CAN UNNATURAL STRESS PATTERNS BE LEARNED: NEW EVIDENCE FROM KLINGON[*]

Joseph W. Windsor and Robyn Stewart
University of Calgary and Klingon Language Institute

1.   Introduction

In a meta-analysis of acquisition studies based on artificial-phonology learning, Moreton & Pater (2012: 686) state that learning biases must exist since generalizations cannot be made without them (see also Pinker 1979; Mitchell 1980; or Gallistel *et al*. 1991). Moreton & Pater (2012) go on to argue that studies involving artificial-phonologies offer an important opportunity to study learning biases in near-isolation by carefully controlling the learning stimuli to facilitate a particular bias over any others.

(1)   Complexity Bias (Moreton & Pater 2012)
       Simpler patterns (representations) are learned faster/better than complex ones.

(2)   Substantive Bias (Moreton & Pater 2012)
       Phonetically motivated patterns are learned faster/better than phonologically arbitrary ones.

(3)   Domain Generalization Bias (Zymet 2017)
       Learners favour phonological constraints that hold across morphological domains.

      Natural language phonology utilizes the effects of multiple learning biases to facilitate acquisition. However, artificial phonological systems—such as those found in constructed languages—may allow the study of these biases in near-isolation (Moreton & Pater 2012). Moreton & Pater argue that the more arbitrary the bias being exploited by an artificial phonology is, the more directly relevant such artificial language studies are, and the more directly relevant the results are to natural languages. In the present article, we consider evidence from the production of seven advanced learners of the constructed language, Klingon (Okrand 1992) to provide evidence that a complexity bias facilitates learning (largely) independent of a substantive bias or a domain generalization bias.
      In the remainder of this section, we provide a rationale for using constructed languages as a source of acquisition evidence. In section 2, we motivate the position that the phonological system of Klingon facilitates acquisition using a complexity bias, but not a substantive bias nor a domain generalization bias. We motivate that position by

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showing that Klingon has a representationally simple phonological system that relies on arbitrary rules of stress assignment, which differ across morphosyntactic domains. In section 3, we detail a study of seven advanced speakers of Klingon to answer the question of whether the unnatural stress system of the language can be learned such that it is implemented in spontaneous conversation. Our hypothesis is that the degree to which expected stress is realized in spontaneous conversation in the L2 will provide evidence on the importance of the complexity bias relative to the other two learning biases. We show that although speakers are performing significantly above chance in their realization of expected stress, there are several instances of unexpected stress. In section 4, we discuss instances of unexpected stress to understand some of the constraints that prevent speakers from producing expected stress in all instances. Section 5 concludes with directions for future research on this topic.

1.2   Constructed languages as acquisition evidence

Constructed languages, or conlangs, are frequently built using natural language principles of grammar. If the conlanger's goal is to provide a naturalistic language, they must follow natural linguistic tendencies; if the conlanger's goal is to create an unnatural language (from an ethnocentric point of view), they must understand natural linguistic tendencies in order to flaunt them. Klingon, as invented by linguist, Dr. Marc Okrand, is the latter type of conlang – designed to be as unnatural as possible while still being pronounceable by learners (and actors).

Because conlangs represent a controlled and deliberately created input, they necessarily allow for controlled acquisition studies where a particular part of the grammar can be isolated and tested (Schane *et al.* 1974; Buckley 2003; Pycha *et al.* 2003; Wilson 2003, 2006; Carpenter 2005, 2006, 2010; Pater & Tessier 2006; Peperkamp & Dupoux 2007; White *et al.* 2008; Zaba 2008; Hayes *et al.* 2009; Kosa 2010; Hracs 2011; Skoruppa & Peperkamp 2011; Skoruppa *et al.* 2011; Culbertson 2012; Moreton & Pater 2012; Hayes & White 2013; White 2014). Like in the present study, Carpenter (2005 *et seq.*) found that substantial insights into learning biases can be discovered using unnatural stress patterns in an artificial phonology.

