

IMPROVISATION, INTERACTION AND ITERATION IN THE EVOLUTION OF LINGUISTIC STRUCTURE

MARIEKE SCHOUWSTRA, YASAMIN MOTAMEDI,
KENNY SMITH, SIMON KIRBY

*Language Evolution and Computation Research Unit, University of Edinburgh
Edinburgh, United Kingdom*

Marieke.Schouwstra@ed.ac.uk, s0813837@sms.ed.ac.uk, [simon,kenny]@ling.ed.ac.uk

We discuss the role of three different mechanisms at play in the cultural evolution of language: improvisation, interaction and iteration. Using examples from recent experimental investigations that implement one or more of these three, we will tease out the distinct roles these three have to play in the origins of linguistic structure.

1. Introduction

Improvisation, interaction and iterated learning are cultural evolutionary mechanisms that play a role in explaining structures observed in emerging language. Improvisation occurs when an individual has to convey information in the absence of rules from a conventional language or established common ground from previous interactions. Mechanisms of interaction are those that apply when two individuals have a history of interaction, and have established (or are establishing) a common ground. Iterated learning is the process where individuals acquire a linguistic system by observing other language users' linguistic behaviour, who learned their language in the same way. In this paper we bring together results, starting with interaction, then adding iteration and improvisation, that show how these mechanisms impact on the structure of emerging language in the laboratory, and how they interact with each other.

2. Interaction

A number of recent experimental studies explore how linguistic systems can be restructured over the course of interaction. Winters, Kirby, and Smith (2016) investigated how contextual predictability affects the structure of the emerging language in a communication game experiment. Participants were trained on expressions for images that differed from each other in shape, colour or both, leaving the language ambiguous with respect to whether the signals referred to colour, shape, or both. Participants then played a communication game (as either speaker or hearer), in different conditions, varying the predictability of the

referential context. When the context was predictable (target and distractors all had the same colour, and the distractors were visible to the speaker), the resulting linguistic systems tended to be less autonomous (more context-dependent) than when the context was unpredictable (distractor array was mixed—containing different shapes and colours—and not visible). The latter condition resulted in more autonomous languages: compositional systems that specified shape and colour.

Fehér, Smith, Ritt, and Wonnacott (2016) show that interaction leads to reduction in unpredictable variation. When participants are trained on a miniature language in which the singular form is sometimes marked with a post-nominal particle and sometimes unmarked, they will correctly reproduce the probabilistic singular marking of the target language in individual testing. When they subsequently communicate with another participant who has learnt a similar language with a different proportion of marked singulars (e.g., 66% and 33% marked forms), they adapt their marker use to become more similar to their partner, and post-interaction individual testing shows that this effect persists: their usage of the marker shifts to reflect their experiences during interaction.

These results show that language structure does change as a result of interaction and that interaction can have a lasting effect on language structure. However, there are circumstances in which interactive pressures combined with transmission to new learners result in language structures that differ from those coming from interaction alone. We will look at these next.

3. Interaction and iteration

Kirby, Tamariz, Cornish, and Smith (2015) investigated the effects of communicative interaction and cultural transmission through iterated learning. They describe two pressures, one favouring expressivity (imposed during communication), and one favouring compressibility (imposed when a language system is learned), and show, using an artificial language learning task, that compositional structure emerges only when both pressures are applied.

Carr, Smith, Cornish, and Kirby (2016) used an open-ended meaning space to see if categorical structure can emerge through interaction or iterated learning. Single individuals were trained on randomly generated triangles that were paired up with randomly generated signals. After training, they were asked to label unseen triangles, which were given to the next participant in the chain. In all of four chains (of ten generations each), the language was eventually discretised into emergent categories based on shape and size of the triangles. In a second experiment, pairs of participants were trained on the same language, and then communicated about unseen triangles. The outcome of interaction was used as training material for the next generation, for ten generations per chain. Categories emerged, like in the previous experiment, but the number of unique labels was higher. Moreover, in two of the four interaction-chains, sublexical structure emerged in addition to the categorical structure.

Both of these studies show that systematic structure emerges when interaction is combined with iterated learning. However, all the experiments discussed so far have a learning phase as a starting point: they start with a prespecified unstructured language. Next, we will discuss a way to investigate how a linguistic system may start ‘from scratch’, by including improvisation in our experimental methods.

4. Adding improvisation to the mix

Improvisation occurs when an individual has to convey information in the absence of rules from a conventional language or established common ground. Examples of improvisation and its relation to interaction and iteration can be observed in emerging languages in the manual modality: homesign systems are largely based on improvisation; in places where multiple homesigners come together with no existing sign language in place, such as in the first cohort of Nicaraguan Sign Language, interactive principles come to play a dominant role. Finally, the influence of iterated learning can be seen in subsequent cohorts of NSL.

