Learnability shapes typology: the case of the midpoint pathology

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The MIDPOINT PATHOLOGY (in the sense of Kager 2012) characterizes a type of unattested stress system in which the stressable window contracts to a single word-internal syllable in some words, but not others. Kager (2012) shows that the pathology is a prediction of analyses employing contextual lapse constraints (e.g. *EXTLAPSER; no 000 strings at the right edge), and argues that the only way to avoid it is to eliminate these constraints from CON. This paper explores an alternative: that systems exhibiting the midpoint pathology are unattested not because the constraints that would generate them are absent from CON, but because they are difficult to learn. This study belongs to a growing body of work exploring the idea that phonological typology is shaped by considerations of learnability.*

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1. INTRODUCTION. One of the goals of linguistic research is to construct theories that make the right typological predictions: theories that predict the existence of all and only those patterns attested in the world's languages. In constraint-based theories of phonology, such as Optimality Theory (OT; Prince & Smolensky 2004), the typological predictions of a constraint set can be evaluated by exploring its factorial typology. The notion of factorial typology is grounded in the classical assumption that the set of constraints (CON) is universal, but constraint rankings are language-specific. If all constraints are freely rankable, then the set of systems predicted by a given constraint set, its FACTORIAL TYPOLOGY, is equivalent to the set of systems generated by each possible ranking of constraints.

When evaluating a factorial typology, there are at least two important questions that the analyst must ask. First, does the predicted typology UNDERGENERATE: does it fail to predict certain attested patterns? Second, does the predicted typology OVERGENERATE: does it fail to predict ONLY the attested patterns? Undergeneration is typically viewed as a serious problem, as we want our theories to be able to account for the full range of linguistic variation. Thus the usual response to undergeneration is to modify the contents or the structure of CON, with the goal of including all attested patterns in the predicted typology. The response to overgeneration, however, is more nuanced. Because there are multiple reasons why a proposal might overgenerate, there are multiple possible responses.

One common response to overgeneration is to take a closer look at CON, and propose modifications that exclude the predicted but unattested patterns from the factorial typology. These strategies can be roughly divided into two groups. Some researchers dispute the idea that all constraints are freely rankable and propose that, in order to model typological generalizations, certain constraint rankings must be universal and therefore immutable (see e.g. Prince & Smolensky 2004 on fixed rankings for peak and margin hierarchies, Steriade 2001 on fixed rankings of correspondence constraints). Others focus on the contents of CON, arguing that certain unwanted predictions can be avoided if we exclude certain (classes of) constraints, and/or include certain others (see e.g. Kager 2001, McCarthy on gradient ALIGN; Alber 2005 on ALL-FEET-RIGHT). What all of these proposals have in common is that they modify the contents or structure of CON in order to constrain its factorial typology. To exclude a pattern in this way is to claim that it cannot be represented by a learner: a pattern that cannot be generated by CON is not part of the learner's hypothesis space.

In addition to investigating the contents and structure of CON, much recent work in phonological theory has begun to investigate the hypothesis that other, additional factors play a role in shaping phonological typology. This paper is part of a growing body of research exploring the idea that one such factor is learnability (another potential factor, for example, is channel bias; see e.g. Ohala 1981, Blevins 2004, Moreton 2008). Work in this area has helped us understand why only certain types of phonotactic patterns are attested (Heinz 2010); why there are (classes of) gaps in the typology of stress systems (Boersma 2003, Heinz 2009, Staubs 2014a,b); why gang effects, predicted by weighted constraint models, are not attested in the larger typology (Hughto et al. 2015); and why some types of phonological patterns are restricted to certain morphological domains (Alderete 2008). While details of implementation vary, the basic insight across these works is the same. Whether a pattern can be generated by a particular constraint set or not, we should only expect for it to be attested if it can be learned, given the input available to an average human learner. In other words, the idea is that learnability shapes typology: the range of attested patterns that we see is shaped by limitations on the kinds of patterns that can be accurately and reliably learned.

In Section 2, I introduce Kager's (2012) midpoint pathology as a type of unattested system that is predicted by a popular set of constraints, anti-lapse constraints (e.g. Green & Kenstowicz 1995, Elenbaas & Kager 1999, Gordon 2002), and discuss how Kager proposes to modify CON in order to exclude midpoint systems from the predicted typology. In Section 3, I introduce an alternative: midpoint systems are unattested not because the constraints necessary to generate them are absent from CON, but because they are difficult to learn. Sections 4 and 5 claim that two independent factors make midpoint systems difficult to learn: first, the forms necessary to learn them are rarely available; second, even when these forms are available, the updates that a machine learner must perform to learn the system are not consistent with one another. Section 6 provides general discussion and concludes. It is important to note at the outset that while this article provides a plausible alternative to Kager's (2012) proposal, the present goal is not to argue that the proposed alternative is superior. Rather, the goal of the article is to develop the alternative – that considerations of learnability can suffice to shape this particular aspect of stress typology – and to explore some of its predictions.

2. THE MIDPOINT PATHOLOGY. In many languages, stress is required to fall within a certain fixed distance from a word edge. Kager (2012) refers to these kinds of systems as METRICAL WINDOW SYSTEMS, and identifies four types: right-edge with a window of two syllables, right-edge with a window of three syllables, left-edge with a window of two syllables, and left-edge with a window of three syllables. Schematic representations, the number of languages of each type in Kager's survey, and one example of each, are provided in Table 1.

Edge	**Window Length**	
	Two syllables	*Three syllables*
Right	*σσσ*{*σσ*} (82 lgs.) Kobon (Trans-New Guinea, Davies 1980)	*σσ*{*σσσ*} (38 lgs.) Latin (Indo-European, Mester 1994)
Left	{*σσ*}*σσσ* (39 lgs.) Hopi (Uto-Aztecan, Jeanne 1982)	{*σσσ*}*σσ* (1 lg.) Choguita Rarámuri (Uto-Aztecan, Caballero 2011)

TABLE 1. Summary of accentual windows (see Kager 2012:1464; { } = accentual domain).

One possible analysis of the typology of window systems employs contextual anti-lapse constraints (Green & Kenstowicz 1995, Elenbaas & Kager 1999, Gordon 2002), which forbid lapses from occurring within certain specified domains of the word. For example, a system enforcing a right-edge trisyllabic window can be modeled with the constraint *EXTENDEDLAPSERIGHT (or *EXTLAPSER, defined in 1), which forbids a sequence of three stressless syllables from occupying the word's right edge. When *EXTLAPSER is active, stress must fall on one of the final three syllables, as shown in 2; other constraints will determine its exact placement within this window.

(1) *EXTLAPSER: assign one * if the final three syllables of the word are stressless.

(2)

		/*σσσσσ*/	*EXTLAPSER
☞	a.	*σσ*{*σσ***σ́**}	
☞	b.	*σσ*{*σ***σ́***σ*}	
☞	c.	*σσ*{**σ́***σσ*}	
	d.	*σ***σ́**{*σσσ*}	*!

Other anti-lapse constraints can be employed to analyze the three remaining types of system in Table 1. *EXTENDEDLAPSELEFT (or *EXTLAPSEL) enforces a left-edge trisyllabic window by forcing stress to fall within that domain; *LAPSERIGHT (*LAPSER) and *LAPSELEFT (*LAPSEL) enforce right- and left-edge disyllabic windows, respectively. See 3-5 for definitions.

(3) *EXTLAPSEL: assign one * if the initial three syllables of the word are stressless.

(4) *LAPSER: assign one * if the final two syllables of the word are stressless.

(5) *LAPSEL: assign one * if the initial two syllables of the word are stressless.

Kager (2012) shows that a grammar including anti-lapse constraints can predict all attested window systems; however, a grammar including these constraint also overgenerates. In particular, anti-lapse constraints give rise to a version of the MIDPOINT PATHOLOGY. The midpoint pathology is a term used by Kager (2012) to describe a type of system in which the stressable window contracts to a single word-internal syllable in some words, but not others.[1] Generally speaking, midpoint systems arise when two anti-lapse constraints dominate all others. For example, when the two top-ranked constraints are *EXTLAPSEL and *EXTLAPSER (in that order), the system in 6 results. Accentual domains where *EXTLAPSEL and *EXTLAPSER can be satisfied are bracketed and subscripted or superscripted with L or R, respectively; stressable syllables given the constraint ranking in 6 are bolded.

(6) *EXTLAPSEL >> *EXTLAPSER

a. ${}_{L}\{{}^{R}\{\boldsymbol{\sigma\sigma}\}_{L}\}^{R}$

b. ${}_{L}\{{}^{R}\{\boldsymbol{\sigma\sigma\sigma}\}_{L}\}^{R}$

c. ${}_{L}\{\sigma{}^{R}\{\boldsymbol{\sigma\sigma}\}_{L}\sigma\}^{R}$

d. ${}_{L}\{\sigma\sigma{}^{R}\{\boldsymbol{\sigma}\}_{L}\sigma\sigma\}^{R}$

e. ${}_{L}\{\boldsymbol{\sigma\sigma\sigma}\}_{L}{}^{R}\{\sigma\sigma\sigma\}^{R}$

f. ${}_{L}\{\boldsymbol{\sigma\sigma\sigma}\}_{L}\sigma{}^{R}\{\sigma\sigma\sigma\}^{R}$

In 6a and 6b, stress may fall on any syllable in the word, as all options satisfy *ExtLapseL and *ExtLapseR. In other words, the accentual domains of *ExtLapseL and *ExtLapseR overlap entirely. In 6c and 6d, however, the accentual domains of *ExtLapseL and *ExtLapseR only partially overlap. To satisfy both window constraints in a four-syllable word, like 6c, it is necessary to stress either the second or third syllable; in a five syllable word, like 6d, the accentual domain is restricted to the word's middle syllable (its midpoint). In words of six syllables or longer, like 6e-f, the domains of the two window constraints no longer overlap. Because *ExtLapseL dominates *ExtLapseR, one of the initial three syllables must be stressed.

Many other midpoint systems can be created through different combinations of context-sensitive varieties of *Lapse and *ExtLapse. For example, a system where *LapseR >> *LapseL is schematized in 7, and a system where *ExtLapseL >> *LapseR is in 8. While the specifics of the patterns in 7-8 are different from those of the pattern in 6, the overall situation is the same: two contextual anti-lapse constraints compete, and in words of a certain length, the stressable domain is restricted to a single syllable in the middle of the word.

(7) *LapseR >> *LapseL

a. ${}_{\mathrm{L}}\{^{\mathrm{R}}\{\boldsymbol{\sigma\sigma}\}_{\mathrm{L}}\}^{\mathrm{R}}$

b. ${}_{\mathrm{L}}\{\sigma^{\mathrm{R}}\{\boldsymbol{\sigma}\}_{\mathrm{L}}\sigma\}^{\mathrm{R}}$

c. ${}_{\mathrm{L}}\{\sigma\sigma\}_{\mathrm{L}}{}^{\mathrm{R}}\{\boldsymbol{\sigma\sigma}\}^{\mathrm{R}}$

d. ${}_{\mathrm{L}}\{\sigma\sigma\}_{\mathrm{L}}\sigma^{\mathrm{R}}\{\boldsymbol{\sigma\sigma}\}^{\mathrm{R}}$

e. ${}_{\mathrm{L}}\{\sigma\sigma\}_{\mathrm{L}}\sigma\sigma^{\mathrm{R}}\{\boldsymbol{\sigma\sigma}\}^{\mathrm{R}}$

f. ${}_{\mathrm{L}}\{\sigma\sigma\}_{\mathrm{L}}\sigma\sigma\sigma^{\mathrm{R}}\{\boldsymbol{\sigma\sigma}\}^{\mathrm{R}}$

(8) *ExtLapseL >> *LapseR

a. ${}_{\mathrm{L}}\{^{\mathrm{R}}\{\boldsymbol{\sigma\sigma}\}_{\mathrm{L}}\}^{\mathrm{R}}$

b. ${}_{\mathrm{L}}\{\sigma^{\mathrm{R}}\{\boldsymbol{\sigma\sigma}\}_{\mathrm{L}}\}^{\mathrm{R}}$

c. ${}_{\mathrm{L}}\{\sigma\sigma^{\mathrm{R}}\{\boldsymbol{\sigma}\}_{\mathrm{L}}\sigma\}^{\mathrm{R}}$

d. ${}_{\mathrm{L}}\{\boldsymbol{\sigma\sigma\sigma}\}_{\mathrm{L}}{}^{\mathrm{R}}\{\sigma\sigma\}^{\mathrm{R}}$

e. ${}_{\mathrm{L}}\{\boldsymbol{\sigma\sigma\sigma}\}_{\mathrm{L}}\sigma^{\mathrm{R}}\{\sigma\sigma\}^{\mathrm{R}}$

f. ${}_{\mathrm{L}}\{\boldsymbol{\sigma\sigma\sigma}\}_{\mathrm{L}}\sigma\sigma^{\mathrm{R}}\{\sigma\sigma\}^{\mathrm{R}}$

While it is not unheard of for the size of the stressable window to be dependent on word length (see section 5.2), systems like 6-8, where the stressable window narrows and then widens again, are unattested. Thus we have a situation where a particular constraint set overgenerates: while including contextual anti-lapse constraints (e.g. *EXTLAPSEL, *EXTLAPSER) in CON results in a theory that generates all attested window systems, it also generates some unattested systems: midpoint systems, like those in 6-8.

2.1. EXPECTED FREQUENCY OF MIDPOINT SYSTEMS. When dealing with cases of overgeneration, there is always the possibility that a predicted but unattested system is an accidental gap: that is, it exists, but hasn't been discovered yet. While we cannot rule out this possibility, we can evaluate whether or not it is realistic by determining how frequent we might expect the predicted pattern to be.

One way to evaluate the expected frequency of a pattern is to determine the number of constraint rankings that are compatible with it. If each possible permutation of rankings within a given constraint set is equally probable,[2] then we might expect that the more rankings are consistent with a single surface pattern, the more frequent that pattern should be. For example: if pattern A (in 9a) can be generated by either of two rankings, but pattern B (in 9b) by only one, then all else equal we might expect for pattern A to be twice as frequent as pattern B, since twice as many rankings generate pattern A as do pattern B.

(9) a. Pattern A:
CONST1 >> CONST2 or CONST3 >> CONST4

b. Pattern B:
CONST5 >> CONST6

Work by Anttila (1997) and Bane and Riggle (2008) has confirmed this expectation: in the domains that have been investigated (such as the typology of quantity-insensitive stress systems), the patterns that are the most frequent are also the patterns that are generated by the largest numbers of rankings.

To know how frequent we expect midpoint systems to be, we have to first determine how many constraint rankings generate them. Kager (2012) claims that midpoint systems are generated when two opposite-edge anti-lapse constraints sit at the top of the hierarchy; assuming a single stress per word, 322,560 (or 8.89%) rankings of Kager’s (2012:1479) anti-lapse constraint set fit this description.[3] But this precondition is not specific enough: in order to generate a midpoint system, several other ranking conditions must hold. For example, in quantity-insensitive midpoint systems, stress must be aligned to the outer edge of the window for the ‘overlapping domains’ effect to be visible. This is illustrated by the systems in 12 and 13, both of which have *ExtLapseL and *ExtLapseR ranked at the top of the hierarchy (as in 6). In 12, stress is pulled towards the outer edge of the window by AlignL, defined in 10; in 13, stress is pulled towards the inner edge of the window by AlignR, defined in 11.

(10) AlignL: assign one * for each syllable separating stress from the left edge of the word.

(11) AlignR: assign one * for each syllable separating stress from the right edge of the word.

(12) *ExtLapseL >> *ExtLapseR >> AlignL

a. ${}_{L}\{^{R}\{\boldsymbol{\acute{\sigma}\sigma}\}_{L}\}^{R}$

b. ${}_{L}\{^{R}\{\boldsymbol{\acute{\sigma}\sigma\sigma}\}_{L}\}^{R}$

c. ${}_{L}\{\sigma^{R}\{\boldsymbol{\acute{\sigma}\sigma}\}_{L}\sigma\}^{R}$

d. ${}_{L}\{\sigma\sigma^{R}\{\boldsymbol{\acute{\sigma}}\}_{L}\sigma\sigma\}^{R}$

e. ${}_{L}\{\boldsymbol{\acute{\sigma}\sigma\sigma}\}_{L}{}^{R}\{\sigma\sigma\sigma\}^{R}$

f. ${}_{L}\{\boldsymbol{\acute{\sigma}\sigma\sigma}\}_{L}\sigma^{R}\{\sigma\sigma\sigma\}^{R}$

(13) *ExtLapseL >> *ExtLapseR >> AlignR

a. ${}_{L}\{^{R}\{\boldsymbol{\sigma\acute{\sigma}}\}_{L}\}^{R}$

b. ${}_{L}\{^{R}\{\boldsymbol{\sigma\sigma\acute{\sigma}}\}_{L}\}^{R}$

c. ${}_{L}\{\sigma^{R}\{\boldsymbol{\sigma\acute{\sigma}}\}_{L}\sigma\}^{R}$

d. ${}_{L}\{\sigma\sigma^{R}\{\boldsymbol{\acute{\sigma}}\}_{L}\sigma\sigma\}^{R}$

e. ${}_{L}\{\boldsymbol{\sigma\sigma\acute{\sigma}}\}_{L}{}^{R}\{\sigma\sigma\sigma\}^{R}$

f. ${}_{L}\{\boldsymbol{\sigma\sigma\acute{\sigma}}\}_{L}\sigma^{R}\{\sigma\sigma\sigma\}^{R}$

In 12, the overlapping domains effect is visible: when the size of the window shrinks in 12c-d, stress is pulled from its default initial position towards the middle of the word, only to return to its default initial position once the domains no longer overlap. But 13, where stress is right-aligned towards the inner edge of the stress window, is indistinguishable from a system with post-peninitial stress, as in Choguita Rarámuri (Caballero 2011) or Ho-Chunk (Winnebago; Miner 1989). In other words, while the ranking in 12 generates a midpoint system, the ranking in 13 does not.

Excluding cases like 13 and others, only 166,480 (or 4.58%) rankings of Kager's constraint set give rise to midpoint systems. Translating this into expected frequency of attestation, we expect that midpoint systems should make up 4.58% of all languages with one stress per word. However, no midpoint systems are attested in either Kager's (2012) survey of accentual window systems or in Gordon's (2002) survey of quantity-insensitive stress systems; a summary of the latter is in Table 2.[4]

	# of lgs.	**%**	**Example**
Initial	61	30.8%	Tinrin (Austronesian, Osumi 1995)
Penultimate	55	27.8%	Mohawk (Iroquoian, Michelson 1988)
Final	63	31.8%	Mazatec (Oto-Manguean, Jamieson 1977)
Antepenultimate	7	3.5%	Wappo (Yuki, Radin 1929)
Peninitial	12	6.1%	Basque (isolate, Hualde 1991)
Total	**198**	**100%**	

TABLE 2. Summary of Gordon's (2002:5) single-stress survey.