In two experiments, Carpenter found that participants displayed a naturalness bias (what I call a substantive bias here, following Moreton & Pater 2012) to the acquisition of stress patterns. In the first experiment, participants were trained on two stress patterns: A typologically uncommon pattern that stresses the leftmost low vowel ([a]) or the leftmost vowel in the absence of a low vowel, and the typologically unattested pattern of the leftmost high vowel ([i, u]) or the leftmost vowel in the absence of a high vowel. Participants were tested with novel words and performed significantly better with the typologically attested pattern. The second experiment Carpenter conducted once again examined two stress patterns: A typologically common pattern of stressing leftmost heavy syllables or the leftmost syllable in the absence of a heavy one, and a typologically unattested pattern of stressing the leftmost light syllable or the leftmost syllable in the absence of a light syllable. Once again, participants performed significantly above chance on the typologically attested pattern. These experiments reveal that there is a substantive bias that learners can utilize in language acquisition (see Moreton & Pater 2012 for additional discussion). Klingon, as will be motivated in the following section, does not allow for the use of a substantive bias in acquisition and thus allows testing of the usefulness of a complexity bias in near-isolation during acquisition.

2. The phonological system of Klingon

Klingon is perhaps the "world's largest fictional language" (Okrand *et al.* 2011: 111) with as many as 7,500 self-declared learners, up to 120 fluent speakers, and at least one first language learner (*cf.* Okrent 2009). The language was designed to be as unnatural as possible, utilizing some of the typologically rarest phonemes, never found together in any language (e.g., the affricates [qχ] and [tɬ]) and substantively unmotivated contrasts (e.g., the voiced counterpart of [tʰ] is [d]). The phonological system of the language generally lacks alternations with epenthesis only evidenced in a single morpheme,[1] however, there are complex stress placement rules which do provide variability to the system. In this section, we outline the metrical representations that Klingon provides evidence for and the rules for expected stress realization.[2]

2.1 Moraic representations

The prosody of Klingon is also unnatural by design (personal correspondence, Okrand 2016), further restricting the use of a substantive bias in acquisition. It is an unnaturally choppy language, which intentionally flaunts metrical theory. Klingon can be described as an iambic language which typically assigns stress to the final syllable of a root regardless of any additional syllables added to the root through suffixation. However, if a suffix ending in [ʔ] is added, that suffix becomes stressed instead, if the root is a noun (as in 4), or adds an additional stress if the root is a verb (as in 5). This is despite a lack of evidence that [ʔ] adds any moraic weight to the syllable:[3]

(4)　a.　[(dʒɪn.ˈmol)]
　　　　jInmol
　　　　project
　　　　'(a) project'

　　　b.　[(dʒɪn.ˈmol.)xom.meɪ.qʰoqʰ.vɑm]
　　　　jInmol-Hom-mey-qoq-vam
　　　　project-DIM-PL-so^called-PROX
　　　　'these so called minor projects'

　　　c.　[(dʒɪn.mol.)xom.meɪ.qʰoqʰ.vɑm.ˈvoʔ]
　　　　jInmol-Hom-mey-qoq-vam-vo'
　　　　project-DIM-PL-so^called-PROX-ABL
　　　　'from these so called minor projects'

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[1] The endearment nominal suffix *–oy* is frequently realized with an epenthesized [ʔ] onset if the root does not contain a coda consonant which can be used to satisfy the obligatory onset constraint.
[2] Standardized stress rules come from Okrand (1992), and are the model that speakers learn from.
[3] Rounded brackets in Klingon examples are used to denote the lexical root (noun or verb).

(5) a. [(qχɑn)]
Qan
protect
'to protect'

b. [bɪ.(ˈqχɑn.)ʔɛɣ.bɛdʒ.tʰɑx.vɪʂ]
bI-Qan-'egh-bej-taH-vIS
2>Ø-protect-self-certain-PROG-while
'while you are undoubtedly protecting yourself'

c. [bɪ.(ˈqχɑn.)ʔɛɣ.bedʒ.tʰɑx.ˈmoʔ]
bI-Qan-'egh-bedj-taH-vIS-mo'
2>Ø-protect-self-certain-PROG-because
'because you are undoubtedly protecting yourself'

The forms in (4c) and (5c) create the impression that a coda [ʔ] adds moraic weight to the syllable, thus allowing it to attract stress according to a Stress-to-Weight principle (Myers 1987; Riad 1992). Looking at example (5c), there are three preceding morphemes that have coda consonants which could all plausibly be able to attract stress as well, so why is it the coda [ʔ] that does attract the stress? It is possible for /ʔ/ to pattern as a sonorant sound rather than a stop (Zec 1988, 1995; Kavitskaya 2002), but if there was a restriction that only sonorant sounds receive moraic weight (*cf.* Irish as described in Ní Chiosáin 1991) then the examples in (4) cannot be explained: The suffixes [xom] and [vɑm] have sonorant codas but do not attract stress, and the suffix [meɪ] contains a diphthong, but also fails to attract stress. In fact, it is not difficult to find forms in Klingon where light syllables receive stress rather than heavy ones:

