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How communication changes when we cannot mime the world: Experimental evidence for the effect of iconicity on combinatoriality

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ABSTRACT

Communication systems are exposed to two different pressures: a pressure for transmission efficiency, such that messages are simple to produce and perceive, and a pressure for referential efficiency, such that messages are easy to understand with their intended meaning. A solution to the first pressure is combinatoriality — the recombination of a few basic meaningless forms to express an infinite number of meanings. A solution to the second is iconicity — the use of forms that resemble what they refer to. These two solutions appear to be incompatible with each other, as iconic forms are ill-suited for use as meaningless combinatorial units. Furthermore, in the early stages of a communication system, when basic referential forms are in the process of being established, the pressure for referential efficiency is likely to be particularly strong, which may lead it to trump the pressure for transmission efficiency. This means that, where iconicity is available as a strategy, it is likely to impede the emergence of combinatoriality. Although this hypothesis seems consistent with some observations of natural language, it was unclear until recently how it could be soundly tested. This has changed thanks to the development of a line of research, known as Experimental Semiotics, in which participants construct novel communication systems in the laboratory using an unfamiliar medium. We conducted an Experimental Semiotic study in which we manipulated the opportunity for iconicity by varying the kind of referents to be communicated, while keeping the communication medium constant. We then measured the combinatoriality and transmission efficiency of the communication systems. We found that, where iconicity was available, it provided scaffolding for the construction of communication systems and was overwhelmingly adopted. Where it was not available, however, the resulting communication systems were more combinatorial and their forms more efficient to produce. This study enriches our understanding of the fundamental design principles of human communication and contributes tools to enrich it further.

1. Introduction

Emerging communication systems face two substantial challenges. One (which Hockett, 1960b, referred to as the problem of emission and detection) is to guarantee that a message is emitted accurately by its senders and detected

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accurately by its receivers. We will refer to this as the challenge of *transmission efficiency,* as it is concerned with the transmission of messages through a noisy channel. The other challenge (which Hockett referred to as the problem of encoding and decoding) is to establish reference, such that once a message is detected, it is understood with the intended meaning. We will refer to this as the challenge of *referential efficiency*.

A solution to this latter challenge is to adopt communicative forms which are *iconic*, that is, which are not fully arbitrary, but are instead intuitively motivated by what they refer to (Burling, 1999; Donald, 1991). Iconic forms provide "scaffolding for the cognitive system to connect linguistic form and embodied experience" (Perniss, Thompson, & Vigliocco, 2010, p. 12), making it easier to establish new signs (Fay, Arbib, & Garrod, 2013; Fay, Lister, Ellison, & Goldin-Meadow, 2014).

A solution to the challenge of transmission efficiency is to adopt a design feature — *combinatoriality* — by which small sets of meaningless forms (such as phonemes or letters in English) are recombined to express an infinite number of meanings (Abler, 1989; Hockett, 1960a; Hockett, 1960b; Martinet, 1960; Nowak, Krakauer, & Dress, 1999; Studdert-Kennedy, 2000). Because these forms can be "chosen so as to be easily emitted and so as to be easily distinguished by the sensory receptors" (Hockett, 1960b, p. 421), combinatoriality greatly simplifies the task of transmitting signals through a noisy channel.

Two points should be borne in mind concerning the use of the term combinatoriality in this paper. First, it is important to clearly distinguish combinatoriality from *compositionality*, the recombination of meaningful forms (e.g., morphology and syntax in natural language). While compositionality implies a systematic mapping between meanings and signals (Krifka, 2001), combinatoriality implies no such systematic mapping, and the basic combinatorial forms (as in the case of phonemes) are meaningless. Although the two kinds of structure may emerge together, it is not clear that the factors involved in their emergence are likely to be the same. Indeed, as meaning–motivated structure, compositionality can be seen as an abstract form of iconicity, constituting a solution to the challenge of referential efficiency (cf. Tria, Galantucci, & Loreto, 2012).

The second point is that combinatoriality and iconicity are better treated as continuous variables than all-or-nothing features. In the former case, a communication system in which a small set of forms recur a great deal can be considered more combinatorial than a system in which a large set of forms recur very little. Morse code, for instance, exhibits extremely high combinatoriality, relying as it does on the recombination of only two basic meaningless forms. At the other extreme, Al-Sayyid Bedouin Sign Language (ABSL) exhibits almost no combinatoriality (Sandler, Aronoff, Meir, & Padden, 2011). With respect to iconicity, non-arbitrariness can range from complete transparency to highly opaque motivation (one of the two British Sign Language signs for "German", for instance, is recognizably iconic only if one knows that the Prussian military used to wear spiked helmets).

Given the difference between ABSL and Morse Code with respect to combinatoriality, it is notable that iconicity is extremely widespread in the former, but essentially absent in the latter. Indeed, based on these two examples, it might seem that iconicity and combinatoriality were entirely incompatible. Such a conclusion would be too strong, however. Most languages exhibit both combinatoriality and iconicity to some extent, and phonologically regular onomatopoeic words, such as English "cock-a-doodle-doo", illustrate that the two features can coexist in the same referring expression. Nevertheless, the mutually exclusive relationship between iconicity and combinatoriality exhibited in ABSL and Morse Code may be an indication that the two features are not fully independent, a possibility proposed by Sandler et al. (2011) to explain the absence of combinatoriality in ABSL. This lack of independence can be understood if one takes into account the requirements of an ideally combinatorial system and the requirements of an ideally iconic one. To best satisfy the pressure for transmission efficiency, combinatorial forms should be few in number (to maximize distinctiveness), simple to produce (to minimize production error, and because the smaller the set, the more frequently a given form is likely to be used), and lacking in independent meaning (otherwise recombination is limited, and larger numbers of forms are required). By contrast, the basic forms of an ideally iconic communication system are meaningful by definition, high in number (because they can be recombined only if the meaning fits), and relatively complex (to maximize distinctiveness[1]). The combinatorial iconic expressions found in languages like English constitute a compromise between these requirements (if it were not constrained by phonology, "cock-a-doodle-doo" might sound more like a real cock-crow). At the extreme ends of the continua, however, no compromise is possible. On the one hand, while iconicity in Morse code is certainly imaginable, the scope for it is extremely limited. On the other hand, if forms are iconic to the point of isomorphism with their referents, then combinatoriality is essentially precluded. That is, if communicative form is governed entirely by referent form, then whatever combinatorial structure a system might appear to have cannot be due to any organizational principle of the system itself, but must simply be a reflection of the structure of the meaning space captured by the system (and is thus at most compositional, not combinatorial).

That combinatoriality and iconicity might be in competition (or at least complementary distribution) was hinted at by Goldin-Meadow and McNeill (1999), who wrote:

> "the oral modality assumed the segmented and combinatorial code not because of its strengths but to compensate for its weaknesses. The oral modality is not well suited to conveying messages mimetically [i.e., iconically], even though that function is also important to human languages. This function is, however, very well served by the manual modality" (p. 155).

[1] It should be noted that ideally combinatorial systems and ideally iconic systems must take different routes to maximizing distinctiveness. In the former, relatively simple signs can be kept distinct if few in number; in the latter, there are more signs, so greater complexity is required to keep them distinct.