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### Authors

Hollander, John

Copping, Brandon



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# Modeling the Role of Cognitive Constraints and Allowances in the Evolution of Language Complexity

**John Hollander[1] (jhollander@astate.edu) and Brandon Copping[2]**
[1] Department of Psychology and Counseling, Arkansas State University
[2]Department of Communication Sciences and Disorders, University of Memphis

## Abstract

The Linguistic Niche Hypothesis suggests languages adapt complexity to learner populations. However, languages also complexify under certain conditions, and the mechanisms behind re-complexification remain computationally underspecified within this framework. We propose a pressure-driven elaboration mechanism where child learners actively extend morphological patterns, with elaboration strength scaling inversely to current complexity levels. To account for demographic transitions, the model varies the proportion of child and adult learners within each cohort. Using an agent-based transmission model, we compared this mechanism against constant and no-elaboration alternatives. Results indicate that while constant elaboration leads to high complexity, pressure-driven elaboration stabilizes at intermediate levels, a pattern more consistent with documented post-creole languages. The model further predicts asymmetric dynamics, where simplification occurs significantly faster than recovery, and incomplete recovery to original substrate complexity. These findings provide a formal, quantitative framework for understanding how demographic transitions and functional pressures interact to shape linguistic structure across many generations.

**Keywords:** language evolution; morphological complexity; linguistic niche hypothesis; agent-based modeling; creolization

## Introduction

The Linguistic Niche Hypothesis proposes that population structure shapes linguistic complexity: languages spoken by communities with many adult learners exhibit reduced morphological complexity, while those transmitted primarily through child learners maintain or develop complex morphology (Lupyan & Dale, 2010; 2012 Trudgill, 2011). Languages described as "exoteric" are characterized by having high adult learner populations, many linguistic neighbors, and overall large speaker bases. These languages often morphologically simplify over time as the cognitive constraints of adult learners result in fewer, easier to remember lexicalizations of previously complexly inflected grammatical concepts. Put concretely, it is easier for an adult learner to remember one word that indicates future tense (e.g., adding *will* before a verb in English), than remembering several morphemes for the same feature. Contact languages with many adult learners, such as pidgins and early creoles, also show systematic simplification of inflectional morphology (McWhorter, 2001). Conversely, languages transmitted primarily through children maintain rich morphological systems (Lupyan & Dale, 2010; 2012).

However, existing theoretical frameworks typically emphasize static population structures or unidirectional change. While bidirectional dynamics within these systems are not refuted, they are often underspecified in favor of the more central narrative: decline in overall morphological complexity over time. Real linguistic communities experience demographic transitions, contact events end, migrant populations stabilize, and pidgins acquire native speakers. In such systems, languages often re-complexify after adult-driven simplification. These occasions create critical questions that the Linguistic Niche Hypothesis must account for such as how fast, to what extent, and through what mechanisms does re-complexification take place?

Empirical observations suggest re-complexification occurs across multiple linguistic contexts. Tok Pisin, which emerged as a pidgin in Papua New Guinea, has developed increased morphological complexity over three generations of native speakers, including systematic verbal morphology and nominal pluralization (Sankoff & Laberge, 1973; Smith, 2002). Haitian Creole has elaborated its tense-aspect-mood system substantially since initial formation, developing from minimal temporal marking to systematic grammatical distinctions (Lefebvre, 1998; Veenstra, 2008). Nicaraguan Sign Language, emerging from gestural pidgin in the 1970s, has developed systematic spatial morphology across successive cohorts of child signers (Senghas & Coppola, 2001; Senghas, Kita, & Özyürek, 2004). These are all qualitative descriptions.

These empirical observations document that re-complexification occurs, but existing frameworks do not generate quantitative predictions about equilibrium outcomes or recovery dynamics. Current theoretical work emphasizes either the linguistic structures that emerge during creolization (Mufwene, 2001; DeGraff, 2001) or typological patterns in established creoles (Michaelis et al., 2013) but does not formalize the mechanisms driving complexity change or predict where languages stabilize under sustained native transmission. We lack formal frameworks that generate testable predictions about recovery rates, asymmetry magnitudes, and long-term equilibria.