The three mechanisms can also be studied in the *laboratory*, in silent gesture experiments in which naïve participants communicate using gesture. Previous work has shown that when improvisation is the dominant mechanism, participants show a language independent preference for word order, favouring SOV for extensional transitive events (e.g., boy-ball-throw), but SVO for intensional events (e.g., boy-search-ball) (Schouwstra & de Swart, 2014).

Motamedi, Schouwstra, Smith, and Kirby (2016) investigated the effects of interaction and iterated learning on the evolution of systematic signals in a silent gesture task, using a set of meanings that differed on two dimensions: a semantic dimension and a functional dimension (organised along the categories of person, location, object and action). Participants took part in one of three conditions: interaction-only, iteration-only and interaction-plus-iteration. Participants communicated about the set of meanings using only gestures, either in pairs (in the interaction-only and interaction-plus-iteration conditions) or individually (iteration-only). In the interaction-plus-iteration and iteration-only conditions, participants learned from the gestures produced by previous participants, creating transmission chains of 5 generations. In the interaction-only condition, pairs of participants communicated repeatedly for 5 rounds. Participants in the interaction-only condition became increasingly aligned as they communicated with each other, producing gestures that became progressively shorter and idiosyncratic to a particular pair. Some systematicity was introduced through participants gesturing markers for categories, but individual markers did not become widespread over each category. Participants in the iteration-only and interaction-plus-iteration conditions showed widespread use of systematic category markers across all categories. However, gestures in the iteration-only condition lacked the communicative efficiency provided by interaction; gestures in the iteration-only condition became longer and more repetitive, showing substantial redundancy. In

the interaction-plus-iteration condition, the combination of iteration and interaction led to category markers that were part of systematic two-part signs, in which the two dimensions of the meaning space were represented compositionally.

Schouwstra, Smith, and Kirby (2016) apply silent gesture in two different communicative setups. In an interaction-only experiment, two participants interact using silent gesture, for six rounds, alternating roles as actor and interpreter. An interaction-plus-iteration experiment implemented a gradual turnover design: in round one, participants 1 and 2 were communicators, and 3 was an observer. At each subsequent round, one of the communicators left, the observer became a communicator, and a new participant became the observer. The stimuli in both experiments were extensional events and intensional events. Both experiments were carried out in an equal frequency condition (with equal proportions intensional and extensional) and a skewed condition (80% extensional events).

The results showed that in silent gesture communication *and* transmission, semantically conditioned word order tends to disappear in favour of regular word order: in both the interaction-only and interaction-plus-iteration conditions, some gesture systems converged on one word order. The frequency of event types determines how regularisation progresses: the skewed conditions led to an increase in the usage of SOV word order. This suggests that transmission of an emerging sign system to new learners is not essential to induce word order regularisation: it already happens in dyadic interaction. However, Motamedi et al. show that where interaction leads to idiosyncratic systems with limited usage of category markers, transmission to new learners was necessary for the evolution of widespread systematic structure, in the form of comprehensive category marking.

As the results above show, a lot is still to be uncovered about the pressures involved in the emergence of linguistic structure. Developing sound terminology, as well as comparing many strands of experimental work and field observations will eventually help us understand how individual humans improvise solutions to communicative challenges, how groups of individuals create conventions through interaction, and how these conventions are transmitted through iterated learning.

References

- Carr, Smith, Cornish, & Kirby. (2016). Cultural evolution and communication yield structured languages in an open-ended world. (In Roberts et al., 2016)
- Fehér, Smith, Ritt, & Wonnacott. (2016). Communicative interaction leads to the elimination of unpredictable variation. (In Roberts et al., 2016)
- Kirby, S., Tamariz, M., Cornish, H., & Smith, K. (2015). Compression and communication in the cultural evolution of linguistic structure. *Cognition*, 141, 87–102.
- Motamedi, Schouwstra, Smith, & Kirby. (2016). Linguistic structure emerges in the cultural evolution of artificial sign languages. (In Roberts et al., 2016)
- Schouwstra, Smith, & Kirby. (2016). From natural order to convention in silent

gesture. (In Roberts et al., 2016)

Schouwstra, M., & de Swart, H. (2014). The semantic origins of word order. *Cognition*, 131(3), 431–436.

Winters, J., Kirby, S., & Smith, K. (2016). Signal autonomy is shaped by contextual predictability. (In Roberts et al., 2016)