For these models, the first stage of validation means reliably producing vowel shifts across short and long time scales. In real life, we see vowel shifts across dialects, languages, and eras. Notable examples in English are the Great Vowel Shift (spanning over 300 years), the Northern Cities Shift (about 50 years), or the Southern Shift (about 30 years). For validation, the model must at least produce some shifts (defined as apparently sustained movement in population-language). The time scales of these shifts is also important: in real life, a shift may be on the order of generation(s), or much longer. For validation, the model should produce shifts across short and long time frames. Further validation will consider more precise aspects of the nature of the shifts: distance, speed, duration, trajectory patterns, etc.

*Results*

Shift patterns resulted across nearly all experiment treatments. Figures 1, 2, 3 show examples of what these shift patterns look like (Figure 1 shows a trajectory that mostly lacks any shifts). Note that the time frame is 3000 Ticks, which corresponds in the model to between 3000 and 600 generations; even quite short periods of excursion could be interpreted by humans living through them as ‘shifts’.

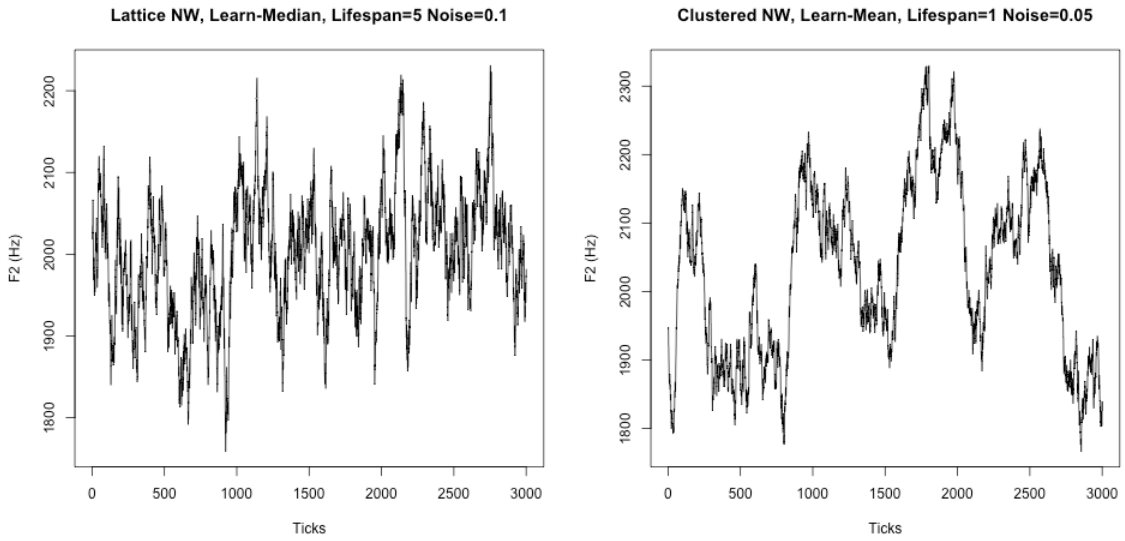


*Figure 1, Figure 2: Formant trajectories showing no-shift, long-shift*

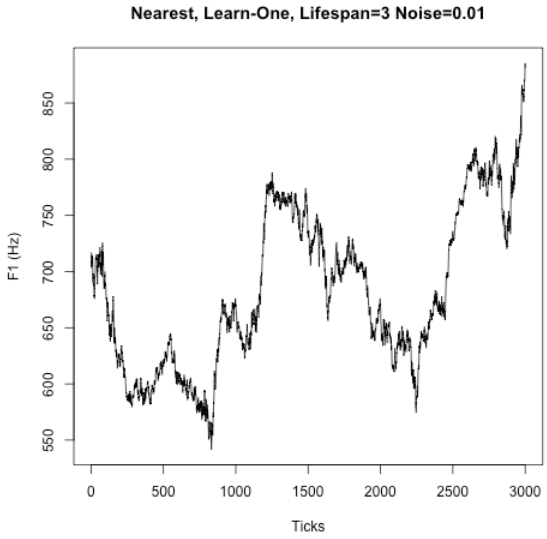


*Figure 3: Formant trajectory showing shift*

Figure 4 and 5 show that shifts are present across all tested Locality categories, Noise levels, and Lifespans; for certain combinations (e.g., ClusterNW with 10% Noise), shifts are less common. In general, the ClusterNW was most likely to inhibit shift presence, followed

somewhat by the LatticeNW locality; other localities did not inhibit shifts. Noise above 10% also inhibited shift presence in some cases, because the noise was so strong that it overwhelmed the (weak) shift itself. Though it was hypothesized that longer lifespans might exert a stabilizing effect on the language population, this effect did not materialize: Lifespan did not appear to play a significant role in shift presence. The presence of 'long' shifts was also evaluated; a long shift is one which was stable in its new position for more than 10% of the time span (i.e., more than 300 Ticks). These effects are shown below in Figures 6 and 7.

