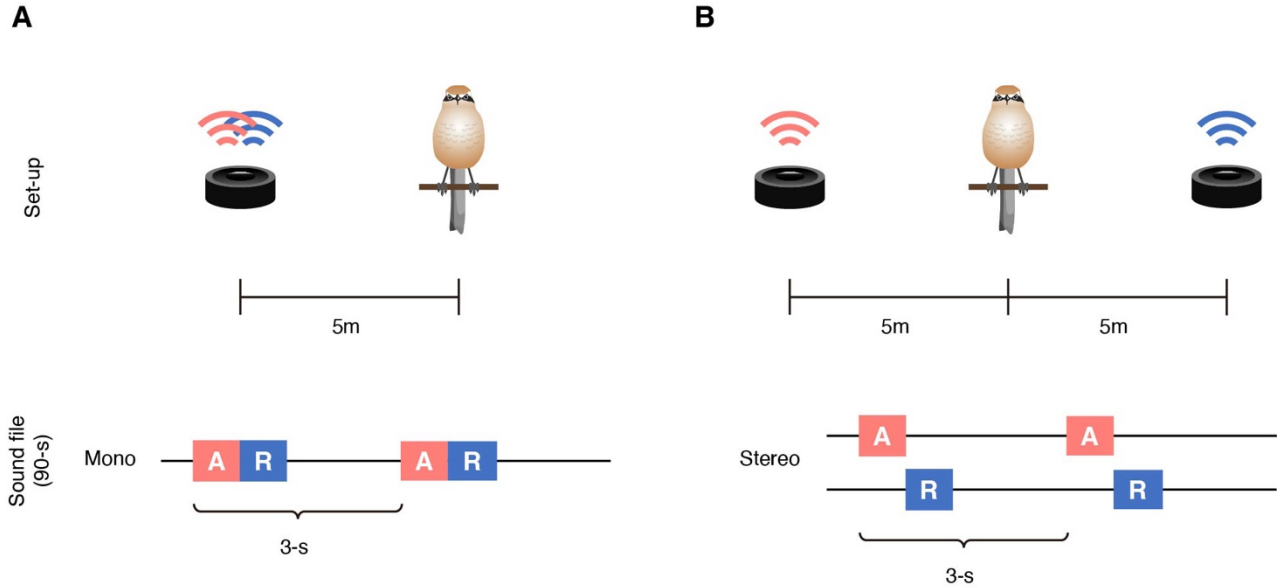
Figure 1. Schematic representation of the experimental design by Suzuki and Matsumoto (2022). If an

animal uses core-Merge for recognizing call sequences, it should be capable of assessing whether the

component calls originate from a single individual. Japanese tits were exposed to a shrike specimen (a

predator specimen) along with playback stimuli: (**A**) alert calls and recruitment calls were broadcast

from one speaker as temporally linked, alert-recruitment sequences; (**B**) the same two calls were

broadcast from two speakers while maintaining temporal linkage. This figure was partially adapted

from Suzuki and Matsumoto (2022).