In Gordon's (2002) survey, 198/262 languages (numbers from Gordon 2002:3-5) have a single stress per word. Assuming that this is representative, and that 75.57% of all languages have one stress per word, then 3.46% of all languages should be midpoint systems. As of August 2014, 510 languages were included in StressTyp (Goedemans & van der Hulst 2009). 3.46% of these, or 18, should be midpoint systems. 18 is not a huge number, but the difference between 18/510 (expected) and 0/510 (attested) is significant (binomial test, $p < .001$). Thus appealing to the expected frequency of midpoint systems is not sufficient to explain their absence: given that these systems are expected to be reasonably frequent, we must continue to look for reasons why they are unattested.

2.2. ONE SOLUTION: KAGER (2012) AND WEAKLY LAYERED FEET. Kager (2012) proposes to exclude midpoint systems from the predicted typology by removing contextual anti-lapse constraints from CON, and by introducing weakly layered feet.[5] Weakly layered feet are composed of two constituents: a maximally binary head (so ✓([*σσ*]) or ✓([*σ*]), but not *([*σσσ*])), and an optional monosyllabic adjunct (✓(*σ*[*σσ*]) or ✓(*σ*[*σ*]), for example). In Kager's theory, feet are maximally ternary, and this is assumed to be hard-wired into GEN: feet with more than one adjunct (e.g. *(*σ*[*σσ*]*σ*)), or more than one head (e.g. *(*σ*[*σσ*][*σσ*])), are not admitted as possible candidates. Thus the foot inventory includes the feet listed in Table 3 (see Kager 2012:1482).

	head + adjunct	adjunct + head	no adjunct
binary head, trochee	([***σ́***σ]*σ*)	(*σ*[***σ́***σ])	([***σ́***σ])
binary head, iamb	([*σ*σ́]*σ*)	(*σ*[*σ*σ́])	([*σ*σ́])
unary head	([***σ́***]*σ*)	(*σ*[***σ́***])	([***σ́***])

TABLE 3. Foot inventory (Kager 2012:1482; ( ) = foot, [ ] = foot head).

The size and composition of the foot is determined by a number of constraints that regulate foot form. In addition to standard foot-based constraints, i.e. IAMB and TROCHEE (see Kager 2012:1482 for the full list and definitions), two new constraints, ALIGNHEADL (= heads are left-aligned with feet) and ALIGNHEADR (= heads are right-aligned with feet), regulate the linear ordering of the foot's head and its adjunct. When ALIGNHEADL >> ALIGNHEADR, the adjunct appears on the right, as in ([*σσ*]*σ*); when ALIGNHEADR >> ALIGNHEADL, the adjunct appears on the left, as in (*σ*[*σσ*]). Binary feet arise when the foot head must be both right- and left-aligned with the foot boundary: in other words, when an adjunct is not allowed to intervene on either side.

The crucial property of the weakly layered model that allows it to avoid the midpoint pathology is that the constraints governing foot form are independent of the constraints that specify the foot's location within the word (see Kager 2012:1484). Put more precisely, foot form constraints that determine the SIZE and SHAPE of the constituent do not interact with alignment constraints that determine its LOCATION. This independence of foot form and alignment constraints makes it impossible to trap stress in the middle of some words, but not others: there is no way to derive the 'overlapping domains' effect that midpoint systems exhibit. Kager shows that this property of the weakly layered model does indeed prevent it from predicting midpoint systems: a factorial typology explored with the weakly layered constraint set excludes them entirely (see Kager 2012:1485ff).

Our focus here is not on the details of the weakly layered model; interested readers are referred to Kager (2012) for more information. What is important to take away from this short discussion is only the nature of the proposal, and its implications. Kager identifies the midpoint pathology as an unattested prediction of contextual anti-lapse constraints. By removing these constraints from CON, and modifying the structure of GEN, he constructs a theory whose predicted typology closely mirrors the attested typology. And these modifications to CON, if they are the correct response to the problem posed by the midpoint pathology, have important theoretical consequences. Purely grid-based (foot-free) theories of stress (e.g. Prince 1983, Gordon 2002) DEPEND on contextual anti-lapse constraints, like those introduced in section 2, to model the typology of stress windows. If the midpoint pathology is indicative of a fundamental problem with contextual anti-lapse constraints, it is indicative of a fundamental problem with foot-free theories of stress. And if there is no alternative to Kager's (2012) explanation for the absence of midpoint systems – that anti-lapse constraints are not part of CON – then the midpoint pathology is a strong argument for the necessity of weakly layered feet in metrical theory.

3. AN ALTERNATIVE: MIDPOINT SYSTEMS ARE HARD TO LEARN. The remainder of this article explores an alternative hypothesis for the absence of midpoint systems: namely, that they ARE part of the learner's hypothesis space, but that they are unattested because they are difficult to learn. I will show that there are two distinct learnability problems that midpoint systems pose to a machine learner (hereafter just 'the learner'). The first problem arises because the forms necessary to learn certain kinds of midpoint systems are only rarely presented to the learner; this is the LONG-WORD PROBLEM (section 4). The second problem arises because the learner, when attempting to acquire a midpoint system, receives inconsistent information about the placement of stress relative to the word edge; this is the CREDIT PROBLEM (section 5). The current section provides some necessary background information on the learner chosen to explore this alternative hypothesis (section 3.1), as well as the specifics of how the learner functions (section 3.2).

3.1. SELECTING A LEARNER. When trying to determine whether some system X would be difficult for a child to acquire, the most straightforward way to test such a hypothesis would be to observe how first-language acquisition of X proceeds. As midpoint systems are unattested, however, this option is unavailable. As a proxy for a human learner, in this article we will focus on the performance of a machine learner as it attempts to learn midpoint systems. The learner used in this article is Magri's (2012) convergent implementation of the Gradual Learning Algorithm (the GLA; see also Boersma 1997, Boersma & Hayes 2001).

The main motivation for selecting the GLA is that it is frequently cited as a plausible model of human phonological acquisition. Studies taking into account natural language data have shown that the GLA is capable of realistically modeling generalizations regarding order of acquisition and learning curves: for example, Boersma and Levelt (2000) show that a GLA learner accurately predicts the order of acquisition of syllable types in Dutch. The GLA is also able to predict that children's repair strategies in response to marked structures can change over time (McLeod et al. 2001), or differ from child to child (Pater & Barlow 2003); see Magri 2012:23 for discussion. In addition, recent work has suggested that, with regards to certain kinds of phonotactic learning, the GLA converges on more restrictive grammars than competing alternatives (Magri 2014).

Although the GLA is a plausible model of phonological acquisition, its apparent failure in some cases to make the correct empirical predictions has led some researchers to develop and endorse other learning models (e.g. Pater 2009, Tessier 2009). As can be expected, these different models make different predictions regarding the kinds of systems that are easiest, or most difficult, for a learner to acquire. This, in turn, means that the results of the present investigation are to some extent dependent on the choice of learner. In 14-16, I outline those properties of the GLA that are necessary to derive the results that will be discussed in sections 4 and 5. First, the learner assumes STRICT DOMINATION; second, it assumes that error is ERROR-DRIVEN; and third, it assumes that learning is GRADUAL.

(14) CONSTRAINTS ARE RANKED

All constraints stand in relations of strict domination: two lower-ranked constraints cannot gang up to overcome a higher-ranked constraint. This can be contrasted with ranking algorithms in which constraints are weighted, and ganging is possible (e.g. Goldwater & Johnson 2003, Jäger 2007, Jesney & Tessier 2011, Boersma & Pater 2016).

(15) LEARNING IS ERROR-DRIVEN

The learner only adjusts its grammar when it guesses the incorrect output form for the current piece of data it is considering. This can be contrasted with learners that adjust their grammar in response to all forms, even those on which it guesses correctly (Jarosz 2013).

(16) LEARNING IS GRADUAL

The learner's grammar is adjusted in response to individual pieces of data. The learner cannot access data it has seen previously, nor can it determine whether the adjustment precipitated by an individual form is consistent with the forms it has previously seen. This can be compared to a batch or ERC learner, which can make decisions about how to adjust its grammar based on generalizations extrapolated from the entirety of data presented to it (e.g. Hayes 2004, Prince & Tesar 2004, Tessier 2009, Brasoveanu & Prince 2011).

Later on, where it becomes more relevant, I will flag those portions of the modeling results that would likely look much different given a learning model that differs according to one or more of the above assumptions. What I aim to show in the remainder of this article, then, is that midpoint systems as a class are difficult to learn for a GLA learner, and more broadly the class of machine learners with the properties in 14-16. Whether or not human learners also exhibit these properties is an open question. If it can be shown that they do not, then the viability of a learnability-based explanation for the absence of midpoint systems will have to be reconsidered.

3.2. HOW THE LEARNER WORKS. The GLA learner used in the simulations that follow is provided with three kinds of information: (i) a constraint set, (ii) a set of input and candidate output forms, and (iii) advance knowledge of which forms are consistent with the system it is trying to learn. The learner's task is to discover a constraint ranking that is guaranteed to generate all of the forms present in its input. The constraint set that will be used in the midpoint simulations, adapted from Kager 2012:1479, is provided in 17. It includes general anti-lapse constraints (those that penalize sequences of stressless syllables), contextual anti-lapse constraints (those that penalize sequence of stressless syllables in certain locations), alignment constraints (those that prefer for stress to be at some edge), and NONFINALITY, a markedness constraint penalizing words with final stress.

(17) Adaptation of Kager's (2012) anti-lapse constraint set (based on Gordon 2002)

a. General anti-lapse constraints
   i. *LAPSE: assign one * for each sequence of two stressless syllables.
   ii. *EXTLAPSE: assign one * for each sequence of three stressless syllables.

b. Contextual anti-lapse constraints
   i. *LAPSEL: assign one * if neither of the initial two syllables is stressed.
   ii. *LAPSER: assign one * if neither of the final two syllables is stressed.
   iii. *EXTLAPSEL: assign one * if none of the initial three syllables is stressed.
   iv. *EXTLAPSER: assign one * if none of the final three syllables is stressed.

c. Alignment constraints
   i. ALIGNL: assign one * for each syllable separating stress from the left edge.
   ii. ALIGNR: assign one * for each syllable separating stress from the right edge.

d. NONFINALITY: assign one * if the final syllable is stressed.

I assume that the learner is exposed to forms of one through seven syllables. The candidate set I assume makes a couple of expository simplifications, none of which are crucial here. First, the learner is exposed only to words containing all light syllables: our focus will be on systems where syllable weight is not at issue. Second, I assume that each word has one and only one stress. The set of inputs and outputs provided to the learner, then, is fairly small: see Table 4 for a full list.[6]

Input	σ	σσ	σσσ	σσσσ	σσσσσ	σσσσσσ	σσσσσσσ
Candidate(s)	**σ́**	**σ́**σ	**σ́**σσ	**σ́**σσσ	**σ́**σσσσ	**σ́**σσσσσ	**σ́**σσσσσσ
		σ**σ́**	σ**σ́**σ	σ**σ́**σσ	σ**σ́**σσσ	σ**σ́**σσσσ	σ**σ́**σσσσσ
			σσ**σ́**	σσ**σ́**σ	σσ**σ́**σσ	σσ**σ́**σσσ	σσ**σ́**σσσσ
				σσσ**σ́**	σσσ**σ́**σ	σσσ**σ́**σσ	σσσ**σ́**σσσ
					σσσσ**σ́**	σσσσ**σ́**σ	σσσσ**σ́**σσ
						σσσσσ**σ́**	σσσσσ**σ́**σ
							σσσσσσ**σ́**

TABLE 4. Inputs and outputs considered.

The learner is provided with information about which of the output forms in Table 4 is optimal given the system it is learning, as well as the frequency at which that particular form is attested in its input. Frequency information and its effects on learning will be further discussed in section 4.

To illustrate how learning proceeds, consider the following simplified demonstration, in which a learner is taught a system with penultimate stress. I will assume that the learner is equipped with the constraint set in 18, a simplified version of the constraint set in 17. Furthermore, I will assume here and throughout that all of the constraints in 17 are unranked with respect to one another at the beginning of learning (the INITIAL STATE), as they are all markedness constraints (see Tessier 2009:13 for an explicit statement of this common assumption). Arbitrarily, as shown in 18, all of the constraints will begin with a ranking value of 100. Values can be directly translated into rankings: if constraint A has a value of 100 and constraint B has a value of 99, then A >> B; if the two have identical values, then there is no crucial ranking between them.

(18) Sample simulation: initial ranking values

Constraint	**Ranking value**
*LAPSEL	100
*LAPSER	100
ALIGNL	100
ALIGNR	100

Let us assume that the first input form is disyllabic. As the learner's initial state is one in which all constraints are unranked with respect to one another, the learner will randomly permute all of the constraints to form a fully stratified hierarchy (see Tesar & Smolensky 2000:47-50). Let us further assume that the resulting grammar causes the learner to make the wrong guess, *σ**σ́***. The learner, informed of its error, must update its grammar. Each update consists of two parts: promotion of the WINNER-PREFERRING constraints (those penalizing the incorrect guess more than the correct one; here ALIGNL), and demotion of the LOSER-PREFERRING constraints (those penalizing the correct guess more than the incorrect ones; here ALIGNR). Constraints that prefer neither the winner nor the loser (*LAPSE, *LAPSEL, and *LAPSER) remain at their current values. The learner's updated grammar is in 19. The update rule (i.e. the relative amounts of promotion and demotion) is Magri's (2012): if the demotion amount is X, then the promotion amount equals the number of constraints demoted, divided by X + the number of constraints promoted. Here, I assume that the demotion amount is 1; therefore, ALIGNR is demoted by 1 and ALIGNL is promoted by .5.

(19) Sample simulation: first update

Constraint	Ranking value
ALIGNL	100.5
*LAPSEL	100
*LAPSER	100
ALIGNR	99

This process – the presentation of a form, the learner's guess, and its update in response to an error (if there is one) is referred to as a TRIAL, and the entire learning procedure, composed of a number of trials, is referred to as a RUN. On Trial 2 of this run, let's again assume that the learner encounters a disyllabic form. This time, ***σ́**σ* is the optimal choice: incorrect *σ**σ́*** is penalized by high-ranked ALIGNL. The learner thus correctly guesses that the output form is ***σ́**σ*, and no update is necessary.

At Trial 3, let us assume that the learner encounters a four-syllable form, *σσσσ*. As the learner's grammar is now one in which initial stress is preferred, it will guess that the form should have initial stress (***σ́**σσσ*) – but this is incorrect, as the language it is learning is one with penultimate stress (so *σσ**σ́**σ* is correct). In response to this error, the learner will promote the winner-preferrers (*LAPSER and ALIGNR) and demote the loser-preferrers (ALIGNL and *LAPSEL), yielding the result in 20.

(20) Sample simulation: second update

Constraint	Ranking value
*LAPSER	100.66
ALIGNR	99.66
ALIGNL	99.5
*LAPSEL	99

At Trial 4, the learner encounters another four-syllable form. Notice, in 20, that the update in Trial 3 has caused the relative ranking of ALIGNR and ALIGNL to switch. The learner will therefore guess that four-syllable *σσσσ* should have final stress (*σσσ*$\acute{\boldsymbol{\sigma}}$), when it in fact should have penultimate stress (*σσ*$\acute{\boldsymbol{\sigma}}$*σ*). In response to this error, the learner promotes ALIGNL (the winner-preferrer) and demotes ALIGNR (the loser-preferrer), resulting in the grammar in 21.

(21) Sample simulation: third and final update

Constraint	Ranking value
*LAPSER	100.66
ALIGNL	100
*LAPSEL	99
ALIGNR	98.66

The learner has now converged at Trial 4: it will cease to make errors, as the constraint ranking it has reached is consistent with the data it receives (in which each word has penultimate stress).

Throughout, I will treat the number of trials required for the learner to converge on a ranking that generates some system X as a rough indication of the difficulty of acquiring that system. Although we do not yet know what the human equivalent is of a single machine learning trial – could a human learner infer, after hearing only four words, that it is learning a system with penultimate stress? – it seems reasonable to believe that there is a positive correlation between the number of trials required for the learner to converge and the difficulty of the system that it is attempting to learn. For example, if a learner takes 4 trials to converge on Grammar A and 400 trials to converge on Grammar B, I will assume that Grammar B is more difficult than Grammar A for the learner to acquire.

This section has introduced the mechanics of the learner that will be utilized for the rest of the article. In the following two sections, I show that the learner, when equipped with the constraint set in 17 and the input-output set in Table 4, takes longer on average to converge on rankings that generate midpoint systems than on rankings that generate superficially similar, but attested, systems. I show that the learner's difficulty in acquiring midpoint systems stems from fundamental properties of gradual error-driven learning: rankings that generate midpoint systems are difficult for the learner to discover. The hypothesis that midpoint systems are unattested because they are difficult to learn also makes broader predictions about stress typology; I show that these predictions are borne out.

4. THE LONG-WORD PROBLEM. In this section, I argue that many classes of midpoint systems suffer from the LONG-WORD PROBLEM: certain crucial rankings needed to arrive at the correct total ranking are only available in long (5+ syllable) words. Results from a cross-linguistic study on word length distribution show that long words are rare in most languages, and modeling results presented in section 4.1 show that the rarity of long words makes learning midpoint systems difficult. In section 4.2, I explore consequences of the long-word problem. I show that the few languages that appear to suffer from the long-word problem also happen to be languages with many long words.

4.1. MODELING RESULTS. Consider the trio of midpoint systems in 22-24. While all display the behavior characteristic of midpoint systems (the stressable window shrinks, then expands), they differ in one crucial respect: the minimum word length in which the relative ranking of the two anti-lapse constraints can be determined. In 22, it is possible to infer from all words of four or more syllables that *LAPSEL >> *LAPSER; I refer to 22 as a LIMITED midpoint system, as the conflicting anti-lapse constraints are both varieties of *LAPSE. In 23, words of five or more syllables are required to infer that *LAPSEL >> *EXTLAPSER; this is a MIXED midpoint system, as one anti-lapse constraint is a variety of *LAPSE, and the other is a variety of *EXTLAPSE. And finally, in 24, words of six or more syllables are necessary to determine that *EXTLAPSEL >> *EXTLAPSER; systems like 24, where both anti-lapse constraints are varieties of *EXTLAPSE, are EXTENDED midpoint systems.

