LINGUISTIC STRUCTURE EMERGES IN THE CULTURAL EVOLUTION OF ARTIFICIAL SIGN LANGUAGES

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The growing body of research into homesign and emerging sign languages offers insight into languages at their earliest stages of creation and development. The study of such languages allows us to monitor the types of structures that emerge and how they develop through the first generations of a language; for example, although evidence of lexical categories in Nicaraguan Sign Language and spatial grammar in Al-Sayyid Bedouin Sign Language appear in initial generations, these structures have been shown to take time to conventionalize and become systematized (Goldin-Meadow et al, 2014; Padden et al, 2010). Furthermore, recent laboratory experiments in which hearing participants are asked to communicate using gesture can be used to test the factors that shape languages, such as cross-linguistic word order preferences (Goldin-Meadow et al., 2008; Schouwstra and de Swart, 2014), while minimizing interference from participants' native languages. Because of this, results can be compared to data from natural emerging sign languages.

We present an iterated learning study (Kirby, Griffiths and Smith, 2014) that uses the silent gesture paradigm to investigate how the use and transmission of manual communication systems drives the emergence of systematic structure.

Pairs of participants take part in an artificial language learning experiment in which they are first trained on a set of gestures and then must communicate with a partner using only gesture. In the training stage, participants are shown videos of a previous participant gesturing a concept taken from a meaning space of 24 concepts. These concepts are presented orthographically and share either a functional association (person, location, object or action) or a semantic association (based on six professions) with other items in the meaning space. For example, "hairdresser" and "hair salon" share a semantic but not a functional association, and "hairdresser" and "police officer" share a functional but not a semantic association. The first participants in each transmission chain are trained on gestures from a seed set (generation 0), where a different

individual produces a gesture for each meaning. Participants in subsequent generations are trained on gestures produced in the previous generation, for a total of five generations. In the testing stage, pairs of participants take it in turns to be director (the gesturer) and matcher (the interpreter). The director is presented with a concept from the meaning space and must communicate that concept to their partner using only gesture (presented via video streaming between computers in two separate experiment booths). The matcher then attempts to match their partner's gesture to the correct item from the meaning space, presented as a grid of lexical items.

We use both a gesture coding system as well as direct video frame analysis to produce a set of measures capturing the presence of systematic structure in the sets of gestures our participants produce. Our data show three main results concerning the structures that emerge: 1. The entropy of gesture shapes used by participants reduces over time, suggesting that participants increasingly re-use and re-combine gestures from a smaller pool of gesture shapes; 2. The gestural systems become more efficient over time as the range of movement used by participants reduces; 3. Markers for functional categories in the meaning space emerge over generations in the evolution of the gestural systems, such as a roof gesture used to signal the location category, or a point at the director's body to signal the person category (figure 1 shows the frequency of the markers used in each category across the five generations). These results suggest that, as the systems are used in communication and transmitted through generations, gestures develop from pantomimes to conventionalized signs that demonstrate language-like segmentation through the marking of functional categories. Our results also indicate that the gestures produced by participants become more learnable as the systems are transmitted to naïve learners, and that participants in later generations become increasingly aligned with their communication partner. We suggest that the need for learnable and efficient communicative systems may drive the emergence of structure in the gestures our participants produce.

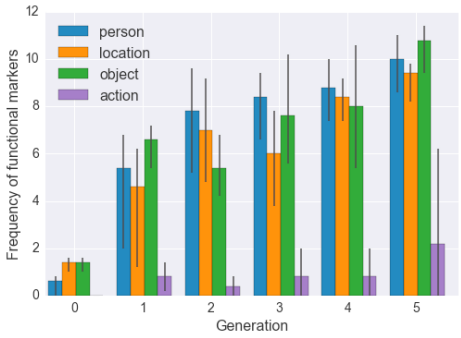

Figure 1. Mean frequency of functional markers at each generation. Coloured bars represent the four categories: person, location, object and action. Error bars represent bootstrapped 95% confidence intervals.

References

Goldin-Meadow, S., Brentari, D., Coppola, M., Horton, L., & Senghas, A. (2014). Watching language grow in the manual modality: Nominals, predicates, and handshapes. *Cognition*, *136C*, 381–395.

Goldin-Meadow, S., So, W. C., Ozyürek, A., & Mylander, C. (2008). The natural order of events: how speakers of different languages represent events nonverbally. *Proceedings of the National Academy of Sciences of the United States of America*, *105*(27), 9163–8.

Kirby, S., Griffiths, T., & Smith, K. (2014). Iterated learning and the evolution of language. *Current Opinion in Neurobiology*, *28C*, 108–114.

Padden, C., Meir, I., Aronoff, M., & Sandler, W. (2010). The grammar of space in two new sign languages. *Sign Languages: A Cambridge Language Survey*. *Cambridge University Press, Cambridge, UK*, 570–592.

Schouwstra, M., & de Swart, H. (2014). The semantic origins of word order. *Cognition*, *131*(3), 431–6.