We propose a pressure-driven elaboration mechanism. Specifically, child learners are capable of generalizing and extending morphological patterns with elaboration strength scaling inversely to current complexity. When complexity is low, communicative pressure drives pattern extension. When complexity is high, pressure diminishes. This mechanism has empirical grounding in three domains. First, sign language



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emergence demonstrates children elaborating pidgin-like input into systematic morphology (Senghas et al., 2004; Padden et al., 2010). Second, laboratory studies show children tend to regularize inconsistent input more strongly than adults (Hudson Kam & Newport, 2009; Singleton & Newport, 2004; Smith & Wonnacott, 2010), though this interpretation is debated, an alternative account holds that children's output reflects lower distributional fidelity rather than active systematization (see also Hudson Kam & Newport, 2005)..

However, empirical observations alone cannot discriminate among alternative mechanisms or derive quantitative predictions. Computational modeling enables us to formalize competing mechanisms mathematically, derive their long-term equilibrium predictions, and generate testable hypotheses about recovery dynamics (Kirby, Griffiths, & Smith, 2014; Christiansen & Chater, 2016).

We formalize this mechanism in an agent-based transmission model with empirically grounded learning parameters. Critically, we test it against two alternatives: constant elaboration (fixed amount regardless of complexity) and no elaboration (high fidelity only) by examining long-term equilibria under predominantly native speaker transmission. This equilibrium test reveals different outcomes. If post-creole languages under sustained native transmission stabilize at intermediate rather than high complexity levels, pressure-driven elaboration is more consistent with this pattern than alternatives. Empirical validation of this hypothesis requires quantifying actual complexity trajectories in documented cases.

The model generates three quantitative predictions. First, re-complexification should be asymmetric. Recovery proceeds slower than simplification due to opposing processes: adult regularization is subtractive and relatively fast while child elaboration is additive but relatively slow. Second, recovery should be incomplete. Languages stabilize at equilibria determined by the balance between transmission loss and elaboration, not at original complexity. Third, extremely simplified languages should show stronger elaboration pressure, as the complexity deficit is larger.

# Model

## Operationalizing Morphological Complexity

We model morphological complexity as a continuous variable ranging from 0.01 to 1. This variable represents the overall richness of inflectional paradigms, regularity of forms, and productivity of morphological processes. The operationalization is deliberately abstract. It enables mathematical modeling of equilibrium dynamics without requiring precise quantitative measurements of specific languages, which do not currently exist in the literature.

To provide qualitative grounding, we map approximate ranges to language types based on typological descriptions. Very low complexity (0.10 to 0.25) corresponds to pidgins and minimal contact languages with little to no inflectional morphology, such as early Tok Pisin (1900-1930), Russenorsk (a Norwegian-Russian pidgin used in Arctic trade from the 18th to 20th centuries; Broch & Jahr, 1984), and Chinese Pidgin English (17th to 19th centuries; Baker & Mühlhäusler, 1990). Low-intermediate complexity (0.25 to 0.40) corresponds roughly to languages with reduced but systematic morphology. Intermediate complexity (0.40 to 0.60) corresponds to creoles after several generations and languages with moderate inflectional systems. High complexity (0.60 to 0.80) approximates languages with rich inflectional paradigms. Very high complexity (0.80 to 0.95) represents languages with extensive morphological systems, such as Turkish, Finnish, and Georgian. These mappings are approximate and based on qualitative typological descriptions rather than quantitative measurements. The model generates predictions about relative differences between mechanisms and equilibrium patterns rather than absolute values for specific languages. The code for generating all models and figures can be found in an anonymized OSF repository: https://osf.io/tn4xz.

## Transmission Framework

Transmission follows the iterated learning framework (Kirby, Cornish, & Smith, 2008). At each iteration, a cohort of 10 learners acquires the language from the previous cohort's output. Each learner applies the appropriate learning biases based on age. The mean complexity across all 10 learners becomes the input for the next iteration.

The key variable is population composition, specifically the proportion of child versus adult learners in each cohort. By varying this proportion across iterations, we model demographic transitions such as shifts from predominantly adult learning during initial pidgin or creole formation to predominantly child learning during post-creole stabilization. We run simulations for 150 iterations to examine demographic transition dynamics and 200 iterations for equilibrium tests. These timescales appear sufficient for complexity to converge to stable long-term outcomes.

