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Cognition

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Discussion

What baboons can (not) tell us about natural language grammars



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ARTICLE INFO

Article history:

Received 22 November 2013

Revised 23 April 2015

Accepted 27 April 2015

Available online 27 May 2015

Keywords:

Learning natural grammar

Hierarchical grammars

Animal learning

Center Embedded Structures

Origins of language form

ABSTRACT

Rey et al. (2012) present data from a study with baboons that they interpret in support of the idea that center-embedded structures in human language have their origin in low level memory mechanisms and associative learning. Critically, the authors claim that the baboons showed a behavioral preference that is consistent with center-embedded sequences over other types of sequences. We argue that the baboons' response patterns suggest that two mechanisms are involved: first, they can be trained to associate a particular response with a particular stimulus, and, second, when faced with two conditioned stimuli in a row, they respond to the most recent one first, copying behavior they had been rewarded for during training. Although Rey et al. (2012) 'experiment shows that the baboons' behavior is driven by low level mechanisms, it is not clear how the animal behavior reported, bears on the phenomenon of Center Embedded structures in human syntax. Hence, (1) natural language syntax may indeed have been shaped by low level mechanisms, and (2) the baboons' behavior is driven by low level stimulus response learning, as Rey et al. propose. But is the second evidence for the first?

We will discuss in what ways this study can and cannot give evidential value for explaining the origin of Center Embedded recursion in human grammar. More generally, their study provokes an interesting reflection on the use of animal studies in order to understand features of the human linguistic system.

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1. Introduction

The title of Rey, Perruchet, and Fagot (2012) (hereafter RPF)'s paper summarizes their hypothesis: "Centre embedded structures are a by-product of associative learning and working memory constraints: Evidence from baboons". The authors took on the important challenge to investigate the foundations of complex syntax in low level cognitive mechanisms, by looking at non human primates. The present discussion is not about the first part of the proposal,

that "CE structures in human syntax are a by-product of associative learning and working memory constraints". It addresses the second part: "Evidence from baboons". Are RPFs' animal data evidence for this claim? We analyze the methodology and the logic of the RPF study, and discuss the implications about the origins of natural language constructions, accordingly. More generally, we explore the possible contribution of interpreting animal behavior in terms of human linguistic cognition, for understanding human language form.

2. The study

RPF report on data from non human primates (baboons) that, according to the authors, support the view that

DOI of original article: <http://dx.doi.org/10.1016/j.cognition.2015.12.005>

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<http://dx.doi.org/10.1016/j.cognition.2015.04.016>
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hierarchical Center Embedded structures in natural language have emerged as a result of low level mechanisms. The critical evidence supporting this possibility is the baboons' "preference" for a "Center Embedded consistent (CE) pattern" of a pair of subsequent responses over a "non-embedded" (NE) sequential pattern that is not consistent with such pattern.

The animals were trained intensively on sequential associations between pairs of stimuli *a* and *b*, belonging to category A and category B, respectively, in multiple training blocks. The stimuli were shapes, and the associations between A- and B-shapes was arbitrary. In the last training block, the animals were first presented a stimulus "a" on one screen. Next, they were presented a screen with two *b*-stimuli, from which they select one. The animal is rewarded if it selects the *b* associated with the *a* displayed in the previous screen. In a subsequent test phase (Test 2, Fig. 1, p. 182), the last training block procedure is repeated, but now two "A"-screens, each with an *a*-stimulus (first *a*₁, then *a*₂), are presented, before the animal can respond to *b*-stimuli. After the second A-screen (displaying *a*₂), one B-screen with three *b*'s is shown (*b*₁, *b*₂, *b*₃): *b*₂ being the associate of *a*₂, presented on the last A-screen, *b*₁ being the associate of *a*₁ presented on the first A-screen, and *b*₃ being a distractor, i.e. non-associated with any *a* presented in the two preceding screens. The baboon responds to the *b*'s on the B-screen as follows: After having 'tapped' one of the *b*'s, it disappears from the screen. Then nothing happens until the animal taps a second *b*. The baboons are rewarded after having tapped any two of the three *b*'s on the display, in any order. In summary, the animals see one screen with an A stimulus (*a*₁), followed by a screen with another A stimulus (*a*₂), followed by one screen with three *b*-stimuli on random locations: *b*₁ (associated with *a*₁), *b*₂ (associated with *a*₂), and *b*₃ not associated to either of the *a*'s.