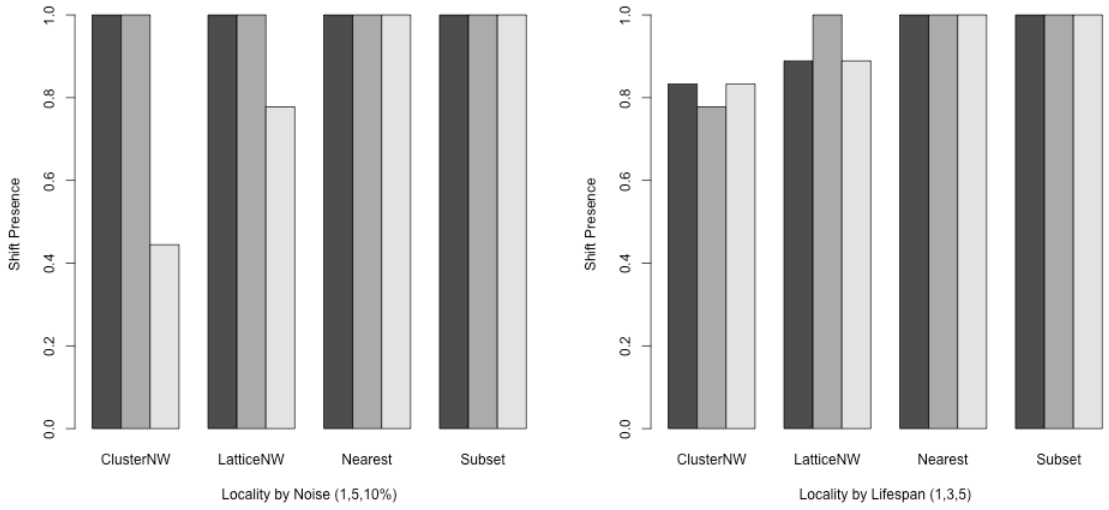


*Figure 4, Figure 5: Shift Presence for Locality by Noise, Lifespan*

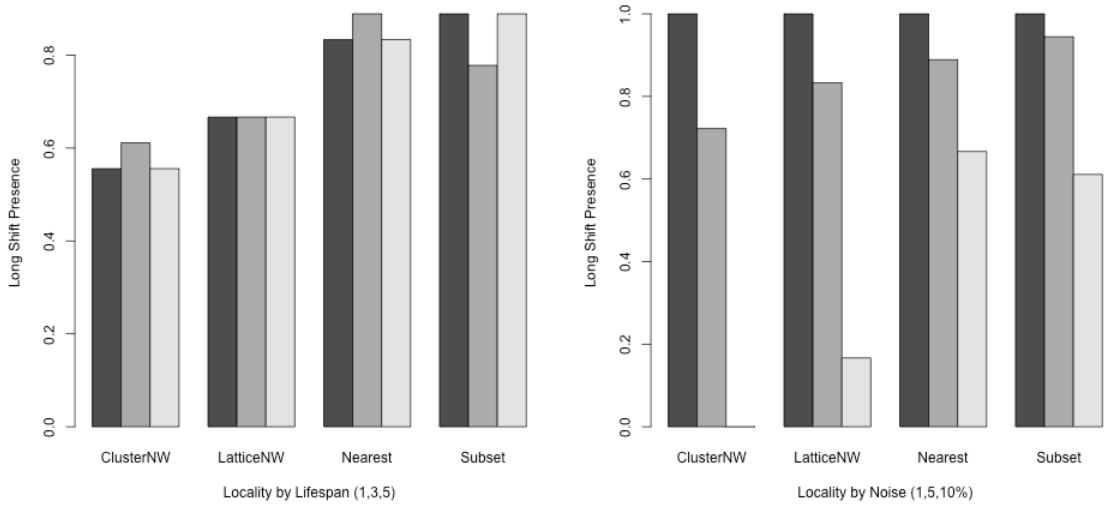


*Figure 6, Figure 7: Long Shift Presence for Locality by Noise, Lifespan*

The effect of the different simple statistical learning strategies was also tested. As shown in Figures 8 though 11, there does not seem to be significant differences in shift or long shift presence based on learner type.

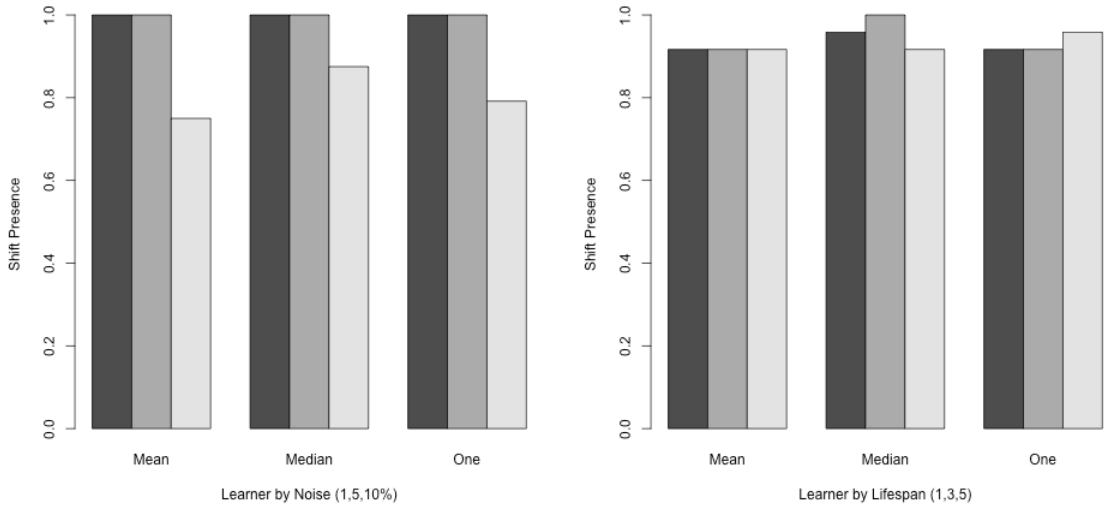


*Figure 8, Figure 9: Shift Presence for Learner by Noise, Lifespan*

The next step is to refine the models used in this experiment, and to accordingly refine the statistical methods used for validation. With more precise time-series analysis methods, it should be possible to quantify the degree to which the experimental vowel trajectories differ from each other, yielding a better understanding of the influence of each variable tested.