## Learning Parameters

Adult and child learners differ in two empirically grounded ways. First, they differ in transmission fidelity, which refers to the proportion of input complexity successfully reproduced. Adult learners have lower fidelity ($M = 0.70$, $SD = 0.08$), reproducing roughly 70% of the morphological complexity they encounter. This approximates the documented difficulty of attaining native-like fluency in adult second language learning (Newport, 1990; Johnson & Newport, 1989). Child learners have higher fidelity ($M = 0.90$, $SD = 0.05$), reproducing approximately 90% of input complexity. This reflects the characteristically strong implicit learning abilities of children (Saffran, Aslin, & Newport, 1996). These values are sampled stochastically from normal distributions for each learner agent.

Second, adults and children differ in regularization bias. Adults apply systematic regularization ($M = 0.10$, $SD = 0.03$), actively removing approximately 10% of morphological complexity beyond what fidelity loss alone would predict.

This reflects documented adult learning biases favoring regular forms (Hudson Kam & Newport, 2005, 2009; Raviv, Meyer, & Lev-Ari, 2019). Children do not apply this bias in our model. Thus, adult output complexity equals input complexity multiplied by fidelity minus regularization. Child output complexity equals input complexity multiplied by fidelity plus elaboration, as described below.

## Elaboration Mechanisms

We implement and compare three elaboration mechanisms to determine which produces equilibria consistent with qualitative observations. In the No Elaboration mechanism, child learners reproduce input with high fidelity (0.90) but do not actively extend patterns. Output complexity depends solely on faithful transmission. With Constant Elaboration, children add a fixed amount ($M = 0.10$, $SD = 0.02$) to input complexity regardless of current level. This represents untargeted pattern extension. Lastly, with our proposed mechanism of Pressure-Driven Elaboration, children elaborate inversely to current complexity. When complexity $C$ is below a target level (0.70), elaboration rate equals baseline (0.02) plus deficit-scaled pressure calculated as (0.70 minus $C$) multiplied by 0.30. When $C$ exceeds 0.70, only baseline elaboration occurs (0.02). This represents functional pressure; communicative need is greater when complexity is low.

Formally, for any learner $i$, output complexity $C_{out}$ is determined by input complexity $C_{in}$ and age-dependent parameters. Adult learners apply:

$$C_{out} = C_{in} \times f_{adult} - r$$

where $f_{adult}$ is fidelity sampled from N(0.70, 0.08) and $r$ is regularization sampled from N(0.10, 0.03). Child learners apply:

$$C_{out} = C_{in} \times f_{child} + E(C_{in})$$

where $f_{child}$ is fidelity sampled from N(0.90, 0.05) and $E(C_{in})$ is the elaboration function. The three elaboration mechanisms differ in how $E(C)$ is specified.

For No Elaboration:

$$E(C) = 0$$

For Constant Elaboration:

$$E(C) = e_{constant}, \text{ where } e_{constant} \sim N(0.10, 0.02)$$

For Pressure-Driven Elaboration:

$$E(C) = e_{baseline} + \max(0, (C_{target} - C) \times p) \text{ where } e_{baseline} = 0.02, C_{target} = 0.70, \text{ and } p = 0.30.$$

This creates elaboration that scales with the complexity deficit: when $C$ is far below $C_{target}$, elaboration is strong; as $C$ approaches $C_{target}$, elaboration weakens.

The next generation's input complexity is the mean of all learners' outputs. Complexity is bounded: $C \in [0.01, 0.95]$ throughout all simulations. The target value $C_{target} = 0.70$ represents high-intermediate complexity on our scale. This approximates languages with rich but not maximally complex inflectional systems. This parameter requires empirical validation but enables our model to generate testable predictions about equilibrium locations. All three mechanisms use identical adult parameters (fidelity = 0.70, regularization = 0.10), isolating the effect of elaboration type. The pressure-driven parameters (baseline = 0.02, pressure coefficient = 0.30, target = 0.70) represent our theoretical proposal about how elaboration scales with communicative need.

## Equilibrium Test

To determine what equilibrium each mechanism produces, we conduct a test with fixed population composition: 90% child learners and 10% adult learners throughout, representing predominantly native speaker transmission in a stable community. This composition is realistic for post-creole societies where the vast majority of speakers are native but some adult learning occurs through intermarriage, migration, or trade contact. Languages initialize at low complexity (0.20), representing post-pidginization. Simulations run for 200 iterations until complexity stabilizes.