(6) a. μ μμ
        | ||
        [(ˈɣu.)ʔoɪ]
        ghu-oy
        baby-endear
        'dear baby'

b. μμμ μμ
    ||| ||
    [(xɛɣ. ˈwɪʔ)]
    HerghwI'
    hypospray
    'hypospray'

c. μ μμμ
    | |||
    [(ˈɖɑ.)lɑʊʔ]
    Da-law'
    act^like-seem
    'he seemingly acts like it'

d. μ μ μμμ   μμ
    | | ||| ||
    [(ˈɣodʒ.)lɑʊʔ. ˈtʰɑʔ]
    ghoj-law'-ta'
    learn-seem-PERF
    'he seemingly learned it'

The forms provided in (6a, c, d) can have alternate stress patterns due to the role of information structure (discussed in §3.3); example (6b) cannot be stressed differently without adding suffixes to the root. In each of the examples in (6), we can see that stress is realized by default on lighter syllables.
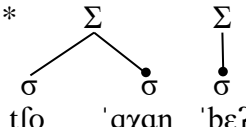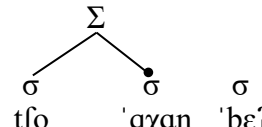
The fact that moraic representations are irrelevant for stress assignment suggests that learners of the conlang do not need to compute moraic representations in acquiring the stress pattern – rendering the prosodic representations in (6) unnecessary for the learner and contributing to the hypothesis that Klingon is representationally simple. In the next section, we show that metrical feet are likewise unnecessary for stress assignment.
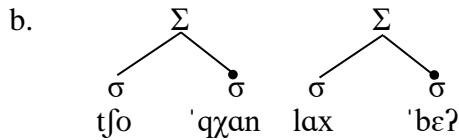
2.2   Metrical foot representations

The pre-Optimality Theory constraint *CLASH (Liberman 1975; Liberman & Prince 1977; Prince 1983; Hammond 1984; Selkirk 1984 – see Kager 1999 for discussion) was used to explain systems that prohibited two stressed syllables in adjacency. Specifically, in languages like Estonian and Finnish where the Stress-to-Weight principle assigns stress to heavy syllables, the higher ranking *CLASH constraint prevented adjacent syllables from both being realized with stress despite both being heavy (*cf.* Abler 1997). This constraint also seems to be at work in one condition in Klingon: A suffix ending in glottal stop may not be simultaneously stressed with a verb root if the syllables are in adjacency:

(7)   a.   [tʃo.(ˈqχɑn.) bɛʔ]   (*cf.* [tʃo.(qχɑn.)ˈbɛʔ] – pragmatic focus on negation)
                cho-Qan-be’
                2>1-protect-NEG
                ‘you don’t protect me’

      b.   *[tʃo.(ˈqχɑn.)ˈbɛʔ]
                cho-Qan-be’
                2>1-protect-NEG
                Intended: ‘you don’t protect me’

      c.   [tʃo.(ˈqχɑn.)lɑx.ˈbɛʔ]
                cho-Qan-laH-be’
                2>1-protect-able-NEG
                ‘you’re not able to protect me’

The above stress-assignment rule may provide evidence for metrical structure in Klingon, suggesting that the form in (7b) was ungrammatical because it would lead to a stress-clash if the negative suffix formed an iambic foot by itself – in adjacency to the stressed syllable of the iambic foot containing the subject/object agreement prefix (cho-) and the verb root:

(8)   a.   *   Σ   Σ   a'.   Σ

                      σ   σ   σ   σ   σ   σ
                     tʃo   ˈqχɑn   ˈbɛʔ   tʃo   ˈqχɑn   ˈbɛʔ

b.

$$\text{tʃo} \quad \text{ˈqχɑn} \quad \text{lɑx} \quad \text{ˈbɛʔ}$$

The stress clash violation in (8a) would be resolved by leaving the final syllable unfooted (as in 8a'). When an additional syllable separates the stress-attracting syllable that ends in [ʔ] from the lexical root, there is no stress clash violation, and two stresses are able to surface. However, that explanation cannot be correct: Adjacent suffixes ending in [ʔ] can both bear stress:

(9)   a.   [tʃo.(ˈqχɑn.)lɑx.ˈbɑʔ.ˈbɛʔ]
              cho-Qan-laH-ba'-be'
              2>1-protect-able-obvious-NEG
              'you're obviously not able to protect me'

      b.   [tʃo.(ˈqχɑn.)lɑx.ˈbɛʔ.ˈʔɑʔ]
              cho-Qan-laH-ba'-'a'
              2>1-protect-able-NEG-Q
              'are you not able to protect me?'