(22) Limited Midpoint (*LAPSEL >> *LAPSER >> ALIGNL)

a. ${}_{L}\{^{R}\{\boldsymbol{\acute{\sigma}\sigma}\}_{L}\}^{R}$

b. ${}_{L}\{\sigma^{R}\{\boldsymbol{\acute{\sigma}}\}_{L}\sigma\}^{R}$

c. ${}_{L}\{\boldsymbol{\acute{\sigma}\sigma}\}_{L}{}^{R}\{\sigma\sigma\}^{R}$

d. ${}_{L}\{\boldsymbol{\acute{\sigma}\sigma}\}_{L}\sigma^{R}\{\sigma\sigma\}^{R}$

e. ${}_{L}\{\boldsymbol{\acute{\sigma}\sigma}\}_{L}\sigma\sigma^{R}\{\sigma\sigma\}^{R}$

f. ${}_{L}\{\boldsymbol{\acute{\sigma}\sigma}\}_{L}\sigma\sigma\sigma^{R}\{\sigma\sigma\}^{R}$

(23) Mixed Midpoint (*LAPSEL >> *EXTLAPSER >> ALIGNL)

a. ${}_{L}\{^{R}\{\boldsymbol{\acute{\sigma}\sigma}\}_{L}\}^{R}$

b. ${}_{L}\{^{R}\{\boldsymbol{\acute{\sigma}\sigma}\}_{L}\sigma\}^{R}$

c. ${}_{L}\{\sigma^{R}\{\boldsymbol{\acute{\sigma}}\}_{L}\sigma\sigma\}^{R}$

d. ${}_{L}\{\boldsymbol{\acute{\sigma}\sigma}\}_{L}{}^{R}\{\sigma\sigma\sigma\}^{R}$

e. ${}_{L}\{\boldsymbol{\acute{\sigma}\sigma}\}_{L}\sigma^{R}\{\sigma\sigma\}^{R}$

f. ${}_{L}\{\boldsymbol{\acute{\sigma}\sigma}\}_{L}\sigma\sigma^{R}\{\sigma\sigma\}^{R}$

(24) Extended Midpoint (*EXTLAPSEL >> *EXTLAPSER >> ALIGNL)

a. ${}_{L}\{^{R}\{\boldsymbol{\acute{\sigma}\sigma}\}_{L}\}^{R}$

b. ${}_{L}\{^{R}\{\boldsymbol{\acute{\sigma}\sigma\sigma}\}_{L}\}^{R}$

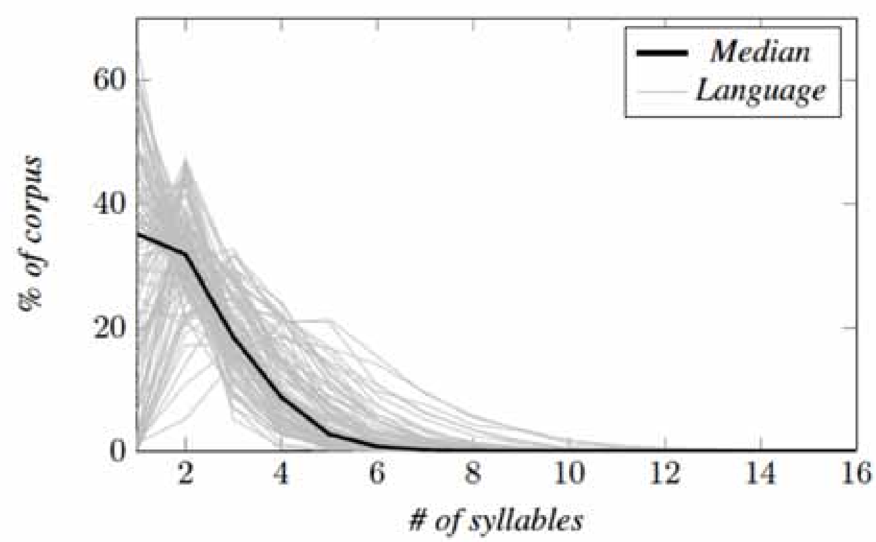
c. ${}_{L}\{\sigma^{R}\{\boldsymbol{\acute{\sigma}\sigma}\}_{L}\sigma\}^{R}$

d. ${}_{L}\{\sigma\sigma^{R}\{\boldsymbol{\acute{\sigma}}\}_{L}\sigma\sigma\}^{R}$

e. ${}_{L}\{\boldsymbol{\acute{\sigma}\sigma\sigma}\}_{L}{}^{R}\{\sigma\sigma\sigma\}^{R}$

f. ${}_{L}\{\boldsymbol{\acute{\sigma}\sigma\sigma}\}_{L}\sigma^{R}\{\sigma\sigma\sigma\}^{R}$

In the case of the mixed and extended midpoint systems, the fact that certain crucial rankings are only visible in longer (5+ syllable) words has implications for acquisition. For example, in order for a learner to successfully acquire all rankings associated with 24, she would have to be exposed to words that are six syllables or longer. A survey of text corpora from 102 languages reveals that this situation is, on average, unrealistic: long words are infrequent (on the distribution of word lengths, see also Hatzigeorgiu et al. 2001, Sigurd et al. 2004, Piantadosi et al. 2011, Kalimeri et al. 2015). The results of the survey are presented in Figure 1: each thin gray line represents the frequency distribution of an individual language, while the thicker black line represents the median values. More details about how the survey was conducted, as well as more information on the surveyed languages (including frequencies by language, genetic classification information, and sources of the data) are in the Appendix.



#	Median
1	35%
2	32%
3	18%
4	9%
5	3%
6	1%
7	0%

FIGURE 1. Results of the word counting study (see the Appendix for more details).

The important point to take away from Figure 1 is that, assuming the median values represent approximately what the average learner would be exposed to, words of five or more syllables make up only 4% of the learner's input, and words of six or more syllables make up only 1%. What this means, then, is that for a learner attempting to learn a midpoint system like 23 or 24, evidence as to the relative ranking of the anti-lapse constraints comes from a small minority of forms present in the input. As there is reason to believe that long words are even less frequent in child-directed speech (see e.g. Vihman et al. 1994:656 for properties of child-directed speech in English, French, and Swedish, where 1-2 syllable words predominate), patterns where crucial rankings are only available in these longer words might therefore be difficult for a child to acquire.

The rest of this subsection focuses on the following question: if a learner samples long words at the rate they are attested cross-linguistically, does it have a difficult time learning midpoint systems? To address this question, we will focus on the learner's behavior as we steadily decrease the number of long words that it encounters. To model this decrease in the number of long words, I selected five word length distributions from the word counting study, detailed in Table 5. Here, Portuguese represents the “average” language, as its distribution is closest to the median. Inuktitut represents the upper bound, as it has more long words than any other language in the study; Haitian represents the lower bound, as it has very few. English and Ganda represent intermediate points along the continuum.

Distribution	**1σ**	**2σ**	**3σ**	**4σ**	**5σ**	**6σ**	**7+σ**
Inuktitut	1.3%	5.2%	14.4%	20.7%	21.3%	15.3%	21.8%
Ganda	22.6%	21.7%	20.7%	17.4%	10.4%	5.0%	2.1%
Portuguese	32.6%	35.4%	18.2%	10.0%	3.0%	0.7%	0.1%
English	56.6%	28.0%	11.5%	3.0%	0.6%	0.3%	<0.1%
Haitian	58.0%	36.1%	5.1%	0.7%	0.1%	0.0%	0.0%

TABLE 5. Word length distribution used in modeling.

To probe the effects of the word length distribution on learning different systems, I taught each learner five different systems: the three midpoint systems in 22-24, a system with initial stress (Initial, 25), and a system with antepenultimate stress (AP, 26). Notice that, for AP, words of four syllables or longer are required to establish that *EXTLAPSER >> ALIGNL, as only in words of this length is it clear that there is a right-edge window actively prohibiting ALIGNL from being fully satisfied. In this sense, AP is exactly like the limited midpoint system in 22, in that four-syllable words are required to establish all crucial rankings.

(25) Initial (ALIGNL >> all)

a. ***σ́***σ

b. ***σ́***σσ

c. ***σ́***σσσ

d. ***σ́***σσσσ

e. ***σ́***σσσσσ

f. ***σ́***σσσσσσ

(26) AP (*EXTLAPSER >> ALIGNL)

a. $^{R}\{\boldsymbol{\acute{\sigma}\sigma}\}^{R}$

b. $^{R}\{\boldsymbol{\acute{\sigma}\sigma\sigma}\}^{R}$

c. $\sigma^{R}\{\boldsymbol{\acute{\sigma}\sigma\sigma}\}^{R}$

d. $\sigma\sigma^{R}\{\boldsymbol{\acute{\sigma}\sigma\sigma}\}^{R}$

e. $\sigma\sigma\sigma^{R}\{\boldsymbol{\acute{\sigma}\sigma\sigma}\}^{R}$

f. $\sigma\sigma\sigma\sigma^{R}\{\boldsymbol{\acute{\sigma}\sigma\sigma}\}^{R}$

Each system was presented to each learner ten times, for a maximum of 2,000 trials each. The results are in Table 6. Across word length distributions, the two attested systems (Initial and AP) were learned very quickly. For Initial, word length distribution has little effect on the number of trials required for convergence. For AP, word length distribution has some effect: compare the Haitian learner's average of 287 trials to the Portuguese learner's 27. This is not surprising, as four-syllable words (necessary to infer all crucial rankings for AP) are rarely presented to the Haitian learner. The limited midpoint system (LM, in 22) is also learned relatively quickly by all learners; the fact that the learner takes slightly longer on average to converge on LM than it does on AP is reflective of the fact that LM poses an additional problem to the learner (discussed in section 5).

For the two remaining systems – the mixed midpoint system in 23 (MM) and the extended midpoint system in 24 (EM) – the rate at which the learner is exposed to long words has a marked effect on the number of trials required for convergence. Although MM and EM are learned relatively quickly by the Inuktitut and Ganda learners, the Portuguese and English learners take longer to converge on EM and MM than they do on the other three systems. The difficulty that these systems pose is only made clearer by the performance of the Haitian learner, which failed to converge on the correct ranking within 2,000 trials for three of the MM runs and all ten of the EM runs.

Distribution	Initial	AP	LM	MM	EM
Inuktitut	2	10	25	29	17
Ganda	3	14	23	35	48
Portuguese	4	27	39	98	199
English	7	58	109	289	689
Haitian	18	287	317	1,593+	2,000+

TABLE 6. Rarity of long words negatively affects learning of midpoint systems.

The results in Table 6 support the hypothesis that the long-word problem plays a significant role in the absence of some types of midpoint systems. For MM and EM, the number of long words presented to the learner is inversely correlated with the number of trials necessary to converge on a ranking that generates a midpoint system. But there is still an additional question: given that the data presented to the learner are CONSISTENT with a ranking that generates a midpoint system, why is this not the preferred analysis? In other words: in the absence of overt evidence that the learner is attempting to acquire a midpoint system, why is it systematically biased against this hypothesis?

To explore this question, we will focus on the Haitian learner's failed attempts to learn EM. When the Haitian learner attempts to learn EM, it is never exposed to 27d-e, as words of six or more syllables are entirely absent from its input. Without these forms, 27 is identical to what the Haitian learner sees when learning AP, in 28. In other words: when long words are absent, the data are ambiguous.

(27) 3-5 syllable forms for EM

a. ${}_{\mathrm{L}}\{^{\mathrm{R}}\{\boldsymbol{\acute{\sigma}\sigma\sigma}\}_{\mathrm{L}}\}^{\mathrm{R}}$

b. ${}_{\mathrm{L}}\{\sigma^{\mathrm{R}}\{\boldsymbol{\acute{\sigma}\sigma}\}_{\mathrm{L}}\sigma\}^{\mathrm{R}}$

c. ${}_{\mathrm{L}}\{\sigma\sigma^{\mathrm{R}}\{\boldsymbol{\acute{\sigma}}\}_{\mathrm{L}}\sigma\sigma\}^{\mathrm{R}}$

d. $\cancel{{}_{\mathrm{L}}\{\boldsymbol{\acute{\sigma}\sigma\sigma}\}_{\mathrm{L}}{}^{\mathrm{R}}\{\sigma\sigma\sigma\}^{\mathrm{R}}}$

e. $\cancel{{}_{\mathrm{L}}\{\boldsymbol{\acute{\sigma}\sigma\sigma}\}_{\mathrm{L}}\sigma^{\mathrm{R}}\{\sigma\sigma\sigma\}^{\mathrm{R}}}$

(28) 3-5 syllable forms for AP

a. ${}^{R}\{\boldsymbol{\acute{\sigma}\sigma\sigma}\}^{R}$

b. $\sigma^{R}\{\boldsymbol{\acute{\sigma}\sigma\sigma}\}^{R}$

c. $\sigma\sigma^{R}\{\boldsymbol{\acute{\sigma}\sigma\sigma}\}^{R}$

d. ~~$\sigma\sigma\sigma^{R}\{\boldsymbol{\acute{\sigma}\sigma\sigma}\}^{R}$~~

e. ~~$\sigma\sigma\sigma\sigma^{R}\{\boldsymbol{\acute{\sigma}\sigma\sigma}\}^{R}$~~

Given the data from EM in 27, both AP and EM are possible hypotheses, but AP is the preferred one.[7] Every time the Haitian learner is exposed to 27 or 28, it converges on a grammar that generates AP. To see where this bias comes from, consider the schematic learning trajectory presented in Figure 2 (based on Run 1 of the Haitian learner's EM trials). Forms that the learner encounters (1-5 syllables) are in black; forms that the learner does not encounter (6+ syllables) are in gray.

At the beginning of the learning procedure, the learner's initial state (State i) is one in which all markedness constraints are unranked with respect to one another. When the learner is presented with monosyllabic and disyllabic forms, all of the constraints in its grammar are randomly permuted to form a fully stratified ranking. As for the stress of monosyllabic forms, the learner will always make the correct guess because there is no other option (the candidate set assumes that all forms must bear a stress). For the disyllabic forms, more of the possible fully stratified rankings prefer $\boldsymbol{\acute{\sigma}}\sigma$ (with initial stress; target) to $\sigma\boldsymbol{\acute{\sigma}}$ (with final stress; non-target), so the learner often makes the correct guess.

When presented with a trisyllabic form, the guess compatible with the most fully stratified rankings is second-syllable stress ($\sigma\boldsymbol{\acute{\sigma}}\sigma$), but this is the wrong guess: in the target system (State iv), trisyllabic forms have initial stress. In response to its error, the learner promotes ALIGNL (and demotes several other constraints),[8] resulting in a grammar in which all forms have initial stress (State ii). When the learner encounters a four- or five-syllable form, it makes another error: the learner guesses that the form should have initial stress ($\boldsymbol{\acute{\sigma}}\sigma\sigma\sigma$), when in fact stress should be antepenultimate ($\sigma\boldsymbol{\acute{\sigma}}\sigma\sigma$). In response to this error, the learner promotes *EXTLAPSER (preferring the correct form with antepenultimate stress) and demotes ALIGNL (preferring the incorrect form with initial stress). As learning is gradual, it can take the learner more than one error of this type to eventually converge on a grammar that generates AP (State iii).

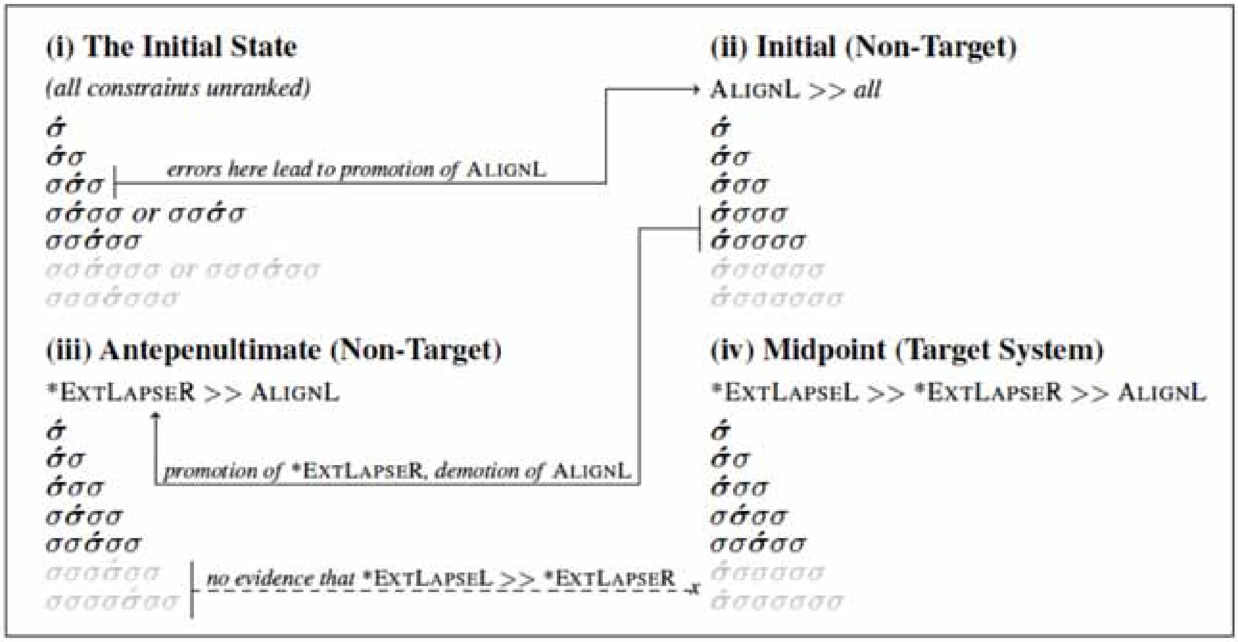


FIGURE 2. Learning trajectory for the Haitian EM learner.