This test isolates elaboration mechanisms from demographic variation. Through this, we hope to observe what equilibrium of complexity emerges given sustained native speaker transmission. Presumably, different mechanisms produce different equilibria. We examine whether these equilibria are consistent with qualitative patterns observed in post-creole languages.

Having established that different elaboration mechanisms produce different equilibria under stable populations, we now examine how languages behave during demographic transitions. Because pressure-driven elaboration produced equilibria consistent with qualitative observations of creole complexity (intermediate rather than high or low), we focus on this mechanism for transition scenarios. These scenarios test our three quantitative predictions: asymmetric dynamics, incomplete recovery, and differential elaboration pressure.

## Population Transition Scenarios

We examine four demographic transition scenarios using pressure-driven elaboration: Abrupt Recovery, Gradual Transition, Cyclical Fluctuation, and Failed Recovery. Each represents different real-world patterns of population change. These models attempt to represent sociocultural shifts in speaker populations. For all models we set the populations at percentages of adult and child learners totaling 100%, as these are the only two groups of interest.

In the Abrupt Recovery condition, we set population composition at 60% adult learners for iterations 1 through 50, representing a contact or colonial situation with heavy adult learning. At iteration 50, which we interpret as a critical demographic shift (for example, end of plantation economy, pidgin acquiring native speakers), the population shifts to 20% adults for iterations 51 through 150. This represents stable native speaker communities. The transition at iteration 50 is marked with a vertical line in Figure 2.

The Gradual Transition condition models demographic drift. Population changes linearly from 60% adults (iterations 1 to 25) to 20% adults (iterations 76 to 150), with intermediate values during iterations 26 through 75. This represents gradual population stabilization.

In the Cyclical Fluctuation condition we attempt to model periodic migration. Child proportion oscillates sinusoidally between 20% and 80% with period of 30 iterations. This represents recurring seasonal or economic migration patterns.

The Failed Recovery condition tests whether extreme simplification permits recovery. Population is 0% children (pure adult learning) for iterations 1 through 40, inducing maximal simplification. At iteration 40, population shifts to 90% children, testing recovery from extreme simplification similar to documented pidgin cases.

Languages initialize at moderate to high complexity ($M$ = 0.80, $SD$ = 0.05) in the first three scenarios, representing a typical substrate language. Failed Recovery initializes at low complexity (0.15) representing a fully pidginized starting point. Complexity is bounded between 0.01 and 0.95 throughout. All simulations use stochastic parameters sampled from the distributions specified above. We conducted sensitivity analyses using five elaboration pressure values (0.20, 0.25, 0.30, 0.35, 0.40) to determine whether qualitative patterns depend on specific parameter choices.

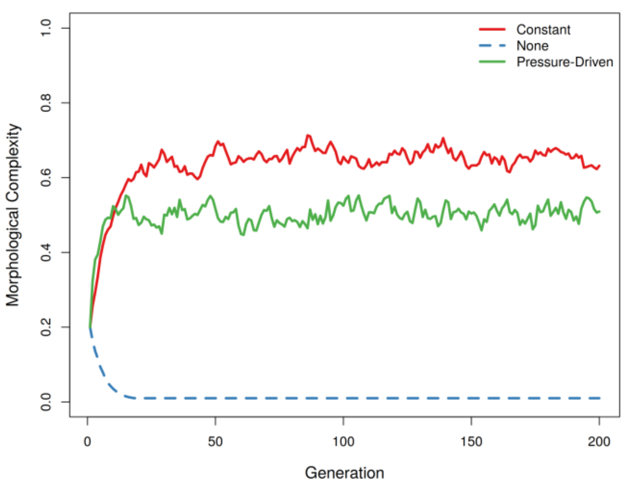


Figure 1: Long-term equilibria under predominantly native speaker transmission over 200 iterations.

## Results

### Equilibrium Test

The equilibrium test reveals that different elaboration mechanisms produce different long-term outcomes. Figure 1 shows complexity trajectories under predominantly native speaker transmission. All three mechanisms start from low complexity (0.20), representing post-pidginization.

Under constant elaboration, complexity increases steadily to 0.63 by iteration 200, near equilibrium. Mathematical analysis predicts equilibrium around 0.67 under these conditions. This value falls in the high complexity range, corresponding to languages like Spanish or German with rich inflectional paradigms.