Since the metrical explanation of stress clash fails to explain the ability of adjacent stresses to surface when both are realized on a suffix, we are forced to conclude that—just like the moraic discussion in the previous section—learners of the conlang do not need to compute metrical representations in acquiring the stress pattern – rendering the prosodic representations in (8) unnecessary for the learner, and further contributing to the hypothesis that Klingon is representationally simple.

2.3   Summary: Learning biases in Klingon prosody

Default stress in Klingon is assigned by a series of phonologically arbitrary rules that effect different morphosyntactic categories in different ways. Lexical roots are stressed with the stress appearing on the right-most syllable. If a suffix ending in [ʔ] is at least one syllable away from a verb root, both syllables will be stressed. If a suffix ending in [ʔ] attaches to a noun, stress shifts from the root to the suffix. Adjacent suffixes ending in [ʔ] are both stressed.

The arbitrariness of the Klingon stress system does not facilitate a substantive bias.[4] Further, because the rules of stress application treat nouns, verbs, and affixes differently, learners cannot gain the benefit of a domain generalization bias for stress acquisition in this language. Therefore, if speakers of Klingon successfully acquire the stress system, they must be relying (primarily) on a complexity bias to form representations.

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[4] We are grateful to Daniel Currie Hall for pointing out the phonetic link between pitch rise and coda-[ʔ] (Klingon stress is characterized by higher pitch and raised amplitude) as is frequently argued to be a factor in tonogenesis. While this phonetic motivation does facilitate pitch increase before non-moraic [ʔ], it does not aid learners in acquiring the different rules for nouns, verbs, and affixes, nor explain why not all glottal stops attract stress (as in 7a-b). However, it is useful to note that this sort of potential confound is what is meant by examining learning biases in near-isolation, and what makes examining these biases in total isolation impossible.

Buckley (2003) suggests that so-called unnatural phonological patterns can develop in natural languages due to historical change (see also Moreton & Pater 2012, White 2014, and Zymet 2017). However, Buckley argues that such unnaturalness (as shown from artificial phonology acquisition studies) does not seem to impede learning, so long as the rule is regular and well attested in the input.

Klingon, therefore, represents the ideal artificial phonology for studying a complexity bias in near-isolation (in Moreton & Pater's 2012 terms): The influences of the substantive bias and domain generalization bias are minimal at best, but the rules require simple representations and are regular and well attested in the input. As such, we predict that the degree to which expected stress is realized in spontaneous conversation will provide evidence on the importance of the complexity bias, relative to the substantive bias and the domain generalization bias.

3.   The study

To test the importance of the complexity bias relative to the substantive bias and the domain generalization bias, we conducted a phonological study on 18 minutes of recorded spontaneous conversation between seven advanced speakers of Klingon. The hypothesis for this study is that the degree to which expected stress is realized in spontaneous conversation in the L2 will provide evidence on the relative importance of the complexity bias in L2 acquisition. In other words, if speakers accurately produce the arbitrary target stress of the L2, there is evidence to suggest that the complexity bias is important for L2 acquisition.

3.1   Methodology

The audio conversation was transcribed orthographically and translated by the second author (an advanced Klingon speaker), then glossed, and annotated for expected stress based on the rules for stress application provided in Okrand (1992) by the first author.

Each word containing two or more syllables was then analyzed in Praat (Boersma & Weenink 2016) to determine which syllable(s) was stressed. Which syllable(s) was stressed in any given word was decided based on increased pitch (Hz) and amplitude (dB) relative to the other syllables in the word, in accordance with the description of stress provided in Okrand (1992). Words that were not presented with clear audio (*i.e.,* if multiple speakers were talking at once, or if there was background noise) such that a reliable stress judgement could not be reached were excluded from the study. This resulted in 320 usable tokens from the 18 minutes of audio.