Although the learner has not yet reached the target grammar (State iv), learning ends when it reaches a grammar that generates antepenultimate stress (State iii). This is because some of the crucial rankings necessary to reach the target grammar (State iv) are not motivated by data that the learner encounters. To reach the target grammar, it is necessary for the learner to infer that *EXTLAPSEL >> *EXTLAPSER, but the learner never sees any evidence that *EXTLAPSEL needs to be promoted. This is because the errors that would cause the learner to promote *EXTLAPSEL are incompatible with other aspects of the system that it is learning. For example, if the learner were to encounter four-syllable $\sigma\sigma\sigma\sigma$ and incorrectly guess that it should be stressed as $\sigma\sigma\sigma\acute{\boldsymbol{\sigma}}$, *EXTLAPSEL would be promoted, as the target form $\sigma\acute{\boldsymbol{\sigma}}\sigma\sigma$ shows the learner that stress must fall within an initial trisyllabic window. But the learner never makes this error or others like it, because it learns very early on that ALIGNL is high-ranked: it has no reason to ever guess that a word should have final stress. In short, AP is the preferred hypothesis given the data in 27a-c because the rankings needed to derive it are supported by data that the learner encounters.

As I am assuming that all markedness constraints are equally ranked in the initial state, another way of viewing the preference for AP is as a preference for the simplest possible hypothesis, meaning here the hypothesis that involves the fewest deviations from the initial state.

Comparing the grammars necessary to generate AP (in 29) and EM (in 30) reveals a fundamental difference between them: the grammar for EM has more strata. If all markedness constraints are unranked with respect to one another in the initial state, then 30 represents a more significant departure. From the learner's perspective, there is no reason to assume that the additional ranking differentiating 29 from 30 is necessary unless it is explicitly motivated by data it encounters.[9]

(29) Grammar for AP

$$\text{*E}{\small\text{XT}}\text{L}{\small\text{APSE}}\text{R} \downarrow \text{A}{\small\text{LIGN}}\text{L}$$

(30) Grammar for EM

$$\text{*E}{\small\text{XT}}\text{L}{\small\text{APSE}}\text{L} \downarrow \text{*E}{\small\text{XT}}\text{L}{\small\text{APSE}}\text{R} \downarrow \text{A}{\small\text{LIGN}}\text{L}$$

This result continues to hold even if we adopt other proposals in the literature arguing for more refined initial rankings. Within a constraint class, such as markedness or faithfulness, proposals about biases in the initial state have typically appealed to the difference between specific and general constraints (though cf. Tesar & Smolensky 2000:68-70 for other proposals regarding the initial ranking of foot form and quantity-sensitive constraints). For example, Hayes (2004) proposes that if both a specific and a general faithfulness constraint can be used to rule out a single losing candidate, the specific constraint should be selected. Favoring specific faithfulness constraints allows the learner to maintain a more restrictive grammar, which helps avoid overgeneration (Hayes 2004:22). With this logic, if learners should favor restrictive grammars, we might expect that general markedness constraints should be favored over specific ones, as general markedness constraints penalize a wider variety of forms (see Albright & Do 2013). But preferring general over specific markedness constraints does not affect the results discussed above, as neither *EXTLAPSEL nor *EXTLAPSER is more specific than the other. Even if we assume the opposite – that specific markedness constraints should be favored over general ones (Do 2013:123) – the result still holds. In fact, it is difficult to envision a reason why a learner would be biased to prefer one of *EXTLAPSEL or *EXTLAPSER over the other in its initial state, as the two constraints are completely symmetrical.[10]

In sum, this subsection has suggested that the long-word problem can help us understand why certain types of midpoint systems are unattested. As demonstrated above, a GLA learner trying to acquire an extended midpoint system has to be exposed to words of six syllables or longer in order to reach the target grammar. In many cases, this is an unrealistic situation: in the word count study described in the Appendix, words of six or more syllables make up a negligible portion of the corpus (0.4% or lower) in 39 of the 102 surveyed languages. The situation is similar, though much less dire, for a learner trying to acquire a mixed midpoint system (as in 19): five-syllable words make up on average 3% of the entire corpus, with 9 of the 102 surveyed languages having very few words of this length (0.4% or lower). As exposure to long words is in many cases necessary for a learner to reliably acquire a midpoint system, the cross-linguistic rarity of long words poses a general problem for the acquisition of these systems.

4.2. CONSEQUENCES OF THE LONG-WORD PROBLEM. Above, I showed that appealing to the cross-linguistic rarity of long words can help us make progress in understanding why certain types of midpoint system are unattested. This claim, if correct, has broader typological consequences: stress systems in which some crucial rankings are only visible in long words should only arise in the small minority of languages in which long words are frequent. In this subsection, I explore these consequences by investigating several types of stress system in which long (6+ syllable) words appear to be necessary to establish all crucial rankings. The results of this investigation suggest that stress systems can be divided into two classes: (i) those in which the stress of long words is predictable given the stress of shorter words, and (ii) those in which the stress in long words is NOT predictable given the stress in shorter words. As expected, the (ii)-type systems appear to only be attested in languages that have far more long words than average.

BEHAVIOR OF LONG WORDS IS PREDICTABLE: BINARY PLUS CLASH SYSTEMS. To illustrate how the stress of long (6+ syllable) words can be predicted given the stress of shorter words, we will focus on the typology of binary plus clash systems (name due to Gordon 2002). In these systems, stress generally alternates in a binary fashion, but clashes arise in words of certain lengths. For example, in Passamaquoddy (LeSourd 1988, LeSourd 1993), odd-parity words license a clash (underlined) at their left edge; examples follow in 31.

(31) Stress in Passamaquoddy (LeSourd 1988:140-143)

a.	wá.sis	'child'	***σ́***σ
b.	wà.sí.sək	'dirt, soil'	***σ̀σ́***σ
c.	wì.coh.ké.mal	'he helps the other'	***σ̀***σ***σ́***σ
d.	wì.còh.ke.ké.mo	'he helps out'	***σ̀σ̀***σ***σ́***σ
e.	wì.coh.kè.ta.há.mal	'he thinks of helping the other'	***σ̀***σ***σ̀***σ***σ́***σ
f.	tèh.sàh.kwa.pà.sol.tí.ne	'let's walk around on top'	***σ̀σ̀***σ***σ̀***σ***σ́***σ

As another example, consider the pattern attested in Southern Paiute (Sapir 1930; also Harms 1966, Wheeler 1979), where even-parity words license a clash (underlined) between the penult and the antepenult. In 32, vowel devoicing is indicated by capitalization, following Sapir.

(32) Stress in Southern Paiute (Sapir 1930:28-40; see also Sapir p. 39 and van Urk 2013:11)

a.	ú.mA	'with it'	***σ́***σ
b.	tï.qá.qːA	'several eat'	σ***σ́***σ
c.	qa.ní.à.ŋA	'his house'	σ***σ́σ̀***σ
d.	pU.cá.ɣa.ì.pːì.ɣa	'looked for'	σ***σ́***σ***σ̀σ̀***σ
e.	nam.pú.cːa.ɣà.ɪ.pì.ɣa	'looked for trail'	σ***σ́***σ***σ̀***σ***σ̀***σ
f.	tï.v^{w}á.qːaŋ.wà.i.yù.càm.pA	'though not killing game'	σ***σ́***σ***σ̀***σ***σ̀σ̀***σ

In both of these systems, if we focus only on words of five syllables or fewer, the preferred location of the clash is ambiguous. In Passamaquoddy, five-syllable <wì.còh.ke.ké.mo> (***σ̀σ̀***σ***σ́***σ) is consistent with two seven-syllable forms: the attested <tèh.sàh.kwa.pà.sol.tí.ne> (***σ̀σ̀***σ***σ̀***σ***σ́***σ), with a clash at the edge, and the unattested *<tèh.sah.kwà.pà.sol.tí.ne> (****σ̀***σ***σ̀σ̀***σ***σ́***σ), with a word-internal clash. In Southern Paiute, the stress pattern of four-syllable [qa.ní.à.ŋA] (σ***σ́σ̀***σ) is consistent with two possible six-syllable forms: the attested [pU.cá.ɣa.ì.pːì.ɣa] (σ***σ́***σ***σ̀σ̀***σ), with a clash between two secondary stresses, and the unattested *[pᴜ.<u>cá.ɣà</u>.i.pːì.ɣa] (*σ<u>***σ́σ̀***</u>σ***σ̀***σ), with a clash between the primary and a secondary. At face value, then, it appears that a learner would have to be exposed to long words in order to successfully acquire systems like those in 31 and 32.

But as Kager (2001) and van Urk (2013) note, there are typological generalizations regarding the typology of binary plus clash systems that render the stress patterns in these long words entirely predictable. The first generalization is that stress clash is typically realized AWAY FROM THE PRIMARY STRESS: this is the case for both Passamaquoddy and Southern Paiute.[11] The second generalization, also evident in both languages, is that stress clash is typically realized AT OR CLOSE TO THE EDGE OF A WORD. More precisely, in quantity-insensitive systems, stress clashes that are separated from both word edges by another stress (e.g. ***σ́***σ<u>***σ̀σ̀***</u>σ***σ̀***) are unattested. To encode these asymmetries, two constraints have been proposed: CLASH-AT-EDGE, 33, penalizing all word-internal clashes (definition adapted from van Urk 2013:21; see also Kager 2001:11), and *CLASH-AT-PEAK, 34, penalizing all primary-adjacent clashes (definition adapted from Kager 2001:10).

(33) CLASH-AT-EDGE: assign one * for each sequence of two stressed syllables that is both preceded and followed by another stressed syllable.

(34) *CLASH-AT-PEAK: assign one * if the syllable bearing primary stress is immediately adjacent to one or more syllables bearing secondary stress.

Simply admitting CLASH-AT-EDGE and *CLASH-AT-PEAK into CON is sufficient to render the seven-syllable forms of Passamaquoddy, and the six-syllable forms of Southern Paiute, predictable. In Passamaquoddy, five-syllable <<u>wì.còh</u>.ke.ké.mo> (<u>***σ̀σ̀***</u>σ***σ́***σ) and all shorter forms show us that the initial and penult must receive stress, and that *LAPSE is inviolable. Given this, it is predictable that, in seven-syllable <<u>tèh.sàh</u>.kwa.pà.sol.tí.ne> (<u>***σ̀σ̀***</u>σ***σ̀***σ***σ́***σ), the clash should be realized at the edge opposite the primary stress. As shown in 35, the alternatives are harmonically bounded: they cannot win under either ranking of the two constraints.

(35) Passamaquoddy <<u>tèh.sàh</u>.kwa.pà.sol.tí.ne> (<u>***σ̀σ̀***</u>*σ*__*σ̀*__*σ*__*σ́*__*σ*) is predicted

	/*σσσσσσσ*/	CLASH-AT-EDGE	*CLASH-AT-PEAK
☞	a. ***σ̀σ̀****σ*__*σ̀*__*σ*__*σ́*__*σ*		
	b. __*σ̀*__*σ*___*σ̀σ̀*___*σ*__*σ́*__*σ*	*!	
	c. __*σ̀*__*σ*__*σ̀*__*σ*___*σ̀σ́*___*σ*		*!

Similar considerations apply for Southern Paiute. A learner can infer from four-syllable [qa.<u>ní.à</u>.ŋA] (*σ*<u>***σ́σ̀***</u>*σ*) and other shorter forms that stressing peripheral syllables is dispreferred (the initial is only stressed in disyllabic forms, e.g. 32a, to avoid stressing the final), and that *LAPSE is inviolable. Once we take CLASH-AT-EDGE and *CLASH-AT-PEAK into account, it is predictable that six-syllable [pU.cá.ɣa.<u>ì.pːì</u>.ɣa] (*σ*__*σ́*__*σ*<u>***σ̀σ̀***</u>*σ*) and longer even-parity words should license their clashes at the side of the word not adjacent to the primary stress.

In short, binary plus clash systems are not systems in which very long (6+ syllable) words are necessary to establish crucial rankings: the stress of these longer words is predictable given the stress of shorter (five or fewer syllable) words. We might expect, then, that a learner would not face any difficulty in learning binary plus clash systems, as exposure to long words is not necessary to reach the target grammar. This expectation is borne out: a learner equipped with CLASH-AT-EDGE and *CLASH-AT-PEAK takes 68 trials on average to learn Passamaquoddy, and 69 to learn Southern Paiute.[12]

The discussion here has focused entirely on binary plus clash systems, but there are other classes of systems in which the stress patterns of long (e.g. 7 syllable) words are predictable given the stress of shorter words. Another class of examples comes from the typology of binary plus lapse systems (see Kager 2001, Gordon 2002), where several typological generalizations also render the stress of long words predictable. Kager (2001) shows that when lapses are licensed in quantity-insensitive systems, they are realized either (i) adjacent to the peak, or (ii) at the right edge of the word. Given five-syllable __*σ́*__*σσ*__*σ̀*__*σ* (as in Garawa; see Furby 1974), the learner can infer that the lapse must occur adjacent to the primary stress: the seven-syllable form must then be the attested __*σ́*__*σσ*__*σ̀*__*σ*__*σ̀*__*σ*, and not the unattested __*σ́*__*σ*__*σ̀*__*σσ*__*σ̀*__*σ*. Thus, languages exhibiting binary plus lapse patterns are also systems in which the stress of long (7+ syllable) words is predictable given the stress of shorter words.

Long-word phenomena in languages with many long words: ternary stress. I turn now to the class of systems in which the stress of long words is not predictable from the stress of shorter words; our case study will be languages exhibiting ternary stress patterns. In these systems, each stress is preferably separated by two stressless syllables from another stress (e.g. ***σ́****σσ****σ̀****σσ*). Some ternary systems pose a potential challenge for the long-word hypothesis because they are systems in which a learner must be exposed to long (6+ syllable) words in order to infer all crucial rankings. To illustrate, we will focus on two such systems: Chugach Alutiiq Yupik (hereafter ‘Chugach’; Leer 1985a,b; Hewitt 1992) and Cayuvava (Key 1961, 1967).

The stress pattern of Chugach, as described by Kager (1993:412-413), is as follows: for words with all light syllables, every syllable in position 3N-2 is stressed, and in words with 3N+1 syllables the final is stressed, too. Heavy syllables (closed initials, and all with long or diphthongal nuclei) are stressed. If a heavy syllable is followed by a string of light syllables, stress falls on every third light. In 36a, I provide examples of words with all light syllables from three through eight syllables; in 36b I have provided examples of words where the initial syllable is heavy. In cases where the data are unavailable, I have provided a schematic representation of what the pattern would likely be, based on what we know. Leer reports that all stresses are of equal prominence; following Kager (1993), I transcribe them all as primaries.

(36) Stress in Chugach (32aii from Leer 1985b:164; all others from Leer 1985a:84-113)

a. Words with all light syllables

i.	pa.lá.yaq	‘rectangular skiff’	*σ**σ́**σ*
ii.	a.kú.ta.mék	‘*akutaq* (a food), abl.sg.’	*σ**σ́**σ**σ́***
iii.	ta.qú.ma.lu.ní	‘apparently getting done’	*σ**σ́**σσ**σ́***
iv.	a.kú.tar.tu.nír.tuq	‘he stopped eating akutaq’	*σ**σ́**σσ**σ́**σ*
v.	ma.ngár.su.qu.tá.qu.ní	‘if he (refl.) is going to hunt porpoise’	*σ**σ́**σσ**σ́**σ**σ́***
vi.	*inferred*		*σ**σ́**σσ**σ́**σσ**σ́***

b. Words with heavy initials

i.	taá.ta.qá	‘my father’	***σ̄́**σ**σ́***
ii.	án.ci.qu.kút	‘we’ll go out’	***σ̄́**σσ**σ́***
iii.	naá.qu.ma.lú.ku	‘apparently reading it’	***σ̄́**σσ**σ́**σ*
iv.	*inferred*		***σ̄́**σσ**σ́**σσ*

v.	át.sar.su.qú.ta.qu.ní	‘if he (refl.) is going to get berries’	***σ̄́***σσ***σ́***σσ***σ́***
vi.	tán.ner.lir.sú.qu.ta.qú.ni	‘if he (refl.) is going to hunt bear’	***σ̄́***σσ***σ́***σσ***σ́***σ

In Cayuvava, primary stress falls on the antepenultimate syllable, and secondary stresses occur on every third syllable counting back from the primary stress; see 37.[13]

(37) Stress in Cauyvava (all data from Key 1961:143-150)

a.	dá.pa	‘canoe’	***σ́***σ
b.	tó.mo.ho	‘small water container’	***σ́***σσ
c.	a.rí.po.ro	‘he already turned around’	σ***σ́***σσ
d.	a.ri.pí.ri.to	‘already planted’	σσ***σ́***σσ
e.	à.ri.hi.hí.be.e	‘I have already put the top on’	***σ̀***σσ***σ́***σσ
f.	ma.rà.ha.ha.é.i.ki	‘their blankets’	σ***σ̀***σσ***σ́***σσ
g.	i.ki.tà.pa.re.ré.pe.ha	‘the water is clean’	σσ***σ̀***σσ***σ́***σσ

In both Chugach and Cayuvava, a learner would have to be exposed to long words to infer all crucial rankings. In Chugach, it is only clear in words of six syllables or longer, like 36biv-vi and 36avi, that ternary alternation is completely general in this language, not just licensed following the first stress (as in Indonesian, see Cohn 1989). In Cayuvava, it is only clear in words of six syllables or longer, like 37e-g, that there is more than one stress per word; in all shorter words, the system could just as well be one with a single antepenultimate stress.

The fact that the Chugach and Cayuvava patterns require long words to become clear is completely consistent with the fact that, in both languages, it is probable that long words are frequent. Words of six syllables or more make up 9.4% of a 340-word text from Alutiiq (Anonymous 1980), of which Chugach is a dialect. While a fuller investigation of available Alutiiq resources is necessary to determine the relative frequency of long words, it does appear to be a more general feature of the language family that such words are common. For example, in both Inuktitut and Inupiatun, related Eskimo-Aleut languages, long words are extremely frequent. In Inuktitut, words of six or more syllables make up 49.57% of the word count study; in Inupiatun, they make up 47.77% (compare this to the average of 3.3%; see the Appendix for the full frequency distributions). And while I have not yet investigated the available text resources for another dialect of Yupik, Central Alaskan, it certainly allows long words. I assume that the form in 38, from Miyaoka 2012:132, is a single prosodic word; see Miyaoka 2012:70-71 for information on Central Alaskan prosody, where it appears that morphologically simple and complex forms are treated alike.

(38) angya-cuara-li-yu-kapigte-llru-nric-aaq-sugnarq-llru-yugnarz-annga
boat-small-make-DES-ITS-PST-NEG-CTR-INF-PAST-INF-IND-3sg.1sg
'I'm in doubt that he actually didn't really want to make me a small boat (but he did)'

Would a learner be able to learn the Chugach pattern in 36, based on the data that is available to it? As the learner is not currently set up to handle quantity-sensitive inputs and outputs, nor is it set up to handle a language in which all stresses are of equal prominence, I cannot currently answer this question. It seems reasonable to believe, however, that a learner exposed to far more 6+ syllable words than average would have an easier time learning a system in which it is necessary to be exposed to 6+ syllable words.