With no elaboration complexity remains near minimal (0.01) throughout. High fidelity transmission alone cannot rebuild morphology lost during pidginization. This outcome is inconsistent with documented re-complexification in creoles and sign languages.

Pressure-driven elaboration stabilizes at 0.51 with complexity increasing rapidly initially when elaboration pressure is strong (large deficit from target 0.70) then slowing as it approaches intermediate levels. By iteration 100, complexity oscillates around 0.51 with no further net change. This value falls in the intermediate range, corresponding to creoles and languages like English with moderate morphological systems.

The finding that pressure-driven elaboration stabilizes at intermediate complexity (0.51) while constant elaboration reaches higher complexity (0.63) provides a testable hypothesis. If corpus-based measurements show that creoles under sustained native transmission stabilize at intermediate rather than high complexity, this would support pressure-driven over constant elaboration.

The critical finding is that mechanisms produce different equilibria. If creoles under sustained native transmission stabilize at intermediate rather than high complexity, pressure-driven elaboration is more consistent with this pattern. Testing this hypothesis requires developing corpus-based complexity metrics and measuring trajectories in documented cases such as Haitian Creole. The equilibrium framework and predictions remain our primary contribution.

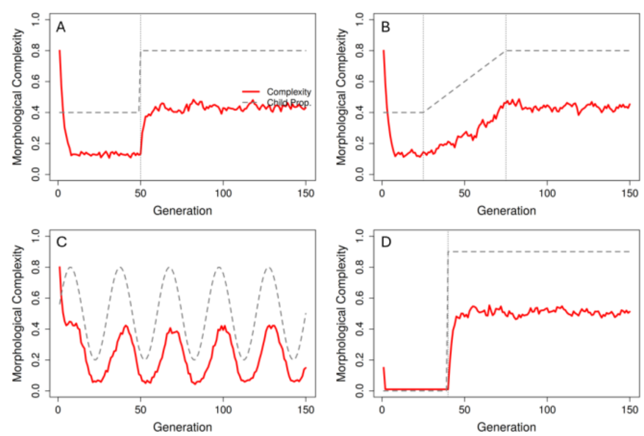


Figure 2: Bidirectional complexity dynamics across four demographic transition scenarios using pressure-driven elaboration: A) Abrupt Recovery, B) Gradual Transition, C) Cyclical Fluctuation, and D) Failed Recovery. The gray dashed line shows child proportion in population.

### Asymmetric Dynamics in Demographic Transitions

Figure 2 shows four scenarios. Panel A (Abrupt Recovery) reveals asymmetric dynamics. Before the population shift (iterations 1 to 50, 60% adults), complexity declines. After the shift (iterations 50 to 150, 20% adults), complexity recovers. This asymmetry emerges from mechanistic differences. Adult regularization is subtractive, directly removing complexity at a constant rate regardless of current complexity. In contrast, child elaboration is additive but gradual, building complexity incrementally. Crucially, elaboration rate varies with current state: stronger when complexity is low, weaker when complexity is high. These different process types (constant-rate subtraction versus variable-rate addition) produce different speeds.

The model simulates contact conditions where simplification to low complexity represents pidginization. This level of simplification seems quite low but is historically documented. Russenorsk had virtually no inflectional morphology (Broch & Jahr, 1984). Early Tok Pisin (1880s to 1920s) similarly showed minimal morphological complexity before acquiring native speakers (Sankoff & Laberge, 1973). Chinese Pidgin English likewise exhibited near-zero inflectional morphology (Baker & Mühlhäusler, 1990). Our model trajectories to low complexity reflect attested pidgin patterns.

## Incomplete Recovery

Across all scenarios in Figure 2, simulated languages stabilized below original complexity levels. In Abrupt Recovery, final complexity (0.44) reaches 51% of initial (0.87). In Gradual Transition, it reaches 0.46 (53%). In Cyclical Fluctuation, complexity oscillates but never returns to initial levels. In Failed Recovery, extreme simplification (0.03) recovers to 0.48, suggesting stronger elaboration from lower starting points but still incomplete recovery.

This pattern reflects the equilibrium dynamics established in Figure 1. Under sustained native transmission (90% children), equilibrium is 0.51. Demographic transition scenarios involve 80% children after recovery, yielding slightly lower equilibria (approximately 0.44 to 0.48) due to ongoing adult learning. Languages do not return to original substrate complexity because transmission loss and elaboration balance at intermediate levels.