Observed stress was compared to the expected stress and organized in a confusion matrix for analysis using a Chi-squared (χ^2) test in R (R core team 2013).[5] Tokens were divided by part of speech (proper nouns, nouns, verbs, exclamations, adverbs, and numbers), and by speaker. Any mismatches between expected and observed stress were also analyzed for a possible influence of information structure on the stress assignment (*i.e.,* contrast, negation, question intonation, or emphasis).

It must be noted that the conversation analyzed in this study was not recorded for the purpose of this study, but rather to document spontaneous L2 conversation in Klingon

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[5] In instances were there was not enough power to allow a χ^2 test (*i.e.,* if a cell in the confusion matrix contained five or fewer counts), Fisher's Exact test was used instead.

by advanced speakers. The speakers gave the authors permission to use the conversation for analysis after the fact.[6]

3.2   Participants

The seven speakers in the recorded spontaneous conversation all report English as their L1. All of the participants have studied other L2s in addition to Klingon with varying degrees of fluency. The other languages reported as studied or spoken by the participants include: Chinese, Modern Hebrew, Spanish, French, Arabic, ancient Greek and Latin, Coptic, Basque, Welsh, Irish, Scottish Gaelic, Esperanto, Russian, Estonian, Cree, and ASL.

3.3   Analysis

The confusion matrix presented below in Table 1 provides the frequency of tokens analyzed ($n = 320$), which displayed the expected stress pattern compared to those which did not, divided by part of speech:

	Proper nouns	Nouns	Verbs	Exclamations	Adverbs	Numbers	Total
Expected Stress	13	64	142	18	5	2	244
Unexpected Stress	14	23	33	4	2	0	76
Fisher's Exact Score: $p = 0.011$							

Table 1: Instances of expected/unexpected stress by part of speech

The omnibus Fisher's Exact test given in Table 1 shows that at least one category has a significantly different distribution than the others. Post hoc testing confirms that that only category where speakers are not performing significantly above chance is with proper nouns, which is addressed in §4. When the data were broken out by person, we found that there was no statistical difference between speakers in terms of the frequency that expected stress was observed ($p = 0.96$). These data show that expected stress was realized with 76.25% accuracy across all tokens and speakers, which is significantly better than chance ($p < 0.001$).

Of the 76 words that appeared with unexpected stress, 24 tokens can be explained by information structure. For example, although stress was expected to remain on a verbal root if a suffix ending in [ʔ] is not separated from the root by at least one syllable, when that suffix is the emphatic marker *-qu'* or the negation marker *-Ha'* ('undo'), these suffixes can be stressed due to information structure:

(10)   a.   [(ˈrur.)quʔ]   →   [(rur.)ˈquʔ]
                Ø-rur-qu'
                3>3-resemble-EMPH
                'it resembles (something)'

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b.   [(ˈpɪdʒ.)xɑʔ] →   [(pɪdʒ.)ˈxɑʔ]
          pIj-Ha'
          often-undo
          'rarely'

Once the effects of information structure are considered, this improves the speakers' performance to 83.75% accuracy.

These data show that the advanced speakers in this study have successfully acquired the arbitrary stress pattern of the conlang, Klingon to 83.75% accuracy, which is significantly better than chance ($p < 0.001$). The speakers have acquired this system despite it being unnatural (*i.e.,* not providing a substantive bias advantage for acquisition) and not allowing generalizability across morphosyntactic domains (*i.e.,* not providing a domain generalization bias advantage for acquisition). Therefore, the results from this study suggest that a complexity bias—facilitated by a simplex representational system and by alternations being regular and well attested in the input—provide a significant advantage for L2 stress acquisition in the (near) absence of a substantive bias and a domain generalization bias.

In the following section, we discuss the remaining 16.25% of tokens which did not show expected stress, and which could not be explained by appealing to information structure. The discussion of the unexpected stress provides insight into what constraints prevent target-like L2 pronunciations when the overall pattern can be said to have been acquired.

4.   Unexpected stress

In this study, we looked at 320 tokens of multisyllabic words produced by seven advanced speakers of Klingon. Of those 320 tokens, 244 were realized with expected stress (76.25% accuracy). When information structure and the pragmatic stressing of emphatic or negation suffixes, for example, were considered, the number of tokens displaying unexpected stress fell from 76 to 52 – increasing the accuracy to 83.75%, with no significant difference in the performance of any of the seven speakers ($p = 0.96$). In this section, we look at the two most common predictors of unexpected stress based on the data available: Over application of a phonological rule, and proper nouns.

