Lateral Inhibition Strategies

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In chapter ?? we explored five different lateral inhibition strategies, and concluded that they always converge to an effective, shared language. Do these conclusions indeed generalize to the rest of the 6-dimensional, strategy space? The convergence proof suggests so, but does not apply to the naming games directly. In this appendix part of the parameter space is therefore explored systematically. The results indicate that effective languages eventually emerge for all strategies, although the dynamics before convergence can vary substantially.

Recall that the space of lateral inhibition strategies is defined by five nonnegative parameters

$$\delta_{\text{inc}}, \quad \delta_{\text{inh}}, \quad \delta_{\text{dec}}, \quad s_{\text{init}}, \quad s_{\text{max}}. \tag{1}$$

I have not been able to find a systematic analysis of the parameter space. Wellens (2012) does compare several strategies and suggest that the the value of the parameters determines the strategy. For example concluding that "a higher value [of δ_{inh}] improves alignment". I belief this is slightly inaccurate, since the strategies are invariant under scaling. In other words, it is the *relative* value of the parameters that matters. There are many more such equivalences. One could for example use any other $\delta_{\text{inh}} \geq s_{\text{init}}$ without altering the minimal strategy; or fix $s_{\text{max}} := s_{\text{init}}$ and use any $\delta_{\text{inc}} > 0$. Similarly, a different $\delta_{\text{inc}} > 0$ leaves the frequency strategy unchanged, since scores greater than s_{init} are of the form $s_{\text{init}} + k \cdot \delta_{\text{inc}}$ and essentially track the frequency k anyway.

We map two slices of the strategy space by fixing either the increments or inhibition parameter and varying the other (following Wellens 2012). Figure 1 reports the results. Fixing $\delta_{\text{inc}} = 1$ while varying δ_{inh} (figure 1A) reveals that the inhibition parameter δ_{inh} interpolates between the minimal strategy ($\delta_{\text{inh}} = 4^2$ or larger; purple) and and the frequency strategy ($\delta_{\text{inh}} = 0$; black). Both reach eventually reach perfect communicative success, but the stronger the lateral inhibition, the faster so. The number of unique words N_{unique} initially grows identically for all δ_{inh} as inhibition plays hardly any role at the start of the game. In the frequency strategy, no words are ever removed and the resulting vocabulary is therefore not *efficient*. It is hard to tell if the amount of lateral inhibition matters in the long-term. The plot seems to suggest that this is not the case, and even the slightest lateral inhibition will (after a significantly longer time) result in a one-word language.

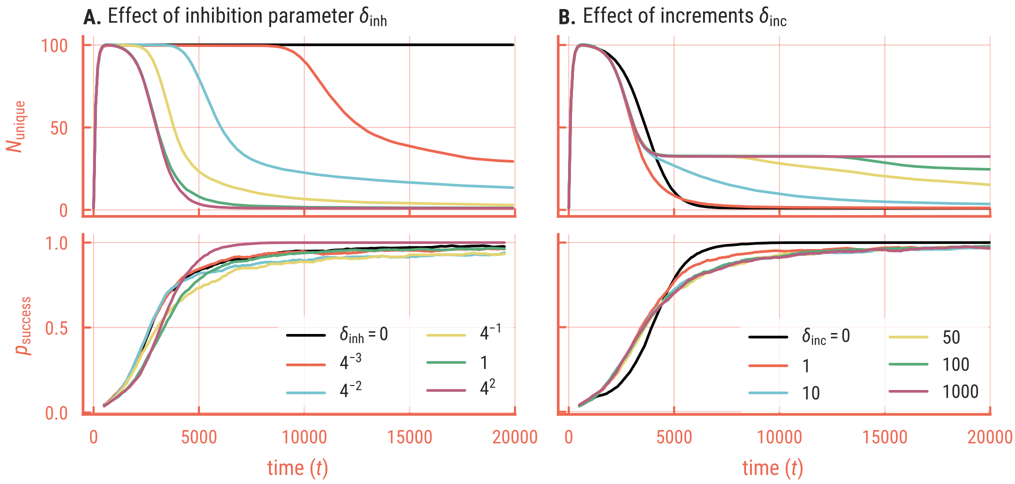

FIGURE 1 A. The effect of δ_{inh} keeping $\delta_{inc} = 1$ fixed. It interpolates between the minimal strategy and frequency strategy. B. the effect of δ_{inc} for $\delta_{inh} = 1$ fixed. For large δ_{inc}, the inhibition is rendered ineffective.

LINGO3 Results shown for $N = 200$, $\delta_{dec} = 0$, $s_{init} = 1$, $s_{max} = \infty$; avg. of 300 runs. $p_{success}$ is moreover a rolling average over a centered window of 1000 iterations.

The effect of the increment δ_{inc} is shown in figure 1B. One can see that the minimal strategy corresponds to $\delta_{inc} = 0$, but larger increments yield different dynamics. After the peak of N_{unique}, words with score $\delta_{init} = 1$ are quickly removed, as it takes a single inhibition. But words that have been heard multiple times have scores of at least $\delta_{init} + \delta_{inc}$ and need many more inhibitions to be removed. There appear to be around $N/6$ such words. The result is a temporary stabilisation of N_{unique}. Eventually inhibition takes over and competing words start disappearing. The (very) long-term behaviour thus appears to be the same as before: convergence to a single-word language.

Bibliography

Wellens, Pieter (2012). “Adaptive Strategies in the Emergence of Lexical Systems”. PhD thesis. Vrije Universiteit Brussel.