Whether real creoles exhibit this pattern remains an empirical question. Testing requires quantifying complexity trajectories in documented cases and measuring whether they stabilize at intermediate levels or continue converging toward substrate complexity over centuries.

If this incomplete recovery pattern holds empirically, it would have implications for debates about creole exceptionalism. Rather than creoles being structurally exceptional due to special genesis mechanisms (McWhorter, 2001), intermediate equilibria could result from demographic history: the balance between adult and child transmission stabilizes complexity at intermediate rather than substrate levels. This would support accounts emphasizing demographic factors (Michaelis et al., 2013; Bakker et al., 2011) over claims about fundamental structural differences. However, testing this hypothesis requires quantifying actual complexity trajectories in documented creoles.

## Sensitivity and Robustness

Figure 3 demonstrates how findings vary across elaboration pressure parameter values. Panel A shows final complexity after demographic transition increases with pressure, but all values remain below the equilibrium under 90% children. Panel B shows recovery magnitude (complexity change) scales approximately linearly with pressure.

Panel C shows the asymmetry ratio (simplification rate divided by recovery rate) across parameter values. This demonstrates that asymmetry persists across parameter space, though the specific magnitude varies. Panel D shows recovery rate increases with pressure, as expected, but even at highest pressure, recovery remains substantially slower than simplification.

Stochastic robustness testing (30 independent runs with different random seeds) shows tight distributions. All 30 runs show positive recovery (100% success rate). Qualitative patterns (asymmetry, incomplete recovery, intermediate equilibria) persist across sensitivity tests and stochastic variation. Quantitative details (specific ratios, final values) depend on parameter choices. Empirical validation will determine which parameter values best match real language dynamics.

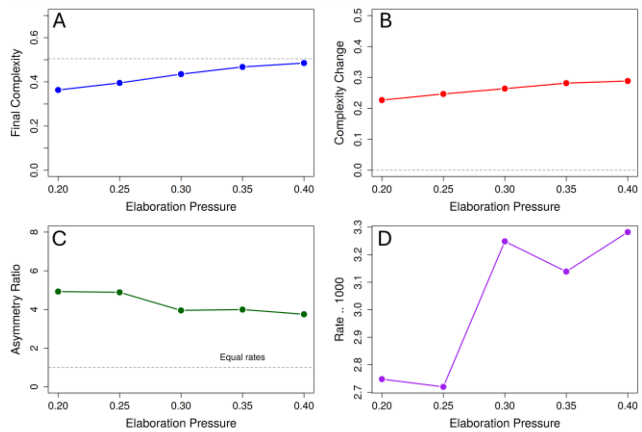


Figure 3: Sensitivity analysis across elaboration pressure parameter values (0.20, 0.25, 0.30, 0.35, 0.40) in the Abrupt Recovery scenario.

## Differential Elaboration Pressure

Comparing Failed Recovery to Abrupt Recovery reveals differential elaboration effects predicted by the pressure-driven mechanism. Failed Recovery shows faster recovery rate compared to Abrupt Recovery and reaches higher final complexity.

This result tests the prediction that extremely simplified languages should show stronger elaboration pressure. The Failed Recovery scenario, starting from near-zero complexity shows faster recovery than Abrupt Recovery starting from moderate pidgin complexity. The pressure-driven mechanism predicts this pattern through its deficit-scaled formula, and the simulation confirms it. If this pattern holds empirically, extremely simplified languages would experience greater functional pressure to rebuild expressive capacity.

# Discussion

This work suggests three main contributions. First, we propose and formalize pressure-driven elaboration, specifically that child learners extend morphological patterns with strength inversely proportional to current complexity. Second, we develop an equilibrium framework for comparing elaboration mechanisms. Constant elaboration produces high-complexity equilibria, no elaboration remains minimal, and pressure-driven produces intermediate equilibria. If creoles under sustained native transmission stabilize at intermediate rather than high complexity, pressure-driven is more consistent with this pattern. Third, we derive testable quantitative predictions: asymmetry ratios, incomplete recovery, and differential pressure effects.

