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A characterization of the grammars that satisfy Hayes' Shifted Sigmoids Generalization

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A characterization of the grammars that satisfy Hayes' Shifted Sigmoids Generalization

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- This talk offers an explicit formulation of the Shifted Sigmoids Generalization pioneered by Hayes and Zuraw (2017) and Hayes (2021) and a complete characterization of the harmony-based probabilistic grammars that satisfy it, showing that they are essentially MaxEnt grammars.
- **Nasal substitution** (NS) in Tagalog (Zuraw 2010) coalesces the nasal at the end of an **affix** and the obstruent at the beginning of a **stem** into a single consonant that is nasal as the former and homorganic to the latter. For instance, /**maŋ**+**bigáj**/ ('to distribute') is realized as [mamigáj]. Whether an **affix**+**stem** concatenation undergoes NS in Tagalog cannot be predicted based on the identity of the **affix** and the quality of the **stem**-initial consonant. Yet, we can count the **empirical frequency** of NS for concatenations of a certain **affix** with **stems** starting with a certain obstruent. To illustrate, for the affixes /**maŋ**/ and /**paŋ**/ and for stems that start with /**k**/ and /**b**/, we obtain the empirical frequencies of NS in fig. 1. Is there anything special about these numbers?

	/maŋ/	/paŋ/
/k/	0.993	0.909
/b/	0.916	0.434
- The curve in figure 2a plots the **sigmoid** $S(x) = \frac{1}{1+\exp(-x)}$. Since the sigmoid takes values between 0 and 1, we can plot frequencies onto it. Thus, fig. 2a plots onto the sigmoid the frequencies 0.993 and 0.916 of NS for the underlying concatenations with the affix /**maŋ**/. **Shifted sigmoids** $S(\Delta + x) = \frac{1}{1+\exp(\Delta-x)}$ are obtained by adding a constant Δ to the argument of the sigmoid. Fig. 2b determines Δ so that the frequency 0.909 of NS for /**paŋ**+**k**/ falls on the shifted sigmoid right underneath the frequency for /**maŋ**+**k**/ with the same **stem**-initial stop. Hayes and Zuraw (2017) make the surprising observation that the frequency 0.434 of NS for /**paŋ**+**b**/ falls almost perfectly on the same shifted sigmoid right underneath the frequency of NS for /**maŋ**+**b**/ with the same **stem**-initial stop, as in fig. 2c. If we know three of the frequencies, we can predict the fourth!
- Hayes (2021) indeed shows that, for a variety of processes in a variety of languages (vowel harmony in Hungarian; liaison in French; final devoicing in Dutch; genitive plurals in Finnish; schwa/zero alternations in French; stress placement in Hupa), the empirical frequencies of the process applying on two-by-two underlying forms fall on two shifted sigmoids. What is driving this pattern? Let us focus on NS. Some constraints are sensitive to the identity of the **affix** but not to the quality of the **stem**-initial obstruent: the number of violations is constant across **stem**-initial obstruents, namely $C(/maŋ+k/, NS) = C(/maŋ+b/, NS)$. Some other constraints are sensitive to the quality of the **stem**-initial obstruent but not to the identity of the **affix**: the number of violations is constant across **affixes**, namely $C(/maŋ+k/, NS) = C(/paŋ+k/, NS)$. Crucially, no constraint is sensitive to both **affixes** and **stems**, because **affixes** and **stems** are **independent** phonological dimensions. Equivalently, every constraint is constant either across **stem**-initial obstruents or across **affixes**.
- These considerations lead to the following formulation of Hayes' **Shifted Sigmoids Generalization** (SSG). Suppose that four underlying forms can be organized into a two-by-two square along two phonological dimensions, as in fig. 3a. Suppose that these two phonological dimensions are independent in the sense that no relevant constraint is sensitive to both dimensions. Equivalently, every constraint is constant along one of the two dimensions, as stated in fig. 3b. Then, the empirical frequencies of the relevant process applying to those four forms can be fitted on two shifted sigmoids, as in fig. 3c. Once again, if we know three of the frequencies, we can predict the fourth.
- Which probabilistic phonological grammars satisfy this SSG? We focus on **harmony-based** grammars defined as follows. We start from a set **C** of n **constraints** C_1, \dots, C_n that assign to each



