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Learning the Role of Intervocalic Constraints in Vowel-to-Vowel Dynamics

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Introduction

In a previous work (Coelho et al., 2002), we have shown that phonotactic constraints in the lexicon are robust enough to allow for the learning of the V-to-V relations of harmony and contour (the tendencies for vowels to share or avoid repetition of phonic properties). What rationalizes these results is that: (a) the environment is structured enough for a connectionist learning mechanism to extract the information needed (Elman et al., 1996), and (b) distributional biases in the lexicon code phonetic information (Albano, 2001). Here we report on experiments about the role of information carried by intervocalic segments in learning V-to-V relations.

Experiments

We trained the same connectionist architecture (an SRN) with different training sets, reflecting different intervocalic conditions. They were made up of non-words which preserved the format of the words in the original work (i.e. trisyllabic penultimate-stressed phone strings corresponding to 3,700 nouns in Brazilian Portuguese). The general form of the strings was $C_1XC_3V_3$, where C_1 , C_3 and V_3 were randomly generated. The X substrings were manipulated in order to partially (Exp. 1) or fully (Exp. 2) preserve the distributional biases in the previous simulation.

First Experiment

The most natural interpretation for the results of the original simulation would be that harmony and contour are learned solely on the basis of the distributional biases affecting V_1 and V_2 . Thus, we trained the network with a set of non-words where the X substrings represented $V_1C_2V_2$ sequences – C_2 s were randomly generated and V_1 and V_2 preserved the same distributional pattern of the original 3,700 word corpus.

A principal component analysis of the activation of the hidden units revealed that, as in the original experiment, PC 1 distinguished between pre-stressed (V_1) and stressed (V_2) vowels. The distinction between harmony (H) and contour (C) was only weakly marked by PCs 2 and 3.

Second Experiment

In the second experiment, the X substrings preserved exactly the same distributional pattern for V_1 and V_2 , and exactly the same distribution of intervocalic segments as in

the original corpus. As a result, PC 1 kept marking the distinction between V_1 and V_2 , while PC 2 now clearly distinguished between harmony and contour.

Discussion

Table 1 shows that reduced (random) intervocalic consonant information (Exp. 1) hinders the ability of the network to learn H/C dynamics. On the contrary, complete intervocalic information (Exp. 2), allowed learning of H/C dynamics comparable to that obtained in the original experiment.

Table 1: PCs coding of phonotactic features in words and non-words (NW). Factor loading for each PC is indicated.

	Words	Exp. 1 NW	Exp. 2 NW
V_1/V_2	PC 1	PC 1 >99,99%	PC 1 95,87%
H/C	PC 6	PCs 2 <0,001%	PC 2 04,13%

A cluster analysis of the hidden units' vectors shows that, in both the original and the second experiment, the network organizes its representational space in terms of linguistic constraints, yielding distinctions between vowels and consonants, and between stressed and non-stressed vowels. In the first experiment, however, given the poorer linguistic information available, it tends to structure representations according to positional constraints only.

Acknowledgments

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