As I have been unable to locate a larger text collection for Cayuvava (nor does it have any known relatives), it is hard to know what the word length distribution in this language was. A short text in Key 1967, however, gives us an idea: as shown in Table 7, words of six syllables or longer make up 26.4% of this 76-word text. This is an unusually large percentage, compared to the survey average of 3.3% (see the Appendix). As expected, a learner that samples long words at the high rate they are attested in Table 7 easily learns the Cayuvava pattern: it requires 45 trials on average to converge.

Syllables	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
# of syllables	5	0	19	21	8	10	5	4
% of total	6.9%	0%	26.4%	29.2%	11.1%	13.9%	6.9%	5.6%

TABLE 7. Word length distribution of Key's (1967) text.

Although it is currently unclear exactly how many long words a human learner would have to encounter for a pattern dependent on long words (like those discussed above) to be easily learned, we have seen in this section that the long-word hypothesis makes correct predictions about stress typology. Systems where some crucial rankings are only discernible in long words appear to only be attested in languages that independently have many long words, far more than is cross-linguistically average (I leave a more quantitative formulation of this generalization to future work). We can therefore safely point to the general cross-linguistic rarity of long words as a contributing factor to the unattested status of certain types of midpoint systems.

5. THE CREDIT PROBLEM. In section 4, we saw that it is difficult for the learner to acquire midpoint systems when it is deprived of the forms necessary to infer all crucial rankings. But this cannot be the only factor leading to the absence of midpoint systems from the attested typology, for two reasons. First, not all learners are deprived of long words: although languages like Inuktitut (where we would expect learners to be exposed to many long words) are rare, they do exist: in 6 of the 102 languages included in the word length study, words of six syllables or more make up 10% of the corpus. Second, not all kinds of midpoint systems require a learner to be exposed to long words for expedient acquisition: in the limited midpoint systems discussed in section 4.1, learners need only be exposed to words of four or more syllables, which are cross-linguistically frequent.

This section discusses an additional factor that makes midpoint systems difficult for a learner to acquire. In section 5.1, I show that the inconsistent placement of stress with respect to a word edge poses a CREDIT PROBLEM for the learner: in short, updates in response to words of different lengths are mutually antagonistic, causing the learner to make many errors that cancel one anther out before it converges, more or less by chance, on the correct grammar. Unlike the long-word problem, the credit problem is fully general: it applies to all kinds of midpoint systems, and it applies regardless of the relative frequency of long words. In section 5.2, I show that this dispreference for midpoint systems is part of a much larger dispreference for systems in which the placement of stress depends on word length, as is predicted by the results in section 5.1.

5.1. MODELING RESULTS. To examine the credit problem in more detail, we will focus on the Portuguese learner's attempts at learning midpoint systems. While the Portuguese learner always converges on a grammar that generates the midpoint systems, it takes longer on average to learn these systems than it does to learn either Initial or AP (see Table 6 for a summary of results).

To understand why it takes the learner a relatively long time to converge on the correct ranking for EM, consider the schematic learning trajectory presented in Figure 3 (based on a simplified Run 6 of the Portuguese learner's EM trials). As was the case with the simulations discussed in section 4.1, at the beginning of the learning procedure, the learner's initial state (State i) is one in which all markedness constraints are unranked with respect to one another. When the learner is presented with monosyllabic and disyllabic forms, it correctly guesses that they should have initial stress. When presented with a trisyllabic form, the learner makes an error: it guesses that the form should have second-syllable stress (*σ**σ́**σ*), when it should in fact have initial stress (***σ́**σσ*). In response to this error, the learner promotes ALIGNL, leading to a grammar that predicts all forms should have initial stress (State ii). But this is incorrect: when the learner encounters a four- or five-syllable word, it predicts that the form should have initial stress (***σ́**σσσ*), when it should have second-syllable stress (*σ**σ́**σσ*). This error causes the learner to promote *EXTLAPSER and demote ALIGNL, eventually reaching a grammar that generates forms with antepenultimate stress (State iii).

So far, the learning trajectory is identical to the Haitian learner's trajectory (see section 4.1). The difference is that the Portuguese learner is exposed to six- and seven-syllable words. While in State iii, a Portuguese learner seeing a 6+ syllable word will make an incorrect guess: its grammar tells it that stress should be antepenultimate (*σσσ**σ́**σσ*), when in fact it should be initial (***σ́**σσσσσ*). When comparing the winning form (***σ́**σσσσσ*) and the losing form (*σσσ**σ́**σσ*), notice that the winning form satisfies a number of constraints demanding that stress fall near the word's left edge: ALIGNL, *EXTLAPSEL, and *LAPSEL. The learner, not knowing which of these constraints is responsible for choosing the attested form, promotes all of them – in most cases, this update takes the learner back to State ii, causing it to again believe that all words should have initial stress. EM thus poses a credit problem: not knowing which of several markedness constraints is responsible for the attested form, the learner must promote all of them, causing it to revert to an earlier hypothesis.

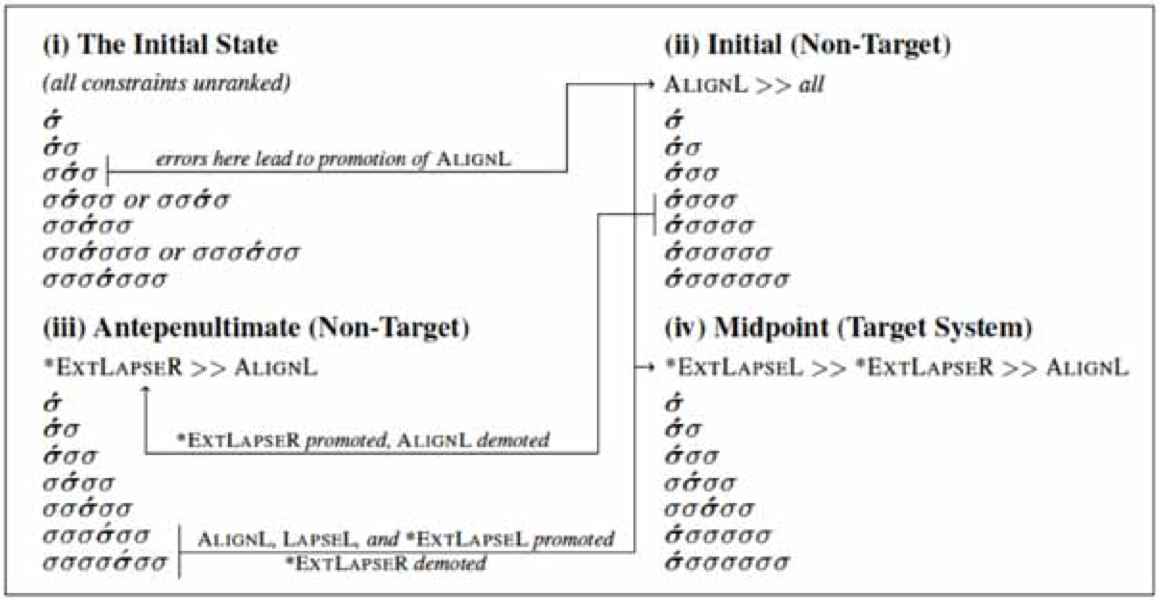


FIGURE 3. Learning trajectory for the Portuguese EM learner.

Learning continues on in this manner for a while longer, with the learner bouncing back and forth between a grammar that generates initial stress (State ii), antepenultimate stress (State iii), and other incorrect hypotheses before converging, more or less by chance, on the target grammar that generates EM (State iv). What is immediately noticeable about the learning trajectory is that the value of ALIGNL is in constant flux: as the position of stress is inconsistent across words of different lengths, the learner receives inconsistent evidence about the relative importance of satisfying ALIGNL. The ranking trace in Figure 4, from the Portuguese learner's Run 6, illustrates: with each update, the ranking value of ALIGNL changes.

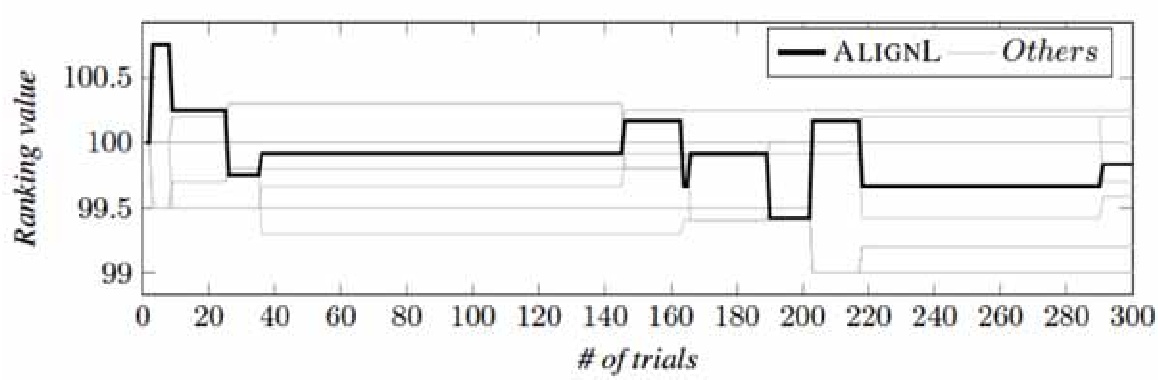


FIGURE 4. Ranking value of ALIGNL over time (EM, Run 6).

The erratic behavior of ALIGNL demonstrates visually why midpoint systems are difficult for the learner. Recall that when the learner (at State ii) incorrectly guesses that a six-syllable form should have antepenultimate stress (*σσσ**σ́**σσ*), there are three constraints that could be responsible for the attested ***σ́****σσσσσ*: *EXTLAPSEL, *LAPSEL, and ALIGNL The learner is agnostic as to which constraint is responsible for the attested form, so it promotes all three. We could imagine a different response to this error: the learner could evaluate its current grammar, see that previous updates have caused it to rank *EXTLAPSER above ALIGNL, and refuse to promote ALIGNL. This reference to previously established rankings is a property of batch and ERC learners (see citations in 16): the updates a learner performs in response to errors are informed by the crucial rankings that it has already learned. Such a learner would not encounter the credit problem described above, as it would require the learner to retain the ranking *EXTLAPSER >> ALIGNL, once it had been established.[14] This is not how the GLA works, though, and the GLA's lack of reference to previously established rankings is in fact a desirable property of the algorithm. If for example the first word a child hears is a speech error – an adult intends to produce the form ***σ́****σ*, but instead produces *σ****σ́*** – we do not want the child to learn that ALIGNR >> ALIGNL is irreversible. In other words, a learner must be able to unlearn incorrect crucial rankings established in response to misproduced or misperceived forms. This ability of the learner to unlearn rankings established in response to previous errors is, in turn, exactly what makes EM so difficult to acquire.

The important point of this section is that the credit problem posed by the midpoint system in 24, as illustrated above, is completely general: all midpoint systems, whether they involve context-sensitive varieties of *EXTLAPSE or *LAPSE, are difficult for the learner in this respect; all midpoint systems involve the inconsistent placement of stress across words of different lengths. For example: a learner acquiring a limited midpoint system, like the system discussed in section 4.1 (LM in 22, in an abbreviated format as 39), does not need to be exposed to long words.

(39) LM (*LAPSEL >> *LAPSER >> ALIGNL)

a. $_{L}\{^{R}\{\boldsymbol{\acute{\sigma}\sigma}\}_{L}\}^{R}$

b. $_{L}\{\sigma^{R}\{\boldsymbol{\acute{\sigma}}\}_{L}\sigma\}^{R}$

c. $_{L}\{\boldsymbol{\acute{\sigma}\sigma}\}_{L}{}^{R}\{\sigma\sigma\}^{R}$

While the relative ranking of *LAPSEL and *LAPSER can be inferred from all forms of four syllables or longer, acquiring the ranking that generates 39 is still difficult for the learner, as the updates performed in response to the trisyllabic form with second-syllable stress, 39b, are not consistent with those performed in response to the other forms. In other words, the learner runs into the same credit problem as it does when attempting to learn EM. The ranking trace in Figure 5 illustrates: the value of ALIGNL oscillates with each update that the learner performs.

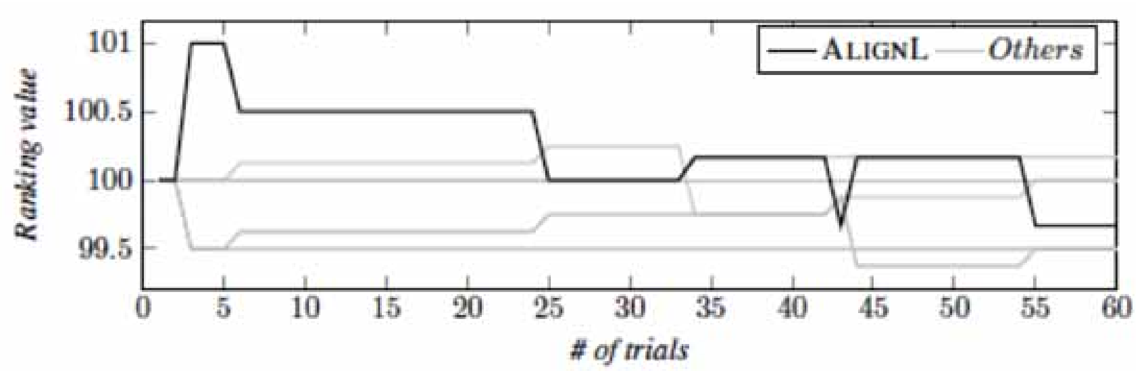


FIGURE 5. Ranking value of ALIGNL over time (LM, Run 8).

In sum, the characteristic of midpoint systems responsible for the credit problem is the variable positioning of stress with respect to a word edge: stress is located at a word edge in words of some lengths, but not others. This inconsistency causes the learner to overgeneralize. When the learner sees a word with initial stress, it will often update its grammar to one that prefers initial stress, regardless of what has come before. The variable positioning of stress with respect to a word edge is a signature characteristic of all midpoint systems; thus, the credit problem can help us understand why these systems, as an entire class, are dispreferred.

5.2. EXTENSIONS: A DISPREFERENCE FOR INCONSISTENT STRESS PLACEMENT. The main observation in section 5.1 is that midpoint systems are hard to learn because the data presented to the learner are not self-consistent: updates performed in response to words of different lengths, in effect, cancel one another out. In this subsection, I suggest that this observation can help us understand why several other classes of systems are unattested, relative to what we might expect. The general picture that emerges is that the absence of midpoint systems is just one symptom of a more general dispreference for systems in which the placement of main stress depends on word length (see also the Stress-Harmony constraint: Bailey 1995:204-205). The fact that is POSSIBLE for stress placement to depend on word length means that we cannot exclude these systems from the predicted typology; the fact that such systems are RARE is consistent with a learnability-based explanation.

The first class of systems we will discuss here, which I refer to as SHRINKING WINDOW systems, are systems in which the size of the accentual window shrinks as the word lengthens. For example, in North Kyungsang Korean (NKK; Kenstowicz & Sohn 2001), pitch accent can occur on either the penultimate or final syllable in words of up to three syllables (so ✓*σ**σ́**σ* and ✓*σσ**σ́***), but is fixed on the penult in words of four syllables or longer (so ✓*σσ**σ́**σ*, but **σσσ**σ́***). Thus, in NKK, the right-edge disyllabic window found in shorter words (1-3 syllables) shrinks to a single syllable in longer words (4+ syllables). A similar pattern arises in Kimatuumbi (Odden 1996:179), where a process shifting final high tone one mora to the left applies only in words of four (and presumably more) moras; examples are in 40.

(40) Leftward tone shift in Kimatuumbi nouns (Odden 1996:179)

a.	ngalibá	'female circumciser'	*σσ**σ́***
	ma-ngalíba	'female circumcisers'	*σσ**σ́**σ*
b.	ngalawá	'canoe'	*σσ**σ́***
	ka-ngalawá	'little canoe'	*σσ**σ́**σ*
c.	mbutuká	'gazelle'	*σσ**σ́***
	ma-putuká	'gazelles'	*σσ**σ́**σ*

The effects of this process mirror the more general fact that almost all tetrasyllabic noun stems in Kimatuumbi carry high tone on the penultimate mora (e.g. *changaláwe* 'gravel', Odden 1996:179), whereas shorter stems (1-3 syllables) can carry high tone on either the penult (e.g. *ndogólo*, Odden 1996:78) or the final (e.g. *ngalawá* 'canoe', Odden 1996:179). A related pattern is also found in Içuã Tupi (Abrahamson 1968:17-18), where accent occurs predominantly on the penult in words of up to four syllables (e.g. [í.tĩŋ] 'it is white', [pa.ti.uá.pɛ] 'bark pan'), but on the antepenult in words of five syllables or more ([a.bi.dá.bi.dab^{m}]). Note however that the Içuã Tupi pattern is subject to some variation: Abrahamson (1968:17-18) notes that words of up to four syllables can have antepenultimate stress ([ta.tá.pũ.ĩ] ‘ashes’), and six-syllable words can have third-syllable stress ([a.hɛ.á.bɛ.bui] ‘his lung’).

Shrinking window systems can be modeled as resulting from an interaction between contextual anti-lapse constraints (like *LapseR) and general anti-lapse constraints (like *Lapse). In both Kimatuumbi and NKK, in words of all lengths, the position of accent is restricted by a right-edge disyllabic window. As before, we will model this window with the constraint *LapseR; candidates where stress does not fall on one of the final two syllables receive a fatal violation (as in 41a). Within the window, accent is free to fall on either the penult, as in 41b, or the final, as in 41c; I assume that this freedom is due to a variable ranking between AlignR and NonFinality.

(41) Freedom of accent in shorter (1-3 syllable) words

		/σσσ/	*LapseR	AlignR	NonFinality
	a.	$\boldsymbol{\acute{\sigma}}^{R}\{\sigma\sigma\}^{R}$	*!	**	
☞	b.	$\sigma^{R}\{\boldsymbol{\acute{\sigma}}\sigma\}^{R}$		*	
☞	c.	$\sigma^{R}\{\sigma\boldsymbol{\acute{\sigma}}\}^{R}$			*

In longer (4+ syllable) words, the desire to keep accent at the left edge of the stressable window (i.e. on the penult) can be attributed to *ExtLapse, a context-free anti-lapse constraint. As demonstrated by the losing candidate 42d, stressing the final syllable of a four-syllable word results in a sequence of three stressless syllables, and a fatal violation of *ExtLapse. Candidate 42c, with penultimate stress, is selected as the winner, as it is the only other candidate that satisfies *LapseR.