The results show that, overall, the *first* *b*-stimulus tapped by the baboons is most often *b*₂ (110 times per baboon on average), which is associated to the *a*₂ on the screen presented just before the B-screen shows up. The next most frequent *first* response is *b*₁ (73 times per baboon). *b*₃ (unassociated to any of the *a*'s presented just before) is chosen as a first response 53 times, on average. The *second* *b* selected was an associate (either *b*₁ or *b*₂) in a slight majority of cases: 55%. 45% of *second* *b*-responses were the non-associated *b*₃. When the initial response was *b*₃, the second response (being necessarily one of the two associated *b*'s left over on the screen) was *equally* often *b*₁ as *b*₂.

Importantly, RPF report the frequencies of baboons' choices in terms of units of *two* consecutive responses selections (Fig. 1). For example, a *b*₂ followed by *b*₁ "*b*₂*b*₁" is a unit, *b*₂*b*₃ is one et cetera; in total six units (i.e. ordered pairs) of two consecutive responses are distinguished and counted. The *b*₂*b*₁ unit is labeled "Center Embedded structure (CE)", or "Center Embedded consistent structure"; likewise, the *b*₁*b*₂ unit is labeled the "Non Embedded structure (NE)" or "Non Embedded consistent structure". The other paired *b*-responses have no special label. Statistical tests show that baboons (1) "produce significantly more CE-structures than

NE-structures", that (2) after selecting a *b*₂, baboons had "a preference for *b*₁, the last element of a CE structure" over a non-associated *b*₃. RPF do not report explicitly two other contrasts in their data, that might yet help to understand the baboons behavior in the task: First, given an initial selection of either *b*₁ or *b*₂, the baboons were equally likely to respond to the other associated element (*b*₂ or *b*₁) as they were to the non-associated one *b*₃. Second, units containing a non-associated response *b*₃ (i.e. *b*₃*b*₁, *b*₃*b*₂, *b*₁*b*₃ or *b*₂*b*₃), were chosen more often than any of the CE- or NE-units.

The baboons' more frequent *b*₂*b*₁ response pairs as compared to *b*₁*b*₂ responses, are interpreted to "reflect their preference for center-embedded structure", and to be "inconsistent with an NE structure". The other four types of response pairs containing a *b*₃ (distractor), and therefore *not* looking like any equivalent syntactic rule in language, are not involved in the main comparative analysis. These type of response pairs were chosen most often.

What do these results tell us about hierarchical syntax in human languages? Many languages, including English, allow for the formation of CE structures (e.g., *a*₁*a*₂*a*₃...*b*₃*b*₂*b*₁) whereas other types of sequential ordering of dependencies, like non-embedded (NE) structures, corresponding to crossed dependencies in natural grammars (e.g., *a*₁*a*₂*a*₃...*b*₁*b*₂*b*₃...), are typologically rare. RPF propose that "the production of CE structures in baboons and humans could be the by-product of associative mechanisms and working memory constraints". CE structures may not reflect a uniquely human capacity to process the long distance dependencies characteristic of recursive CE structures (however see Hauser, Chomsky & Fitch (2002) and Fitch & Hauser's (2004) study that failed to find learning of CE structure in cotton top tamarins), but might have originated in low level cognitive mechanisms, present in baboons.

We acknowledge the importance of RPF's attempts to specify low level memory and associative learning processes that may have favored CE structures in language. Without disputing or advocating their proposal, the aim of the present discussion is to analyze the value and limitations of animal data like the ones presented by RPF, for explaining characteristics of language form.

3. Description of what the baboons do

Crucially, to appreciate RPF's claim, we need to know what is meant by interpretative labels "preference", "production", and "CE-structures" and "the baboons produce/prefer CE-structures/CE consistent structures". RPF's reasoning from the baboons responses to the conclusion is made in three steps. As a first reasoning step, the analyses of the paired responses showing *b*₂*b*₁ > *b*₁*b*₂, the baboons are said to "display a preference for CE (consistent) structures". Secondly, this preference is argued to be clearly *not* caused by an *actual* preference for a grammatical structure ("our findings do not imply that the baboons possess the innate computational device that has been postulated for humans"). So, the frequent *b*₂*b*₁ choices are claimed to be a *by-product* of elementary associative mechanisms and working memory processes, rather than a preference

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