Item-bound vs Category-based Generalizations. An Entropy Model

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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 hypothesizes that rule induction is an encoding mechanism triggered by the interaction between input entropy and the finite encoding power of the human brain (channel capacity).

While traditional cognitive psychology claimed that rule learning relies on encoding linguistic items as abstract categories [1], as opposed to learning statistical regularities between specific items [2], recent views converge on the hypothesis that it is one mechanism – statistical learning – that underlies both item-bound learning and abstract rule learning [3,4,5]. However, it is unclear how a single mechanism outputs two qualitatively different forms of encoding – item-bound and category-based generalizations, and what triggers the transition.

In our model, less input entropy facilitates finding regularities between specific items, i.e. item-bound generalization, while a higher entropy 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.

In two artificial grammar experiments, we exposed adults to a 3-syllable XXY artificial grammar to probe the effect of input entropy on rule induction. We designed six language versions with different input entropy (from 2.8 to 4.8 bits). Participants gave grammaticality judgements on correct familiar XXY strings, correct new-syllable XXY, ungrammatical familiar-syllable X1X2Y, and ungrammatical new-syllable X1X2Y. Results showed that when input entropy increases, the tendency to infer abstract rules increases gradually. Also, in the lower entropy conditions participants correctly accepted familiar XXY, and correctly rejected familiar-syllable X1X2Y.

Since low entropy allows easy memorization, acceptance of familiar XXY might be supported by memory of the specific strings, not necessarily by item-bound generalization. To further test the hypothesis that low entropy facilitates item-bound generalization, we ran another experiment. One group was exposed to the lowest entropy (2.8 bits), and another group to a medium entropy condition (4.25 bits). But instead of familiar XXY strings, we tested familiar-syllable YYX. As expected, participants accepted familiar-syllable YYX strings in the low and medium entropy conditions, based on the *same-same-different* rule, but in the low entropy condition they accepted new-syllable XXY less than in medium entropy. The results support our model that low entropy facilitates item-bound generalization.

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