(42) Restriction of accent in longer (4+ syllable) words

		/σσσσ/	*LapseR	*ExtLapse	AlignR	NonFinality
	a.	$\boldsymbol{\acute{\sigma}}\sigma^{R}\{\sigma\sigma\}^{R}$	*!		***	
	b.	$\sigma\boldsymbol{\acute{\sigma}}^{R}\{\sigma\sigma\}^{R}$	*!		**	
☞	c.	$\sigma\sigma^{R}\{\boldsymbol{\acute{\sigma}}\sigma\}^{R}$			*	
	d.	$\sigma\sigma^{R}\{\sigma\boldsymbol{\acute{\sigma}}\}^{R}$		*!		*

For the Içuã Tupi pattern described above, the analysis is similar: retraction of stress to the antepenult in 5+ syllable words (as in [a.bi.dá.bi.dab^{m}]) can be analyzed as a general tendency to avoid *ExtLapse violations, subject to the constraints of a right-edge trisyllabic window.

The three systems just discussed are the only examples of shrinking window systems that I am aware of. Although these systems are only marginally attested, their expected rate of attestation is quite high: at least 20% of the rankings of Kager's (2012) anti-lapse constraint set, assuming a single stress per word, generate shrinking window systems.[15] Assuming that 75.57% of all systems have only one stress per word, as is the case in Gordon's (2002) survey, the joint probability is that shrinking window systems should make up at least 15.11% of all languages, or at least 77 of the 510 languages in StressTyp (Goedemans & van der Hulst 2009). The fact that they are severely underattested relative to what we might expect is consistent with the discussion in section 5.1: shrinking window systems, like midpoint systems, are difficult to learn because they pose a credit problem. The fact that shrinking window systems are attested, and midpoint systems are not, just reflects the fact that shrinking window systems are expected to be more frequent in the first place.[16]

I turn now to a stark asymmetry in the typology of binary stress systems. In the majority of iterative binary stress systems (143/158 in StressTyp, see Staubs 2014b:429), the placement of primary stress is correlated with the direction of iterative stress (see also Gordon 2002:31). Systems where the primary stress is rightmost generally exhibit right-to-left iteration; systems where primary stress is leftmost generally exhibit left-to-right iteration. The result is a system in which the location of primary stress is consistent across words of all lengths, as in the Maranungku examples below.[17]

(43) Iterative binary stress in Maranungku (Tryon 1970:10 for a-b; 9 for c-d)

a.	tíralk	'saliva'	***σ́****σ*
b.	mǽrapæ̀t	'beard'	***σ́****σ****σ̀***
c.	jáŋarmàta	'the Pleiades'	***σ́****σ****σ̀****σ*
d.	ŋáltirìtirì	'tongue'	***σ́****σ****σ̀****σ****σ̀***

In a smaller number of languages (15/158 in StressTyp, Staubs 2014b:429), the placement of primary stress opposes the direction of iterative parsing: these are systems with right-to-left parsing where the primary stress is leftmost, or left-to-right parsing where the primary stress is rightmost. The result is a COUNT SYSTEM (see also van der Hulst 1996, McGarrity 2003), where the position of primary stress varies as a function of word parity. Data from Nyawagi (Dixon 1983) illustrate this in 44.

(44) Iterative binary stress in Nyawagi (Dixon 1983:443)

a. ɟíŋa ‘man’ ***σ́****σ*

b. bulbíri ‘quail’ *σ****σ́****σ*

c. bíyaɟàla ‘water snake’ ***σ́****σ****σ̀****σ*

Staubs (2014b) shows that a MAXENT learner faces a greater difficulty in acquiring systems like 44, where the position of main stress varies according to word parity, than it does in acquiring systems like 43, where the position of main stress is fixed with respect to some edge. This clear asymmetry in the typology of binary stress systems further illustrates the dispreference for systems in which the placement of main stress varies as a function of syllable count.[18]

As with the comparison between the shrinking window and the midpoint systems: perhaps the reason why count systems are attested (and midpoint systems are not) is because, abstracting away from considerations of learnability, count systems are expected to be far more frequent in the first place. Assuming that the relative placement of primary stress is a parametric choice (leftmost or rightmost: Prince 1983:25, Gordon 2002:20), and that both directionalities of parsing are equally probable, we would expect that in fully half of all binary systems, the placement of main stress should oppose the direction of parsing. In Gordon (2002), 64/262 (24.43%) of the languages surveyed have binary stress (counts were obtained from the online appendix to Gordon 2002). Assuming that this is representative, we would expect 12.21% of all systems to exhibit the kind of binary alternation displayed in 44. We can now compare this expected rate of attestation to that of the midpoint systems, which are expect to make up only 3.46% of all systems (see section 2.2). Given this large difference in expected frequency, it is unsurprising that we also find a difference in attested frequency.

6. DISCUSSION AND CONCLUSIONS. At this point, we can enumerate the factors that potentially contribute to the absence of midpoint systems from the attested typology. First, as discussed in section 2.2, their expected rate of attestation is fairly low: we expect midpoint systems to comprise roughly 2.46% of the total typology. Second, we have seen that a learner attempting to acquire a midpoint system is faced with several difficulties. The credit problem incurred by all midpoint systems, together with the long-word problem incurred by a subset of them, causes midpoint systems as a class to be difficult for a learner to acquire. It is important to note that no one of these factors is independently responsible for the absence of midpoint systems from the attested typology: no one of them is alone sufficient to explain the absence of the entire class. Rather, the hypothesis is that it is ALL of these separate factors, working independently, that drive the attested frequency of midpoint systems down to zero.

This multi-part story, then, is the alternative to Kager's (2012) proposal that midpoint systems should be eliminated from the learner's hypothesis space. And if this learnability-based alternative is successful, there are important theoretical consequences. Recall that Kager's proposed modifications to CON involve the elimination of contextual anti-lapse constraints. As purely grid-based (foot-free) theories of stress depend on contextual anti-lapse constraints to model the typology of stress windows, the elimination of these constraints poses a serious problem for foot-free theories of stress. If, however, it is possible to show that the absence of midpoint systems can be explained in another way, then there is no need to exclude contextual anti-lapse constraints from CON. This means that the midpoint pathology no longer poses a problem for foot-free theories of stress, nor does it serve as an argument for the necessity of weakly layered feet in metrical theory. Whether or not other phenomena taken to be arguments for weakly layered feet (e.g. segmental processes that appear to refer to foot structure, see Martínez-Paricio & Kager 2015) present a fatal blow to foot-free theories of stress is a matter I leave for further investigation.

It is important to keep in mind, however, that what has been shown in this exploration is only a small part of what must be shown for this learnability-based alternative to be truly viable. What the above discussion has established is that midpoint systems are difficult to learn for a specific type of machine learner. Our interest, however, is ultimately in the behavior of human learners: would they find midpoint systems difficult to learn, just like the machine learner does? In order for this alternative to be a valid one, it would be necessary to show that human learners behave like the machine learner, in that midpoint systems are difficult to acquire. While the behavior of human learners could potentially be assessed through artificial grammar learning experiments (see e.g. Carpenter 2010, Greenwood 2014 for experiments involving stress systems), for the time being I leave these questions open. This article has shown that the learnability problem posed by midpoint systems is a possible explanation for their absence from the attested typology. Further work is necessary to determine whether or not this explanation is the correct one.

APPENDIX: PRESENTATION AND DISCUSSION OF THE WORD COUNT DATA. Although it has been shown for a number of lexica that short words outnumber long words, there has been less work investigating the distributional properties of natural language corpora; that is, an approximation of what a learner would encounter (references in 4.1). In order to make a meaningful cross-linguistic comparison, it is necessary to find a standardized text corpus that is readily available for a number of languages. To satisfy this criterion, the Bible was chosen, as it is a single text that has been translated into hundreds of languages. Counts were obtained from the book of Mark; in the rare case that Mark was unavailable, other books were substituted. Analysis was automated with a script that counted the number of words per number of orthographic vowels in a given corpus. Scripts and all other word-counting resources are available from the author upon request.

The Bible has the advantage of being a text that is freely available in hundreds of languages, but using it introduces several methodological issues. First, it is unclear exactly how closely the word length distribution of the Bible mirrors the word length distribution of everyday speech. To explore this, I compared the word length distribution of the King James Bible (790,028 words, representing Biblical language) to a selection of interviews with various former members of the Beatles, from the Beatles Interview Database (90,713 words, representing everyday conversational speech).[19] As shown in Figure 6, despite the difference in both corpus size and corpus type, their word length distributions are nearly identical.

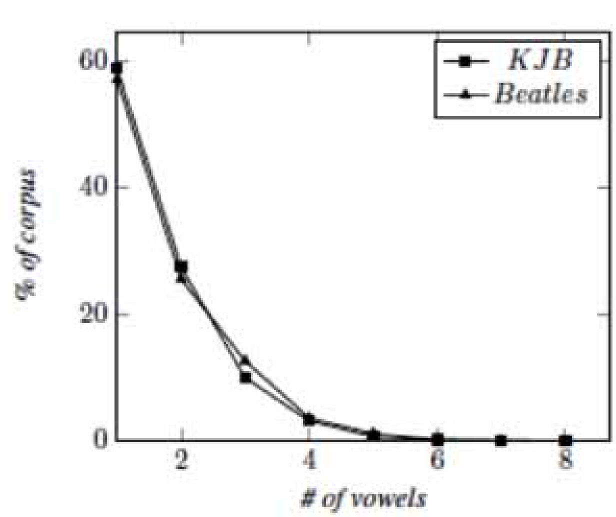


FIGURE 6. The Beatles Interviews Database (Beatles) vs. the King James Bible (KJB).

At least in English, then, the word length distributions in a somewhat archaic Bible translation and more contemporary everyday speech do not appear to differ too greatly. I have not yet investigated to what extent this result holds across other corpora, or in other languages.

Another methodological issue surrounds the question of what counts as a vowel. In many languages, phoneme-to-orthography conversion is not one-to-one, and some graphemes can function as either a vowel or a consonant. English <y>, for example, is pronounced as the diphthong [aɪ] in the word *by*, but as the glide [j] in the word *you*. To avoid under-counting, English <y>, and phonemic chameleons in other languages, were always counted as vowels. More generally, if a given grapheme could function as a vowel in any context, it was counted as a vowel in all contexts; no attempt was made to account for language-specific, context-sensitive processes like glide formation. The set of vowels counted for a given language was generally determined by consulting online resources, like Wikitravel's phrasebooks (http://wikitravel.org/en/List_of_phrasebooks). When this information was unavailable, the most likely set of vowels was determined by examining the distributional properties of suspect graphemes.

As each orthographic vowel was counted individually, this means that sequences of orthographic vowels were treated as sequences of monophthongs, rather than diphthongs (or triphthongs, etc.). It should be noted that counting each individual vowel, rather than each syllable, can sometimes lead to artificial inflation of the counts in languages where the phoneme-to-orthography conversion is not one-to-one. In English, for example, the word *beat* has two vowel symbols, though it has only one syllable (/bit/); Romanian *pierd-ea-i* ('you used to lose') has five vowel symbols, but only two syllables (/pi̯erde̯ai̯/; Donca Steriade, p.c.). No attempt was made to determine which vowel sequences constitute a syllable in a given language, or more generally, to control for differing orthographic conventions.

One final question regards the notion of wordhood. Languages often differ in which combinations of morphemes can be represented together as a single word. Even within a language, orthographic conventions can be inconsistent. Consider, for example, the pronominal clitics of French. In the imperative *Mange-les* ('eat them'), *les* is appended to the verb. In the indicative *Il les mange* ('he is eating them'), however, the clitic is written as a separate word. This orthographic difference does not correspond to a difference in phonology; in neither case is the clitic prosodically independent. Although differing conventions regarding orthographic wordhood introduce a confound, I did not attempt to address it. Here, a space constitutes a word boundary.

At the time of writing, the sample consisted of data from 102 languages, selected on the basis of the availability of online resources. The surveyed languages hail from 26 major language families: Afro-Asiatic (3), Algic (1), Austro-Asiatic (1), Austronesian (10), Eskimo-Aleut (2), Creole (English-based: 3; French-based: 1), Gunwingguan (3), Daly (1), Indo-European (33), Iroquoian (1), Japonic (1), Jivaroan (1), Koreanic (1), Mayan (6), Niger-Congo (8), Nilo-Saharan (2), Pama-Nyungan (10), Quechuan (1), Sepik (1), Sino-Tibetan (2), Trans-New Guinea (2), Turkin (2), Uto-Aztecan (2), Uralic (3), and one isolate (Basque). The number of words counted ranged from 6,415 (Inuktitut; Eskimo-Aleut) to 38,266 (Anindilyakwa; Pama-Nyungan), with an average of 14,402. The investigation yielded two main results. First, the distribution of word lengths is extremely variable across languages. Despite this variability, however, in the large majority of languages, long words are extremely rare.

The overall results are summarized graphically in Figure 1, in the main body of the text. In Table 9, I have included a breakdown of the word length distributions for each of the languages in the survey, together with language family information (from Ethnologue, Lewis et al. 2015) and the online data source. An editable Excel spreadsheet containing this information, as well as some additional material (raw numbers, information on which graphemes were counted as vowels, etc.) is available from the author upon request. The key for the sources is in Table 8.

Key	**Source Name**	**Website**
AB	eBaibul	http://aboriginalbibles.org.au
AKT	Alkitab TOBA	http://alkitabtoba.wordpress.com
B	YouVersion	http://bible.com
BB	Baibala Hemolele	http://baibala.org
BG	BibleGateway	http://www.biblegateway.com
BIT	SABDA-Web	http://bit.net.id/SABDA-Web
BL	Biblica	http://www.biblica.com
G	Project Gutenberg	http://www.gutenberg.org
JA	Jesus Army	http://www.jesus-army.com
PB	Da Hawai’i Pidgin Bible	http://www.pidginbible.org
U	The Unbound Bible	http://unbound.biola.edu
WB	WorldBibles.org	http://worldbibles.org
WP	WordProject	http://wordproject.org/bibles

TABLE 8. Sources for the word count study.

Language	Family	Book(s) counted	Source	1	2	3	4	5	6	7	8	9	10+	Total
Abau	Sepik	Mark	B	37%	34%	18%	7%	2%	1%	0%	0%	0%	0%	18,678
Afrikaans	Indo-European	Mark	JA	47%	38%	10%	4%	2%	0%	0%	0%	0%	0%	15,680
Aguaruna	Jivaroan	Mark	B	3%	30%	28%	21%	11%	5%	2%	1%	0%	0%	11,309
Albanian	Indo-European	Mark	JA	49%	35%	12%	4%	0%	0%	0%	0%	0%	0%	14,337
Alyawarr	Pama-Nyungan	Mark	AB	11%	34%	28%	15%	8%	3%	1%	0%	0%	0%	12,405
Ama	Nilo-Saharan	Mark	B	25%	20%	29%	13%	6%	3%	2%	1%	0%	0%	18,805
Anindilyakwa	Gunwingguan	Luke	AB	1%	14%	26%	19%	14%	10%	8%	4%	3%	2%	38,266
Arabic (Chadic, Romanized)	Afro-Asiatic	Mark	AB	29%	28%	25%	11%	5%	2%	0%	0%	0%	0%	13,792
Armenian (Western)	Indo-European	Mark	U	34%	37%	17%	8%	3%	1%	0%	0%	0%	0%	10,602
Arrarnta (Western)	Pama-Nyungan	Mark	AB	1%	36%	28%	22%	8%	4%	1%	0%	0%	0%	13,100
Aukan	Creole (English)	Mark	B	54%	30%	13%	3%	0%	0%	0%	0%	0%	0%	25,241
Azerbaijani (North)	Turkic	Mark	JA	16%	36%	25%	14%	6%	2%	1%	0%	0%	0%	10,069
Bengali	Indo-European	Mark	B	6%	44%	30%	15%	4%	1%	0%	0%	0%	0%	13,206
Bargam	Trans-New Guinea	Mark	B	36%	41%	17%	5%	15%	0%	0%	0%	0%	0%	20,417
Batak Toba	Austronesian	Mark	AKT	35%	34%	20%	8%	3%	1%	0%	0%	0%	0%	14,382
Breton	Indo-European	Mark	WB	53%	26%	14%	5%	2%	1%	0%	0%	0%	0%	15,047
Bulgarian	Indo-European	Mark	BG	39%	28%	22%	8%	3%	0%	0%	0%	0%	0%	12,455
Burrara	Gunwingguan	Mark	AB	3%	45%	24%	15%	10%	2%	0%	0%	0%	0%	17,756
Cebuano	Austronesian	Mark	BG	37%	34%	19%	9%	1%	0%	0%	0%	0%	0%	16,386
Chamorro	Austronesian	Mark	BG	22%	34%	21%	15%	6%	2%	1%	0%	0%	0%	12,767
Cherokee	Iroquoian	Mark	BG	1%	22%	21%	19%	14%	11%	6%	3%	2%	1%	8,974
Chinese (Mandarin)	Sino-Tibetan	Mark	WP	42%	43%	11%	3%	0%	0%	0%	0%	0%	0%	13,267
Croatian	Indo-European	Mark	JA	40%	30%	19%	8%	2%	0%	0%	0%	0%	0%	11,080
Czech	Indo-European	Mark	JA	42%	34%	16%	6%	2%	0%	0%	0%	0%	0%	10,997
Danish	Indo-European	Mark	BG	61%	27%	9%	3%	1%	0%	0%	0%	0%	0%	15,333
Dholuo	Nilo-Saharan	Mark	BL	30%	38%	24%	7%	1%	0%	0%	0%	0%	0%	13,078
Djambarrpuygnu	Pama-Nyungan	Mark	G	18%	44%	19%	10%	5%	3%	1%	0%	0%	0%	12,250
Dutch	Indo-European	Mark	JA	47%	36%	11%	4%	1%	0%	0%	0%	0%	0%	15,174
English	Indo-European	Mark	BL	57%	28%	11%	3%	1%	0%	0%	0%	0%	0%	14,337
Estonian	Uralic	Mark	JA	25%	43%	21%	8%	2%	1%	0%	0%	0%	0%	11,838
Éwé	Niger-Congo	Mark	BL	44%	34%	14%	5%	1%	0%	0%	0%	0%	0%	17,836
Faiwol	Trans-New Guinea	Mark	B	29%	47%	17%	5%	1%	0%	0%	0%	0%	0%	19,572
Finnish	Uralic	Mark	WB	19%	26%	28%	15%	7%	3%	1%	0%	0%	0%	11,063
French	Indo-European	Mark	JA	42%	31%	16%	8%	3%	0%	0%	0%	0%	0%	13,873
Ganda	Niger-Congo	Mark	WP	23%	22%	21%	17%	10%	5%	2%	0%	0%	0%	9,463
German	Indo-European	Mark	BG	43%	37%	15%	4%	1%	0%	0%	0%	0%	0%	14,138
Gumatj	Pama-Nyungan	Mark	AB	8%	33%	25%	17%	9%	5%	2%	1%	0%	0%	22,906