## Equilibrium Dynamics as Framework Contribution

Previous models of language complexity change focus on trajectories, such as how complexity changes over time under specific conditions. Our current model emphasizes equilibria; where complexity balances under demographic shifts and then stabilizes. This distinction is an important one to make because while certain mechanisms can produce short-term re-complexification, other mechanisms can produce different long-term equilibria. Testing which equilibria match empirical patterns helps to discriminate among mechanisms.

Pressure-driven elaboration produces intermediate equilibria because elaboration and transmission loss balance. When complexity is low, strong elaboration exceeds transmission loss, driving net increase. When complexity is high, weak elaboration cannot overcome transmission loss, driving net decrease. This self-limiting property distinguishes pressure-driven from constant elaboration, which lacks a stopping mechanism and stabilizes at higher complexity.

## Theoretical Implications

These findings extend the Linguistic Niche Hypothesis's emphasis to more dynamic populations. Previous work established that population structure correlates with complexity (Lupyan & Dale, 2010; Bentz & Winter, 2013). We show that equilibrium dynamics determine complexity outcomes. Languages stabilize at equilibria determined by transmission fidelity, regularization, and elaboration mechanisms.

The predicted asymmetry has implications for language evolution theory. If simplification is fast but recovery slow, languages have momentum. Brief contact periods could induce simplification persisting for generations even after child learners return. This may explain why creoles remain structurally distinct from their substrates over extended periods (McWhorter, 2001), and why post-creole continua show gradual rather than rapid convergence (Rickford, 1987). However, testing this requires quantifying actual simplification and recovery rates in documented cases.

The equilibrium framework has implications for debates about creole exceptionalism. McWhorter (2001) argues that creoles represent the world's simplest grammars, exhibiting structural properties that distinguish them from non-creoles. DeGraff (2001) argues against this exceptionalism, claiming creoles follow universal processes. Our framework suggests a third perspective, specifically that if creoles stabilize at intermediate complexity due to their demographic history (periods of heavy adult learning followed by native transmission), their structural properties will reflect transmission dynamics rather than exceptional genesis mechanisms. This predicts that languages with similar demographic trajectories should converge on similar intermediate equilibria regardless of genetic affiliation or substrate languages. Michaelis et al. (2013) documents substantial typological variation among creoles, which would be expected if equilibria depend on specific demographic parameters (proportion of adult learners, duration of contact, etc.) rather than a single creole prototype. Testing these predictions requires quantifying both complexity trajectories and demographic histories across documented cases. Further testing of the model requires developing corpus-based complexity metrics and applying them to historical language data. This empirical validation is the critical next step.

## Limitations and Future Directions

Several limitations merit discussion. First, the model focuses solely on morphological complexity. Real languages have multiple interacting dimensions, and trade-offs across these dimensions, such as morphological simplification paired with syntactic rigidification, are not captured. Multi-dimensional models could reveal whether equilibrium principles generalize or whether dimensions interact in complex ways.

Second, the parameter values we used for pressure-driven elaboration are theoretical proposals. While adult parameters derive from acquisition studies (Newport, 1990; Hudson Kam & Newport, 2005, 2009), elaboration parameters formalize observed patterns (Senghas & Coppola, 2001; Singleton & Newport, 2004; Padden et al., 2010) rather than direct measurements. Sensitivity analysis shows qualitative patterns persist across parameter space, but quantitative predictions depend on these choices. Empirical validation requires quantifying elaboration rates in documented cases.

Third, we model idealized populations with discrete adult/child categories and instantaneous demographic shifts. Real communities involve continuous age distributions, bilingualism, code-switching, and gradual change. The model captures first-order dynamics but abstracts from sociolinguistic complexity.

Fourth, the model does not specify which morphological domains drive elaboration. Real languages may elaborate tense-aspect-mood systems while maintaining simple nominal morphology, or vice versa. Our aggregate complexity measure cannot predict domain-specific trajectories.

Fifth, the abstract morphological complexity scale maps approximately to qualitative typological descriptions but lacks precise quantitative grounding. The critical test is whether the model correctly predicts relative differences and equilibrium patterns, not whether specific values match real languages. Future work should develop corpus-based complexity metrics enabling direct comparison.

Finally, the model has not been validated against historical language data. We have generated predictions about equilibria, asymmetry ratios, and recovery rates, but testing them requires quantifying complexity trajectories in documented cases. Until this empirical validation occurs, our claims about which mechanism is more consistent with creole patterns remain hypotheses.

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