Gradient Lengthening Effects: Evidence from Tagalog

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Tagalog represents a language that has been analyzed as allowing both long and short vowels except in the ultima, where a stressed/prominent ultima does not lengthen (Schachter and Otanes 1972, Soberano 1980). This potentially represents a case of STRESS-TO-WEIGHT (Prince and Smolensky 1993/2003) that does not apply word-finally. However, this study argues for a modified account that supports an alternative grammar in nonlinear dynamical systems.

Experiment: Recordings were made of four native speakers reading five repetitions each of five penultimately and five ultimately stressed disyllabic words, plus 20 fillers, within a carrier phrase in pseudo-randomized order. Vowels were measured for duration. Ultimate stressed vowels did show increased duration as compared to ultimate unstressed vowels, counter to earlier accounts (see figure 1). However, it was also found that penultimate syllables showed greater stress lengthening compared to ultimate syllables. Consequently, syllables fell into two overall modes (long vs. short) with three of the four conditions (stressed/unstressed ultima and stressed penult) in the longer mode and only one type (unstressed penult) in the shorter mode (see figure 2). The lesser degree of lengthening on ultimate syllables causes them to still appear within the same mode, unlike penultimate syllables, which shift modes under stress. These results point to a modified analysis—that stressed final syllables lengthen continuously, but not categorically.

Fig.1.

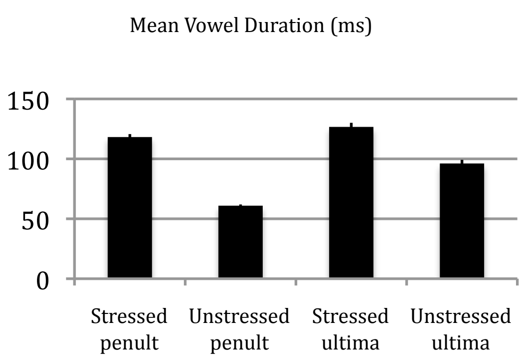
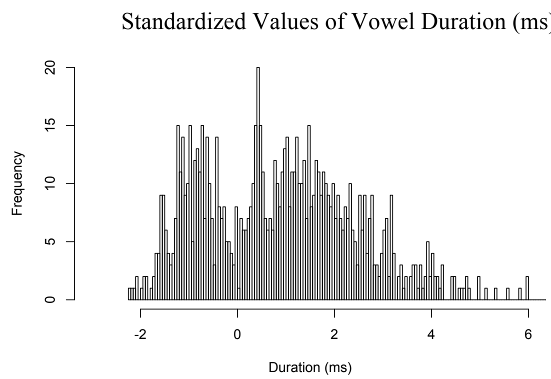


Fig. 2.



Modeling: These facts are accounted for in a grammar based in nonlinear dynamics. Low-level, continuous change can occur until a sudden categorical shift into another state, crucially through the same constraint parameters. Linguistic phenomena have been previously modeled through dynamical systems (Gafos and Benus 2006), and this study follows and builds upon such work.

The system is defined by a potential function $\dot{x} = f(x) = -dV(x)/dx$ where is x is the state of the system and $f(x)$ is the force function. The force function applied here, $f(x) = -x^3 - x$, establishes a maximally bistable space and has been used for modeling binary categories (Gafos and Benus 2006). The corresponding potential, $V(x) = x^4/4 - x^2/2,$ is scaled to produce stable states at the minima of the system through coefficients, as in $V(x) = (a{*}x^4)/4 - (b{*}x^2)/2 + c{*}x$. These values represent grammatical parameters. Values a and b determine the stables states, or attractors, which should align with some relevant linguistic measure (see figures 3 and 4 for examples of different stable states). The parameter c creates tilt, which affects the location and magnitude of the attractors (compare attractors in figures 4 and 5). Outcomes are then modeled probabilistically over n trails with a noise factor, $\dot{x} = f(x) + Noise = -dV(x)/dx + Noise$. Noise adds some variability, but across many trials the data points will still cluster near the minima. Histograms in figures 3, 4 and 5 give the distribution of final positions over 1000 trials.