Haitian	Creole (French)	Mark	BG	58%	36%	5%	1%	0%	0%	0%	0%	0%	0%	17,011
Hawaiian	Austronesian	Mark	BB	38%	37%	16%	6%	2%	1%	0%	0%	0%	0%	20,373
Hawai'i Pidgin	Creole (English)	Mark	PB	55%	35%	9%	1%	0%	0%	0%	0%	0%	0%	19,364
Hiligaynon	Austronesian	Mark	BG	41%	34%	13%	9%	2%	1%	0%	0%	0%	0%	16,981
Hindi (Romanized)	Indo-European	Mark	WP	41%	33%	19%	5%	1%	0%	0%	0%	0%	0%	15,094
Hmar	Sino-Tibetan	Mark	JA	65%	22%	9%	2%	1%	0%	0%	0%	0%	0%	15,925
Hungarian	Uralic	Mark	WB	30%	29%	18%	12%	6%	3%	1%	1%	0%	0%	11,466
Icelandic	Indo-European	Mark	BG	49%	39%	9%	3%	1%	0%	0%	0%	0%	0%	12,439
Indonesian	Austronesian	Mark	BIT	10%	47%	29%	10%	2%	1%	0%	0%	0%	0%	13,718
Inuktitut	Eskimo-Aleut	Mark	B	1%	5%	14%	21%	21%	15%	9%	6%	3%	3%	6,415
Inupiatun (NW Alaska)	Eskimo-Aleut	Mark	B	2%	11%	17%	18%	17%	14%	10%	5%	3%	3%	7,588
Irish	Indo-European	Mark	WB	49%	26%	16%	6%	2%	1%	0%	0%	0%	0%	14,999
Italian	Indo-European	Mark	WB	35%	29%	22%	10%	3%	1%	0%	0%	0%	0%	12,227
Jakalteko	Mayan	Mark	BG	27%	43%	18%	8%	2%	1%	0%	0%	0%	0%	17,911
Japanese	Japonic	Mark	WP	48%	30%	16%	5%	1%	0%	0%	0%	0%	0%	19,239
Kabyle	Afro-Asiatic	Mark	U	28%	42%	21%	7%	2%	0%	0%	0%	0%	0%	10,464
Kaqchikel	Mayan	Mark	BG	48%	26%	16%	7%	2%	0%	0%	0%	0%	0%	25,548
K'iche'	Mayan	Mark	BG	56%	26%	12%	5%	1%	0%	0%	0%	0%	0%	21,155
Korean	Koreanic	Mark	WP	9%	30%	33%	20%	6%	2%	0%	0%	0%	0%	8,700
Kriol	Creole (English)	Mark	AB	37%	44%	15%	4%	1%	0%	0%	0%	0%	0%	20,490
Kuku-Yalanji	Pama-Nyungan	Mark	AB	2%	46%	27%	16%	6%	2%	0%	0%	0%	0%	11,998
Latvian	Indo-European	Mark	JA	36%	31%	19%	9%	3%	1%	0%	0%	0%	0%	11,283
Lithuanian	Indo-European	Mark	JA	27%	27%	24%	13%	6%	2%	1%	0%	0%	0%	9,786
Macedonian	Indo-European	Mark	BG	40%	28%	20%	8%	3%	0%	0%	0%	0%	0%	13,258
Malagasy	Austronesian	Mark	JA	18%	32%	28%	12%	7%	2%	1%	0%	0%	0%	13,392
Mam (Central)	Mayan	Mark	BG	54%	31%	11%	3%	0%	0%	0%	0%	0%	0%	16,539
Manx	Indo-European	Mark	U	53%	21%	16%	6%	3%	0%	0%	0%	0%	0%	15,744
Maori	Austronesian	Mark	BG	44%	30%	18%	5%	2%	1%	0%	0%	0%	0%	18,861
Murrinh-Patha	Daly	Various[a]	AB	20%	46%	19%	7%	4%	2%	1%	1%	0%	0%	12,063
Nahuatl	Uto-Aztecan	Mark	BG	18%	29%	21%	11%	9%	6%	3%	1%	1%	0%	13,568
Ndebele	Niger-Congo	Mark	BL	1%	24%	32%	24%	12%	7%	4%	1%	0%	0%	8,466
Ngaanyatjarra	Pama-Nyungan	Mark	AB	0%	21%	29%	24%	12%	7%	4%	1%	0%	0%	10,987
Norwegian	Indo-European	Mark	BG	61%	28%	7%	3%	1%	0%	0%	0%	0%	0%	14,786
Nunggubuyu	Gunwingguan	Mark	AB	1%	17%	17%	21%	21%	11%	6%	3%	1%	0%	12,801
Pipil	Uto-Aztecan	Mark	BG	37%	29%	18%	10%	5%	2%	0%	0%	0%	0%	11,475
Polish	Indo-European	Mark	JA	36%	32%	19%	8%	3%	1%	0%	0%	0%	0%	11,268
Portuguese	Indo-European	Mark	JA	33%	35%	18%	10%	3%	1%	0%	0%	0%	0%	12,494
Potawatomi	Algic	Mark	U	17%	31%	18%	15%	11%	5%	2%	1%	0%	0%	15,233
Q'eqchi'	Mayan	Mark	BG	45%	27%	16%	9%	3%	1%	0%	0%	0%	0%	18,264

Quechua	Quechuan	Mark	BG	2%	22%	27%	22%	16%	7%	2%	1%	0%	0%	10,163
Romani	Indo-European	Mark	JA	33%	45%	17%	5%	0%	0%	0%	0%	0%	0%	13,735
Romanian	Indo-European	Mark	JA	42%	30%	17%	8%	3%	1%	0%	0%	0%	0%	13,980
Russian	Indo-European	Mark	BG	34%	34%	19%	9%	2%	1%	0%	0%	0%	0%	11,292
Scottish Gaelic	Indo-European	Mark	U	49%	26%	16%	6%	2%	1%	0%	0%	0%	0%	15,024
Serbian	Indo-European	Mark	JA	43%	31%	17%	7%	1%	0%	0%	0%	0%	0%	11,119
Slovak	Indo-European	Mark	JA	37%	33%	18%	9%	2%	0%	0%	0%	0%	0%	11,818
Somali	Afro-Asiatic	Mark	WP	16%	35%	25%	14%	8%	2%	0%	0%	0%	0%	12,839
Spanish	Indo-European	Mark	WB	40%	28%	20%	10%	2%	0%	0%	0%	0%	0%	13,009
Swahili	Niger-Congo	Mark	WB	15%	37%	21%	13%	9%	4%	1%	0%	0%	0%	10,528
Swedish	Indo-European	Mark	WB	46%	34%	13%	5%	2%	1%	0%	0%	0%	0%	14,735
Tagalog	Austronesian	Mark	WB	46%	34%	13%	5%	2%	1%	0%	0%	0%	0%	14,833
Turkish	Turkic	Mark	JA	13%	37%	28%	14%	5%	2%	0%	0%	0%	0%	9,325
Twi	Niger-Congo	Mark	BG	48%	28%	16%	7%	1%	0%	0%	0%	0%	0%	14,622
Ukrainian	Indo-European	Mark	BG	31%	33%	23%	9%	3%	1%	0%	0%	0%	0%	11,925
Uma	Austronesian	Mark	U	16%	39%	27%	12%	5%	1%	0%	0%	0%	0%	14,301
Uspanteko	Mayan	Mark	BG	41%	40%	15%	3%	0%	0%	0%	0%	0%	0%	17,743
Vietnamese	Austro-Asiatic	Mark	JA	59%	34%	7%	0%	0%	0%	0%	0%	0%	0%	15,613
Walmajarri	Pama-Nyungan	Various[b]	AB	3%	27%	24%	14%	6%	2%	1%	1%	0%	0%	10,939
Warlpiri	Pama-Nyungan	Mark	AB	0%	19%	23%	22%	17%	9%	5%	2%	0%	0%	16,151
Wik-Mungkan	Pama-Nyungan	Mark	AB	39%	28%	18%	10%	4%	1%	0%	0%	0%	0%	20,784
Wolof	Niger-Congo	Mark	WB	56%	25%	15%	3%	1%	0%	0%	0%	0%	0%	13,418
Xhosa	Niger-Congo	Mark	JA	7%	22%	31%	21%	11%	5%	2%	1%	0%	0%	9,078
Zulu	Niger-Congo	Mark	WP	2%	27%	29%	22%	12%	5%	1%	0%	0%	0%	7,685

TABLE 9. Word length distributions by language.

[a] Genesis 1-9,11 + Jonah 1-4 + 1 Thessalonians 1-5 + 2 Thessalonians 1-3 (gospels not available).
[b] Mark 1,2,4,5-9,11,14-16 + John 8,11,20,21 + Matthew 1,2,6,11,27. These do not all appear to be full chapters.

REFERENCES

2015. Alkitab TOBA. Online: http://alkitabtoba.wordpress.com.

2015. Baibala Hemolele: The Hawaiian Bible. Ululkau: Hawaiian Electronic Library. Online: http://baibala.org.

2015. The Beatles Interview Database. Online: http://beatlesinterviews.org.

2015. BibleGateway. Online: http://biblegateway.com.

2015. Biblica: Transforming lives through God’s Word. Online: http://www.biblica.com.

2015. Da Hawai’i Pidgin Bible. Online: http://www.pidginbible.org.

2015. eBaibul: Bible text in Australian Aboriginal languages. Online: http://aboriginalbibles.org.au.

2015. Jesus Army. Online: http://jesus-army.com.

2015. List of phrasebooks. Online: http://wikitravel.org/en/List_of_phrasebooks.

2015. Project Gutenberg. Online: http://www.gutenberg.org.

2015. SABDA-Web. Online: http://www.bit.net.id/SABDA-Web/.

2015. The Unbound Bible. Online: http://unbound.biola.edu.

2015. WordProject. Online: http://www.wordproject.org/bibles.

2015. WordBibles.org: Helping you to find God’s Word in over 4,000 languages. Online: http://wordbibles.org.

ABRAHAMSON, ARNE. 1968. Contrastive distribution of phoneme classes in Içuã Tupi. *Anthropological Linguistics* 10.11–21.

ALBER, BIRGIT. 2005. Clash, lapse and directionality. *Natural Language and Linguistic Theory* 23.485–542.

ALBRIGHT, ADAM, and YOUNG AH DO. 2013. Biased learning of phonological alternations. Paper presented at the 21st Manchester Phonology Meeting.

ALDERETE, JOHN. 2008. Using learnability as a filter on factorial typology: A new approach to Anderson and Browne’s generalization. *Lingua* 118.1177–1220.

ANONYMOUS. 1980. SU980A1980-01.pdf. *Assorted Alutiiq Stories.* Online: http://www.uafanlc.arsc.edu/data/Online/SU980A1980/SU980A1980-01.pdf.

ANTTILA, ARTO. 1997. Deriving variation from grammar. *Variation, Change, and Phonological Theory*, ed. by Frans Hinskens, Roeland van Hout and Leo Wetzels, 35–68. Amsterdam: Academic Press.

BAILEY, TODD MARK. 1995. *Nonmetrical constraints on stress*. Minneapolis, MN: University of Minnesota dissertation.

BANE, MAX, and JASON RIGGLE. 2008. Three Correlates of the Typological Frequency of Quantity-Insensitive Stress Systems. *Proceedings of the Tenth Workshop of the Association for Computational Linguistics' Special Interest Group in Morphology and Phonology*, 29–38. Red Hook, NY: Curran Associates, Inc.

BLEVINS, JULIETTE. 2004. *Evolutionary phonology: The emergence of sound patterns*. Cambridge: Cambridge University Press.

BOERSMA, PAUL. 1997. *Functional phonology: formalizing the interactions between articulatory and perceptual drives*. Amsterdam: University of Amsterdam dissertation.

BOERSMA, PAUL. 2003. Bruce Tesar and Paul Smolensky (2000). Learnability in Optimality Theory. Cambridge, Mass.: MIT Press. Pp. vii + 140. *Phonology* 20.436–446.

BOERSMA, PAUL, and BRUCE HAYES. 2001. Empirical Tests of the Gradual Learning Algorithm. *Linguistic Inquiry* 32.45–86.

BOERSMA, PAUL, and CLARA C. LEVELT. 2000. Gradual constraint-ranking learning algorithm predicts acquisition order. *The Proceedings of the 30th Annual Child Language Research Forum*, ed. by Eve V. Clark, 229–237. Cambridge: Cambridge University Press.

BOERSMA, PAUL, and JOE PATER. 2016. Convergence properties of a gradual learning algorithm for Harmonic Grammar. *Harmonic Grammar and Harmonic Serialism*, ed. by John McCarthy and Joe Pater, to appear. London: Equinox Press.

BRASOVEANU, ADRIAN, and ALAN PRINCE. 2011. Ranking and necessity: the Fusional Reduction Algorithm. *Natural Language and Linguistic Theory* 29.3–70.

CABALLERO, GABRIELA. 2011. Morphologically conditioned stress assignment in Choguita Rarámuri. *Linguistics* 49.749–790.

CARPENTER, ANGELA C. 2010. A naturalness bias in learning stress. *Phonology* 27.345–392.

COHN, ABIGAIL C. 1989. Stress in Indonesian and bracketing paradoxes. *Natural Language and Linguistic Theory* 7.167–216.

CROWHURST, MEGAN, and LEV D. MICHAEL. 2005. Iterative Footing and Prominence-Driven Stress in Nanti (Kampa). *Language* 81.47–95.

CUTLER, ANNE, and SALLY BUTTERFIELD. 1992. Rhythmic cues to speech segmentation: Evidence from juncture misperception. *Journal of Memory and Language* 31.218–236.

DAVIES, H. JOHN. 1980. *Kobon phonology*. Canberra: Australian National University.

DIXON, R. M. W. 1983. Nyawaygi. *Handbook of Australian Languages, Volume 3*, ed. by R. M. W. Dixon and Barry J. Blake, 431-525. Amsterdam: John Benjamins B.V.

DO, YOUNG AH. 2013. *Biased learning of phonological alternations*. Cambridge, MA: MIT dissertation.

DRESHER, ELAN, and ADITI LAHIRI. 1991. The Germanic foot: metrical coherence in Old English. *Linguistic Inquiry* 22.251–286.

EISNER, JASON. 1997. What constraints should OT allow? Paper presented at the 71st Annual Meeting of the Linguistic Society of America, Chicago. Online: http://roa.rutgers.edu/files/204-0797/roa-204-eisner-2.pdf.

ELENBAAS, NINE, and RENÉ KAGER. 1999. Ternary rhythm and the lapse constraint. *Phonology* 16.273–329.

FURBY, CHRISTINE. 1974. *Garawa phonology*. Canberra: Australian National University.

GOEDEMANS, ROB and HARRY VAN DER HULST. 2009. StressTyp: a database for word accentual patterns in the world's languages. *The use of databases in cross-linguistics research*, ed. by M. Everaert, S. Musgrave, and A. Dimitriadis, 235–282. Berlin/New York: Mouton de Gruyter.

GOLDWATER, SHARON, and MARK JOHNSON. 2003. Learning OT constraint rankings using a maximum entropy model. *Proceedings of the Workshop on Variation within Optimality Theory*, ed. by J. Spenader, A. Eriksson, and Ö. Dahl, 111–120. Stockholm: Stockholm University.

GORDON, MATTHEW. 2002. A factorial typology of quantity insensitive stress. *Natural Language and Linguistic Theory* 20.491–552.

GREEN, THOMAS, and MICHAEL KENSTOWICZ. The Lapse Constraint. Cambridge, MA: MIT MS. Online: https://rucore.libraries.rutgers.edu/rutgers-lib/46045/.

GREENWOOD, ANNA. 2014. Unpacking the effects of naturalness and simplicity biases in stress pattern learning. Paper presented at the 45th meeting of the North East Linguistics Society, Cambridge, MA.

HARMS, ROBERT. 1966. Stress, voice, and length in Southern Paiute. *International Journal of American Linguistics* 32.228–235.

HATZIGEORGIU, NICK; GEORGE MIKROS; and GEORGE CARAYANNIS. 2001. Word length, word frequencies and Zipf's law in the Greek language. *Journal of Quantitative Linguistics* 8.175–185.

HAYES, BRUCE. 2004. Phonological acquisition in Optimality Theory: The early stages. *Fixing priorities: Constraints in phonological acquisition*, ed. by René Kager, Joe Pater, and Wim Zonneveld, 158–203. Cambridge: Cambridge University Press.

HAYES, BRUCE; BRUCE TESAR; and KIE ZURAW. 2013. OTSoft 2.3.2, software package. Online: http://www.linguistics.ucla.edu/people/hayes/otsoft.

HEINZ, JEFFREY. 2009. On the role of locality in learning stress patterns. *Phonology* 26.303–351.

HEINZ, JEFFREY. 2010. Learning Long-Distance Phonotactics. *Linguistic Inquiry* 41.623–661.

HEWITT, MARK S. 1992. *Vertical maximization and metrical theory*. Waltham, MA: Brandeis University dissertation.

HINTZ, DIANE. 2006. Stress in South Conchucos Quechua: A phonetic and phonological study. *International Journal of American Linguistics* 72.477–521.

HUALDE, JOSÉ IGNACIO. 1991. *Basque phonology*. New York: Routledge.

VAN DER HULST, HARRY. 1996. Separating primary and secondary accent. *Stress Patterns of the World*, ed. by Rob Goedemans, Harry van der Hulst, and Ellish Visch, 1–25. The Hague: Holland Academic Graphics.

HYDE, BRETT. 2008. Alignment continued: distance-sensitivity, order-sensitivity, and the midpoint pathology. St. Louis, MO: Washington University MS. Online: http://roa.rutgers.edu/files/998-1108/998-HYDE-0-0.PDF.

