ITEM-BOUND VS CATEGORY-BASED GENERALIZATIONS. AN ENTROPY MODEL

Silvia Rădulescu (Utrecht University), Efi Giannoupoulou (Utrecht University), Sergey Avrutin (Utrecht University), & Frank Wijnen (Utrecht University)
S.Radulescu@uu.nl

What triggers the inductive leap from memorizing items and statistical regularities to inferring abstract rules? We propose an innovative information-theoretic model for both learning statistical regularities and generalizing to new input. Our entropy model predicts that *rule induction is an encoding mechanism triggered by the interaction between input complexity (entropy) and the limited encoding power of the human brain (channel capacity)*.

While traditional cognitive psychology claimed that rule learning relies on encoding of linguistic items as abstract categories (Marcus et al, 1999), as opposed to learning statistical regularities between specific items (Safran et al., 1996), recent views converge on the hypothesis that it is one mechanism – *statistical learning* – that underlies both item-bound learning and abstract rule learning (Aslin & Newport, 2012; 2014; Frost & Monaghan, 2016). However, it is still not clear how a single mechanism outputs two qualitatively different forms of encoding – item-bound and category-based generalization, and what factors trigger the inductive leap from one to the other.

In our model, less *input complexity (entropy)* facilitates finding regularities between specific items, i.e. item-bound generalization, while a higher complexity exceeding *channel capacity* drives category-based generalization. Rule learning is a phased mechanism that starts out by memorizing specific items and finding regularities between them (*item-bound generalizations)* and it gradually moves to an abstract *category-based* encoding, as a function of increasing input entropy.

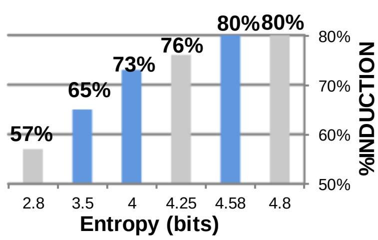

Fig.1.

In two artificial grammar experiments, we exposed adults to a 3-syllable XXY artificial grammar to probe the *effect of input complexity* on rule induction. We designed six experimental conditions with different degrees of input complexity and we used entropy to measure the complexity. Participants gave grammaticality judgements on four types of test items: correct trained XXY strings, correct new XXY, ungrammatical X1X2Y (three different trained syllables), and ungrammatical new X1X2Y strings. Results showed that when input complexity increases, the tendency to infer abstract rules increases gradually (Fig.1). Also, in the lower entropy conditions participants correctly accepted trained XXY strings, and correctly rejected strings of three different trained syllables (X1X2Y_old), but they did not accept new XXY strings as confidently as participants in higher entropy conditions.

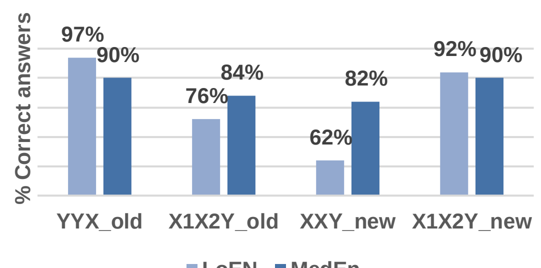

Fig.2

Given that low entropy allows for easy memorization of the specific items and combinations of items, correct acceptance of trained XXY might be supported by memory of the exact items and strings, not necessarily by item-bound generalization. In order to further test the hypothesis that low entropy input facilitates item-bound generalization, we ran another experiment. One group of adults was exposed to the same lowest entropy condition (2.8 bits), and another group to a medium entropy condition (4.25 bits). But in the test, instead of the trained XXY strings, we tested YYX strings with trained syllables (YYX_old). As expected, results showed that participants accepted YYX with trained syllables in the low and medium entropy conditions, based on the rule of *same-same-different*, but in the low entropy condition they accepted new XXY less than in medium entropy. These results support our model that low input entropy facilitates item-bound generalization.