Fig.3. a=0, b=-1, c=0

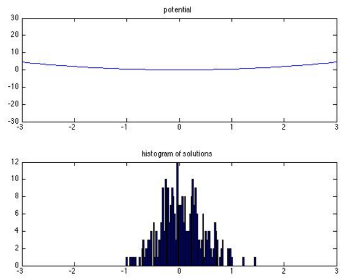


Fig. 4. a=1, b=3, c=0

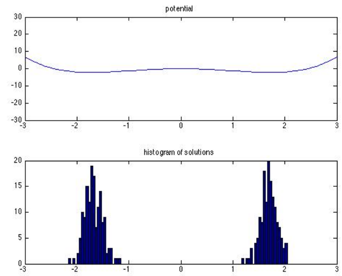
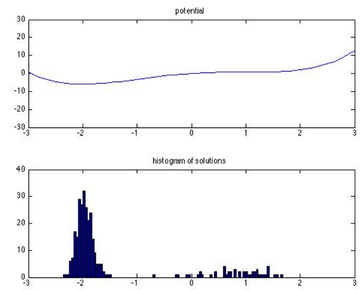


Fig. 5 a=1, b=3, c=2



In a bistable space, tilt is a switch parameter that effectively accounts for vowel durations in Tagalog. If values are determined for both word position and stress (table 1), then *added* to produce the final values for *c* (table 2), the predicted outcome is a gradient bimodal distribution.

Table 1. Input to *c*

Penultimate	1.5
Unstressed	1.5
Ultimate	-4.5
Stressed	-4.5

Table 2. Final values for *c*, representing tilt

	Stressed	Unstressed
Penultimate syllable	-3	3
Ultimate syllable	-9	-3

Based on these values, the unstressed penult falls into the short mode (figure 6), while the stressed penult and unstressed ultima fall into the long mode (figure 7). The stressed ultima (figure 8) is also in the long mode, but by greater tilt it slides *farther* into the mode.

Fig. 6. Unstressed penult

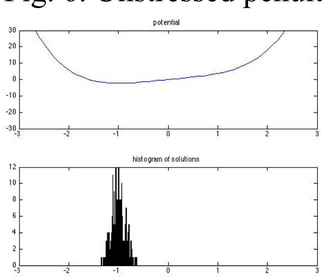


Fig. 7. Str. penult/unst. ult.

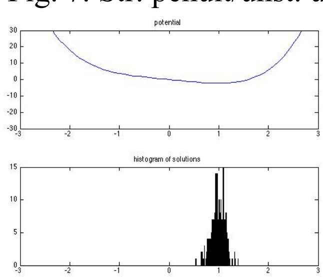
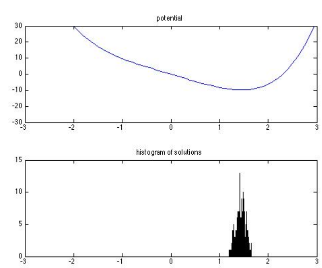


Fig. 8. Stressed ultima



Implications: A dynamical system captures an important aspect of Tagalog vowel duration—that the same STRESS-TO-WEIGHT effect that accounts for categorical length shift on the penult also accounts for non-categorical, fine-grained shift on the ultima. In adding constraints, rather than evaluating by a strict ranking as in Classic OT (Prince and Smolensky 1993/2004, McCarthy and Prince 1993), this grammar captures both the categorical and continuous changes within the language. Crucially, it makes predictions when they stem from the same constraints. Lengthening in Tagalog is then argued to support dynamical systems as a language grammar.

References: Gafos, A. & S. Benus (2006). Dynamics of Phonological Cognition. Cognitive Science, 30:905-943. || McCarthy, J.J. & A. Prince (1993). Prosodic Morphology I: Constraint Interaction and Satisfaction. Technical Report #3, Rutgers University Center for Cognitive Science. Pp. 230. || Prince, A. & P. Smolensky (1993/2004). Optimality Theory: constraint interaction in generative grammar. Ms, Rutgers University & University of Colorado, Boulder. Published 2004, Malden, Mass. & Oxford: Blackwell. || Schachter, P. & F. Otanes (1972). Tagalog Grammar. University of California Press. || Soberano, R. (1980). The dialects of Marinduque Tagalog. Pacific Linguistics B-69. Canberra: The Australian National University.