HYDE, BRETT. 2015. The Midpoint Pathology: What is is and what it isn't. St. Louis, MO: Washington University MS. Online: http://roa.rutgers.edu/article/view/1401.

ITÔ, JUNKO, and ARMIN MESTER. 2003. Weak layering and word binarity. *A New Century of Phonology and Phonological Theory. A Festschrift for Professor Shosuke Haraguchi on the*

Occasion of his Sixtieth Birthday, ed. by Takeru Honma, Masao Okazaki, Toshiyuki Tabata, and Shin-ichi Tanaka, 26–65. Tokyo: Kaitakusha.

JÄGER, GERHARD. 2007. Maximum Entropy Models and Stochastic Optimality Theory. *Architectures, Rules, and Preferences: A Festschrift for Joan Bresnan*, ed. by Jane Grimshaw, Joan Maling, Chris Manning, Jane Simpson, and Annie Zaenen, 467–479. Stanford, CA: CLSI Publications.

JAMIESON, ALLAN. 1977. Chiquihuitlan Mazatec phonology. *Studies in Otomanguean Phonology*, ed. by William Merrifield, 93–106. Arlington, TX: Summer Institute of Linguistics.

JAROSZ, GAJA. 2013. Naive Parameter Learning for Optimality Theory – the Hidden Structure Problem. *NELS 40: Proceedings of the 40th Annual Meeting of the North East Linguistic Society*, ed. by Seda Kan, Claire Moore-Cantwell, and Robert Staubs. Amherst, MA: University of Massachusetts Graduate Linguistics Student Association.

JEANNE, LAVERNE MASAYESVA. 1982. Some phonological rules of Hopi. *International Journal of American Linguistics* 48.245–270.

JESNEY, KAREN, and ANNE-MICHELLE TESSIER. 2011. Biases in Harmonic Grammar: the road to restrictive learning. *Natural Language and Linguistic Theory* 29.251–290.

KAGER, RENÉ. 1993. Alternatives to the Iambic-Trochaic Law. *Natural Language and Linguistic Theory* 11.381–432.

KAGER, RENÉ. 1994. Ternary rhythm in alignment theory. Utrecht: Utrecht University MS. Online: http://roa.rutgers.edu/files/35-1094/35-1094-KAGER-0-0.PDF.

KAGER, RENÉ. 2001. Rhythmic directionality by positional licensing. Paper presented at the Fifth HIL Phonology Conference (HILP 5), Potsdam. Online: http://dspace.library.uu.nl/handle/1874/8745.

KAGER, RENÉ. 2012. Stress in windows: Language typology and factorial typology. *Lingua* 122.1454–1493.

KAGER, RENÉ, and VIOLETA MARTÍNEZ-PARICIO. 2014. Minimally recursive foot structure. Paper presented at the Annual Meeting on Phonology 2014, Cambridge, MA.

KALIMERI, MARIA; VASSILIOS CANSTANTOUDIS; CONSTANTINOS PAPADIMITRIOU; KONSTANTINOS KARAMANOS; FOTIS K. DIAKONOS; and HARRIS PAPAGEORGIU. 2015. Word-length Entropies and Correlations of Natural Language Written Texts. *Journal of Quantitative Linguistics* 22.101–118.

KENSTOWICZ, MICHAEL, and HYANG-SOOK SOHN. 2001. Accentual adaptations in North Kyungsang Korean. *Ken Hale: a Life in Language*, ed. by Michael Kenstowicz, 239–270. Cambridge, MA: MIT Press.

KEY, HAROLD H. 1961. Phonotactics of Cayuvava. *International Journal of American Linguistics* 27.143–150.

KEY, HAROLD H. 1967. *Morphology of Cayuvava*. The Hague: Mouton.

DE LACY, PAUL. 2014. Evaluating evidence for stress systems. *Word stress: Theoretical and typological issues*, ed. by Harry van der Hulst, 149–193. Cambridge: Cambridge University Press.

LEER, JEFF. 1985a. Prosody in Alutiiq. *Yupik Eskimo prosodic systems: descriptive and comparative studies*, ed. by Michael Krauss, 77–134. Fairbanks, AK: Alaska Native Language Center, University of Alaska.

LEER, JEFF. 1985b. Towards a Metrical Interpretation of Yupik Prosody. *Yupik Eskimo prosodic systems: descriptive and comparative studies*, ed. by Michael Krauss, 159–172. Fairbanks, AK: Alaska Native Language Center, University of Alaska.

LESOURD, PHILIP S. 1988. *Accent and syllable structure in Passamaquoddy*. Cambridge, MA: MIT dissertation.

LESOURD, PHILIP S. 1993. *Accent and syllable structure in Passamaquoddy*. New York: Garland.

LEWIS, M. PAUL; GARY F. SIMONS; and CHARLES D. FENNIG. 2015. *Ethnologue: Languages of the World, Eighteenth edition.* Dallas, Texas: SIL International. Online: http://www.ethnologue.com.

MAGRI, GIORIO. 2012. Convergence of error-driven ranking algorithms. *Phonology* 29.213–269.

MAGRI, GIORGIO. 2014. Error-driven versus batch models of the acquisition of phonotactics: David defeats Goliath. *Supplemental proceedings of the 2013 Meeting on Phonology*, ed. by John Kingston, Claire Moore-Cantwell, Joe Pater, and Robert Staubs. Washington, DC: Linguistic Society of America.

MARTÍNEZ-PARICIO, VIOLETA. 2013. *An exploration of minimal and maximal metrical feet.* Tromsø: University of Tromsø dissertation.

MARTÍNEZ-PARICIO, VIOLETA and RENÉ KAGER. 2015. The binary-to-ternary rhythmic continuum in stress typology: layered feet and non-intervention constraints. *Phonology* 32.3, to appear.

MCCARTHY, JOHN J. 2003. OT constraints are categorical. *Phonology* 20.75–138.

MCGARRITY, LAURA. 2003. *Constraints on patterns of primary and secondary stress*. Bloomington, IN: Indiana University dissertation.

MCLEOD, S.; J. VAN DOORN; and V. REED. 2001. Normal acquisition of consonant clusters. *American Journal of Speech-Language Pathology* 10.99–110.

MESTER, R. ARMIN. 1994. The quantitative trochee in Latin. *Natural Language and Linguistic Theory* 12.1–61.

MICHELSON, KARIN. 1988. *A comparative study of Lake-Iroquoian accent*. Dordrecht: Kluwer.

MINER, KENNETH L. 1989. Winnebago accent: The rest of the data. *Anthropological Linguistics* 31.148–172.

MIYAOKA, OSAHITO. 2012. *A grammar of Central Alaskan Yupik (CAY).* New York: Mouton.

MORETON, ELLIOTT. 2008. Analytic bias and phonological typology. *Phonology* 25.83–127.

ODDEN, DAVID. 1996. *Phonology and morphology of Kimatuumbi*. Oxford: Oxford University Press.

OHALA, JOHN J. 1981. The listener as a source of sound change. *Papers from the Parasession on Language and Behavior*, ed. by C. S. Masek, R. A. Hendrick, and M. F. Miller, 178–203. Chicago, IL: Chicago Linguistic Society.

OSUMI, MIDORI. 1995. *Tinrin Grammar*. Honolulu: University of Hawai'i Press.

PATER, JOE. 2009. Weighted Constraints in Generative Linguistics. *Cognitive Science* 33.999–1035.

PATER, JOE, and JESSICA A. BARLOW. 2003. Constraint conflict in cluster reduction. *Journal of Child Language* 30.487–526.

PIANTADOSI, STEVEN T.; HARRY TILY; and EDWARD GIBSON. 2011. Word lengths are optimized for efficient communication. *Proceedings of the National Academy of Science of the United States of America, Volume 108*, ed. by Paul Kay, 3526–3529.

PRINCE, ALAN. 1980. A metrical theory for Estonian quantity. *Linguistic Inquiry* 11.511–562.

PRINCE, ALAN, and PAUL SMOLENSKY. 2004. *Optimality Theory: Constraint interaction in generative grammar*. Oxford: Blackwell.

PRINCE, ALAN, and BRUCE TESAR. 2004. Learning phonotactic distributions. *Fixing priorities: Constraints in phonological acquisition*, ed. by René Kager, Joe Pater, and Wim Zonneveld, 245–291. Cambridge: Cambridge University Press.

PRINCE, ALAN S. 1983. Relating to the grid. *Linguistic Inquiry* 14.19–100.

RADIN, PAUL. 1929. *A grammar of the Wappo language*. Berkeley, CA: University of California Press.

RICE, CURT. 1992. *Binarity and ternarity in metrical theory: parametric extensions*. Austin, TX: University of Texas at Austin dissertation.

RIFKIN, JAY I. 2003. Ternarity is Prosodic Word binarity. *The Phonological Spectrum, vol. ii: Suprasegmental Structure*, ed. by Jeroen van de Weijer, Vincent van Heueven, and Harry van der Hulst, 127–150. Amsterdam: John Benjamins.

SAPIR, EDWARD. 1930. Southern Paiute, a Shoshonean language. *Proceedings of the American Academy of Arts and Sciences* 65.1–296.

SELKIRK, ELISABETH O. 1980. The role of prosodic categories in English word stress. *Linguistic Inquiry* 11.563–605.

SIGURD, BENGT; MATS EEG-OLOFSSON; and JOOST VAN DE WEIJER. 2004. Word length, sentence length, and frequency – Zipf revisited. *Studia Linguistica* 58.37–52.

STAUBS, ROBERT. 2014a. *Computational modeling of learning biases in stress typology*. Amherst, MA: University of Massachusetts Amherst dissertation.

STAUBS, ROBERT. 2014b. Learning and the position of primary stress. *Proceedings of the 31st West Coast Conference on Formal Linguistics*, ed. by Robert E. Santana-LaBarge, 428–437. Somerville, MA: Cascadilla Press.

STERIADE, DONCA. 2001. The phonology of perceptibility effects: The P-map and its consequence for constraint organization. Los Angeles: University of California, Los Angeles MS. Online: http://www.linguistics.ucla.edu/people/steriade/steriade.htm.

Tabain, Marija; Janet Fletcher; and Andrew Butcher. 2014. Lexical stress in Pitjantjatjara. *Journal of Phonetics* 42.52–66.

TESAR, BRUCE, and PAUL SMOLENSKY. 2000. *Learnability in Optimality Theory*. Cambridge, MA: MIT Press.

TESSIER, ANNE-MICHELLE. 2007. *Biases and stages in phonological acquisition*. Amherst, MA: University of Massachusetts Amherst dissertation.

TESSIER, ANNE-MICHELLE. 2009. Frequency of violation and constraint-based phonological learning. *Lingua* 119.6–38.

TRYON, DARRELL. 1970. *An Introduction to Maranungku*. Canberra: Australian National University.

VAN URK, COPPE. 2013. A typology of clash-tolerating languages. Cambridge, MA: MIT MS.

VIHMAN, MARILYN MAY; EDWIN KAY; BÉNÉDICTE DE BOYSSON-BARDIES; CATHERINE DURAND; and ULLA SUNDBERG. 1994. External Sources of Individual Differences? A Cross-Linguistic Analysis of the Phonetics of Mothers' Speech to 1-Year-Old Children. *Developmental Psychology* 30.651–662.

WHEELER, DEIDRE. 1979. A metrical analysis of stress and related processes in Southern Paiute and Tübatulabal. *University of Massachusetts Occasional Papers in Linguistics, Volume 5,* ed. by J. Lowenstamm, 145–175. Amherst, MA: University of Massachusetts Graduate Linguistics Student Association.

ZOLL, CHERYL. 2004. Ternarity vs. final exclusion: a synthesis. Cambridge, MA: MIT MS.

[1] The discussion in this article focuses exclusively on Kager's (2012) referent of the term MIDPOINT PATHOLOGY. Earlier uses of the term, by Eisner (1997) and Hyde (2008), describe a different kind of pattern, in which stress gravitates towards the middle of all words, regardless of their length. These kinds of patterns are predicted by the Generalized Alignment approach to alignment constraints (Prince & Smolensky 2004); see Hyde 2015 for discussion.

[2] This is a simplifying assumption: it isn't always the case that each possible permutation of constraints in a given constraint set will be equally probable. If the ranking of two or more constraints is fixed, permuting them will be impossible. I abstract away from this complication here, as the issue of fixed rankings does not arise in this article.

[3] The expected frequencies in this section were calculated by hand. To keep the size of the typology manageable, the candidates considered were limited to forms with a single stress. This decision was made because midpoint systems are single-stress systems, so the typology of single-stress systems is a logical comparison class. Calculations are available online for the reader to verify at http://web.mit.edu/juliets/www/expected-midpoint.xlsx.

[4] It should be noted, however, that Gordon's (2002) proposal undergenerates to some degree, and that the survey is not completely comprehensive. For example, the proposal precludes the possibility of languages with post-peninitial stress (as in Ho-Chunk, e.g. Miner 1989), and the typology does not include any examples of systems where stress placement depends on word length (e.g. Içuã Tupi, Abrahamson 1968; on these systems see section 5.2).

[5] Earlier works on weak layering cited by Kager (2012) are Hewitt 1992, Rice 1992, Kager 1994, Rifkin 2003, Blevins & Harrison 1999, Itô & Mester 2003, Zoll 2004,and Caballero 2011. Kager also notes that these OT models continue a tradition of exploring weak layering in the prosodic hierarchy; see e.g. Prince 1980, Selkirk 1980, and Dresher & Lahiri 1991. For more recent work, see also Martínez-Paricio 2013, Kager & Martínez-Paricio 2014, and Martínez-Paricio & Kager 2015.

[6] While enriching the candidate set to include inputs with heavy syllables and multiple stresses generally drives up the total number of trials required for convergence, it does not appear to affect how quickly a given system converges relative to other systems, which will be our focus for the remainder of this article.

[7] There are other possible hypotheses given the data in 27a-c: for example, the system could be one in which post-peninitial stress is preferred, but stressing either of the final two syllables is impossible. For simplicity, I do not discuss these other hypotheses.

[8] The full story: for this trial, the learner promotes the winner-preferrer ALIGNL, and demotes the loser-preferrers *LAPSE, *LAPSER, and ALIGNR. For simplicity, here and in what follows I focus on only a subset of the updates.

[9] Stated this way, the preference for AP over EM is one that relies heavily on the GLA's assumption that constraints stand in relations of strict domination: the learner is biased to acquire systems in which there are very few constraint strata. There is no reason to believe that this same metric of simplicity should apply, however, if we assume that constraints are weighted, and that several low-weighted constraints can gang up on a higher-weighted one. In fact, when attempting to teach the ambiguous data presented to the Haitian learner to a Noisy Harmonic Grammar (NHG) learner, using the same constraint set and input-output pairs, the NHG learner was biased to acquire EM (these simulations done in OTSoft, Hayes et al. 2013). This result, however, only arises because ALIGNL and ALIGNR are assessed gradiently. If we replace these constraints with categorical ones, then the weighted and ranked constraint learners behave identically: both are biased to prefer AP.

[10] As the associate editor points out, such a bias might arise during learning as an effect of language processing. Numerous psycholinguistic studies have argued that listeners tend to associate a stressed syllable with the beginning of a word (see e.g. Cutler & Butterfield 1992 for English), which might lead learners to be biased towards acquiring a grammar in which *EXTLAPSEL, and other constraints favoring left-edge stress, are highly ranked. Note, however, that this preference to associate stress with a word's left edge appears to be at odds with the

typology of window systems: in Kager 2012, more languages exhibit a right-edge window (where *LapseR or *ExtLapseR is ranked high) than a left-edge window (where *LapseL or *ExtLapseL is ranked high).

[11] The only exception to this generalization discussed by van Urk (2013) is South Conchucos Quechua (SCQ, Hintz 2006). In SCQ, we find stress clash occurring between the primary and a secondary ([tú.shù.ku.nà.qḁ], **_σ́σ̀_**_σ_**_σ̀_**_σ_). All this shows, though, is that the preference to avoid clashes between the primary and a secondary can be overruled by the preference to place clashes at the edge of the word. In other words, in SCQ, Clash-at-Edge >> *Clash-at-Peak.

[12] The learner used in this subsection differs in non-crucial ways from the learner introduced in section 3.2. For example, it has to consider and evaluate candidates with more than one stress. For comparison, this new learner takes 580 trials on average to learn EM (pattern in 24), which is many more trials than is required to learn either of the binary plus clash systems.

[13] The associate editor raises a concern that evidence for Cayuvava's stress pattern is insufficient, and that the reported facts cannot be confirmed. While we should indeed be cautious of accepting impressionistic descriptions of stress patterns (see e.g. de Lacy 2014, Tabain et al. 2014), the Cayuvava data can still be used as illustration of a broader point, as long as they have not been publicly disputed. As de Lacy (2014) notes, much of the data that stress typologies are based on is open to question.

[14] The situation for ERC-based learners might not be so optimistic if ERCs are stored in cache (see Tessier 2007). In the case of EM, as long words are only infrequently encountered by the learner, they are not statistically strong patterns that the ranking algorithm has to deal with. Thanks to an anonymous reviewer for pointing this out.

[15] For a partial calculation, see: http://web.mit.edu/juliets/www/expected-shrinking.xlsx.

[16] It is worth noting, however, that given the data from the shrinking window systems discussed above, there are alternative analyses available. Kimatuumbi and NKK could just as well be

systems with post-peninitial stress (like Ho-Chunk, Miner 1989); the possibility of penultimate stress in shorter stems could reflect a dispreference for final stress. Içuã Tupi could also be a system with predominantly post-peninitial stress, in which NONFINALITY is inviolable. In the text, I have followed the authors' characterizations of the patterns, but the data necessary to determine which analysis is correct are not available. If these are all post-peninitial stress systems, then the claim of this part of the section could be strengthened: shrinking window systems, like midpoint systems, are unattested because they are difficult to learn.

[17] Stresses for the forms in 43c-d are inferred from Tryon's (1970:10) description of the stress pattern.

[18] There are, of course, other classes of attested systems in which the placement of main stress relative to an edge is inconsistent. Two examples are: quantity-sensitive accentual window systems, where stress can fall anywhere within a certain domain (e.g. English); and languages with qualitatively-driven stress (e.g. Nanti, Crowhurst & Michael 2005). More work is required to determine whether or not these systems are also underattested relative to what we would expect, and if not, what differentiates them from the classes of systems discussed above.

[19] http://www.beatlesinterview.org. All interviews dated 1970 or later were included.