Signaling Games and the Evolution of Structure in Language and Music: A Reply to Ravignani and Verhoef (2018)‡

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Abstract In their commentary on our work, Ravignani and Verhoef (2018) raise concerns about two methodological aspects of our experimental paradigm (the signaling game): (1) the use of melodic signals of fixed length and duration, and (2) the fact that signals are endowed with meaning. They argue that music is hardly a semantic system and that our methodological choices may limit the capacity of our paradigm to shed light on the emergence and evolution of a number of putative musical universals. We reply that musical systems are semantic systems and that the aim of our research is not to study musical universals as such, but to compare more closely the kinds of principles that organize meaning and structure in linguistic and musical systems.

In [8], we demonstrate the emergence of structural regularities in melodic systems using signaling games [6, 14] as a laboratory model of cultural transmission and evolution. In our games, senders and receivers interact by exchanging signals (isochronous five-tone sequences) denoting states (basic and compound emotions). In the course of a game, coordination and transmission occur (the receiver tends to learn the mapping of signals to states used by the sender). In the course of successive games or generations, evolution is observed (the mappings in use gradually acquire specific structural and semantic properties) [7, 8, 10, 11]. The emerging structural regularities include principles of proximity, symmetry, and good continuation. Interestingly, however, we did not observe a clear trend in the emergence of compositionality, which is often assumed to be a core characteristic of natural languages [4]. Our results suggest that universal aspects of melodic structures emerge in signaling games, yet the semantic organization of such structures may follow different principles than those regimenting linguistic structure [8].

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‡ See Ravignani and Verhoef (2018) [12].

In their comment, Ravignani and Verhoef [12] focus on two issues pertaining to our experimental paradigm (the signaling game): the facts that signals were (1) restricted to isochronous sequences of five discrete tones of fixed duration and (2) endowed with meaning by being associated to simple or compound emotions. Specifically, Ravignani and Verhoef argue that these two choices limit the capacity of our experimental paradigm to address the emergence and evolution of all melodic universals [13] in the laboratory. They then propose an experimental paradigm similar to the one used by [16]: an iterated learning paradigm where the set of signals that has to be reproduced is "open" (in several dimensions) and where signals are not associated with meanings. Replying to their criticism gives us the opportunity to reiterate and clarify some theoretical and empirical points already made in our original article [8] and in related research [7].

First, we may agree with Ravignani and Verhoef that signaling games, in the version used by Lumaca and Baggio [7, 8], allow us to study the emergence of a restricted number of putative "musical universals" [13]. Importantly, however, this is not a limitation of signaling games as such: If one wants to investigate how constraints on the organization of signals emerge, one can easily construct signaling games where signals have freer form (e.g., where signal elements are not discretized or limited in duration or number). On the other hand, we did have good reasons to use signals embodying specific constraints, given the aims of this particular study (see our note on compositionality below). Ravignani and Verhoef introduce what seems to us an overly narrow criterion for evaluating alternative or competing laboratory models of the cultural evolution of music: namely, how many putative musical universals the models at stake can "reproduce" (their Table 1 is an evaluation of our work using just this criterion [12, p. 151]). They suggest that the iterated learning paradigm, as used by Verhoef [16], may satisfy this criterion better than signaling games. We argue that taking into account further criteria would show that signaling games and iterated learning are in fact complementary in several respects, as we have suggested previously [7, 11]. For example, the model used by Verhoef [16] requires the direct intervention of the experimenter to filter out "redundant" signals from the training sets: This procedure was intended to mimic the pressure imposed by communication. In signaling games, instead, this pressure is built into the interactive structure of each game, which also means that no intervention by the experimenter is required. A thorough comparison and evaluation of iterated learning and signaling games will likely reveal some of the limitations and strengths of each method and their complementarity for the study of cultural transmission and evolution in the laboratory.

Second, we may again agree with Ravignani and Verhoef that the field of music cognition is split between those who believe that musical systems are semantic systems and those who do not. Given this premise, our choice of assigning meaning to musical signals may divide readers, but the same is true of the choice not to assign meaning to them. We can overcome this impasse by arguing that the property that a given musical system (e.g., a composition, a set of compositions, or a style or lineage within a tradition) is endowed with semantics is not uniformly distributed in the population of musical systems: Some such systems are clearly semantic systems (e.g., where parts of compositions refer to specific emotions) and others are not. At a more fundamental level, there is the issue of the proper treatment of musical semantics. Very few musical systems lack semantic organization of some kind, and most listeners find music "meaningful" in some way. That semantics is not a prerogative of language is shown by a simple game, in which the player sings the lyrics of one song to the tune of another. An old BBC radio program used a game of this kind. A feeling of incongruity is experienced if the sentiments evoked by the musical tune do not match the lyrics. These kinds of associations are precisely how we operationalize the theoretically richer concept "semantics" in our experimental paradigm [8]. In the last two decades, this anecdotal evidence has found plenty of empirical support in behavioral, psychophysiological, and neural-dependent measures [1–3, 5]. Music is

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1 Newer versions of the iterated learning paradigm, such as that of Kirby et al. [15], introduce a phase of interaction between players within a generation, which however follows a phase of individual learning by each player. This design has several advantages, but it does not directly address the issue of how learning may be shaped from the start by coordination or communication pressures. This issue can be addressed more easily in signaling games.
more than its sounds, and the experience of music is much more than a sonic experience [9]. This brings us to our third and most important point.

The aim of our experiment was to test how two very different sets of constraints shape musical systems [8, p. 409]: constraints on compression of information, which are also at work in natural language (compositionality), and constraints on melodic perception or memory, which are rather more specific to the organization of musical structure. In order to apply relevant quantitative measures that allowed us to assess the effects of both kinds of constraints on evolving signaling systems, we had to introduce restrictions on the possible form of signals as well as on the meaning space. This is not a limitation, but a feature of our paradigm, which enables us to conclude that melodic signals are organized more according to aesthetic principles (e.g., proximity, symmetry, and good continuation) than according to principles of information compression (i.e., compositionality). This comparative logic allows us to draw preliminary conclusions on the mechanisms underlying the evolution of language and music: primarily, that these mechanisms are likely different [8, p. 420]. A vigorous interest in musical universals seems to have led Ravignani and Verhoef to partly overlook the aims and conclusions of our research.

References