de Boer, Bart (2012) Iconicity in Structured Form and Meaning Spaces, In: Scott-Phillips, T., Tamariz, M., Cartmill, E. A. & Hurford, J. R. (Eds.) *The Evolution of Language: Proceedings of the 9th international conference (EVOLANG9)*, Hackensack, NJ: World Scientific, pp. 424–425

ICONICITY IN STRUCTURED FORM AND MEANING SPACES

BART DE BOER
AI-lab, Vrije Universiteit Brussel, Pleinlaan 2, 1050 Brussel, Belgium

1. Introduction

Experiments on the emergence of phonological structure show that humans exploit structure in the meaning space to create structure in their sets of signals (Verhoef *et al.*, 2011). This can be regarded as a confounding factor, as *iconicity* is generally considered to play a minor role in language. However, sound symbolism and onomatopoeia are well-documented. Moreover, in sign languages iconicity plays a more prominent role. But what exactly is iconicity? Formal models of language evolution tend to focus either on structure in the form space or structure in the meaning space, but not on the interaction between the two spaces. Zuidema and Westermann (2003) are an exception. They show that in robust signaling systems, meanings that are close together must be represented by forms that are close together. This defines a form of iconicity. The question then arises why and how complex signaling systems (language) loose iconicity.

2. Iconic form-meaning mappings

In order for meanings that are close together to have corresponding signals that are close together, the topology of the form space must correspond to the topology of the meaning space. In Zuidema and Westermann's (2003) model both form and meaning spaces are 1-dimensional. In nature, this occurs for example in chickadee alarm calls, were predator size is coded in the number of calls, fig 1A (Templeton *et al.*, 2005). Such a system is *open*, because forms that have never been observed can be understood and meanings that have never been encountered can be expressed. At the same time it is *holistic*, as the message does not consist of separable components. This is not limited to 1-dimensional form and meaning spaces: bee dance expresses 2-dimensional meanings (direction and distance) with 2-dimensional forms (waggle angle and duration, fig. 1B). Given that form spaces – especially acoustic ones – may be more limited than

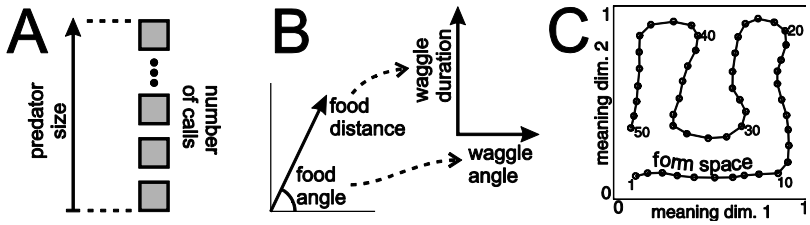

Figure 1: Panel A shows the mapping of 1-D meanings to 1-D forms in chickadee alarm calls. Panel B shows the mapping of 2-D meanings to 2-D forms in bee dance. Panel C shows a mapping of 2-D meanings to 1-D forms and the ensuing discretization of the meaning space: forms 1–10, for example may be used to indicate a low value along meaning dimension 2.

meaning spaces, it is useful to consider what happens when the form space has fewer dimensions than the meaning space. One solution is for the form space to fold to cover the meaning space as fully as possible. The output of a computer model (a Kohonen self organizing map) in fig. 1C shows that this results in *discretization* of the meaning space: most variation in the form space does not cause large changes in one of the meaning dimensions. However, in order to express a point in the meaning space, now a *pair* of forms is needed. Also, the discretization is *arbitrary*: there are many equivalent ways in which the 1-dimensional form space can cover the 2-dimensional meaning space.

3. Discussion

Because iconic form-meaning mappings are robust and open, they may have played a role in the early evolution of human language. The discretization of a meaning space of higher dimensionality than the available form space may provide a transition from a holistic to a combinatorial system. Because the discretization is arbitrary, conventions are then needed. This model provides a theoretical framework for understanding the transition from an iconic signaling system to an arbitrary, discretized and conventionalized one. Both the emergence of an iconic mapping and the transition to a discretized, conventional and possibly combinatorial system can be tested with experimental iterated learning.

References

Templeton, C. N., Greene, E., & Davis, K. (2005). Allometry of alarm calls: Black-capped chickadees encode information about predator size. *Science, 308*, 1934–1937.

Verhoef, T., de Boer, B., Del Giudice, A., Padden, C., & Kirby, S. (2011). Cultural evolution of combinatorial structure in ongoing artificial speech learning experiments. *CRL Technical Report UCSD, 23*(1), 3–11.

Zuidema, W., & Westermann, G. (2003). Evolution of an optimal lexicon under constraints from embodiment. *Artificial Life, 9*(4), 387–402.