4.1   Over application of the glottal stop rule

In §2.1, we discussed the arbitrary phonological rule that caused stress to be shifted to suffixes ending in /ʔ/ in nouns, or a second stress to be added to any suffix ending in /ʔ/ in verbs (as long as it is separated from the root by at least one syllable). This rule facilitates *CLASH violations in realizing multiple adjacent suffixes with equal stress, in addition to stressing the root verb in some constructions. Speakers in this study correctly applied that rule in most instances:

(11) a.   [vɪ.(ˈʂov.)bɛʔ.ˈpuʔ]
            vI-Sov-be'-pu'
            1.SG>3-know-NEG-PERF
            'I didn't know …'

  b.   [bɪ.(ˈqχɑn.)ʔɛɣ.lɑx.ˈbɛʔ.ˈʔaʔ]
      bI-Qan-'egh-laH-be'-'a'
      2.SG>Ø-protect-self-able-NEG-Q
      'Can't you protect yourself?'

The example in (11a) shows that speakers realized target-like stress, putting prominence on both the verbal root and a suffix ending in [ʔ], but not the [ʔ]-final suffix adjacent to the root. In (11b), target-like stress was again realized, but, in this instance, with two adjacent stressed suffixes, both ending in [ʔ]. Data such as these, and the fact that target-like stress was observed in 83.75% of tokens, suggests that these arbitrary phonological rules have successfully been acquired by the speakers in this study.

  However, the over-application of the [ʔ] stress rules leads to one of the two major groups of unexpected stresses in this data set. Of the 52 tokens displaying unexpected stress, 13 can be explained by the over-application of [ʔ] stress rules. Recall that nouns, which frequently contain two-syllable roots, are iambic. In some instances in this data set, nouns were realized with trochaic stress if the initial syllable contained a coda /ʔ/:

(12) a.   [(muʔ.ˈɣom)]   (expected stress)
      mughom
      dictionary
      '(a) dictionary'

   b.   [(ˈmuʔ. ɣom)]   (unexpected stress)
      mughom
      dictionary
      '(a) dictionary'

In the nominal root provided in (12), the iambic stress rule states that the target-like stress application should be as provided in (12a), with stress on the second syllable of the root. However, because the initial syllable of the root ends in [ʔ], stress was occasionally produced on this syllable instead. It should be noted that the data in (12) present a limited production error: Both productions of this lexeme were evidenced in the data set in short succession (the second production was not a correction, it belonged to a different utterance).

  Despite the fact that only 13 of 52 realizations of unexpected stress can be attributed to over-application of the [ʔ] stress rules, such as in (12b), data such as these make up the second largest possible grouping of unexpected stresses within the data set. This observation suggests that, while the general stress rules have been acquired, the arbitrariness of the phonological rule sometimes overrides the role that representations of morphosyntactic categories play in stress assignment. The other major grouping of unexpected stress realizations is in the category of proper nouns, which we turn to now.

4.2 Proper nouns

Unlike all other part-of-speech categories, proper nouns made up the only part of speech where expected stress was realized at chance – speakers produced target-like stress significantly above chance on all other parts of speech. Of the 27 tokens categorized as proper nouns, 14 displayed unexpected stress patterns (again, based on the strict

application of stress rules provided in Okrand (1992)). However, this is not without precedent.

When *Star Trek: The Original Series* (TOS) first aired in the 1960s, the Klingon language had not yet been invented. The only instances of "Klingonese" (as it was called at the time) heard in TOS were character names such as Koloth (*qolotlh* [ˈqʰo.lotɬ]), Mara (*mara* [ˈmɑ.rɑ]), and Kahless (qeylIS [ˈqʰɛɪ.lɪʂ]).[7] When Klingon was later invented in the 1980s, the pronunciations of the names at that time became cannon. This tradition continued into the later *Star Trek* franchises with the *Star Trek: The Next Generation* pronunciation of the Klingon opera, Aktuh (*'aqtu'*) and Melota (*mellota'*) where actor, Michael Dorn (lt. cmdr. Worf) stressed the second, rather than final, syllable of Melota: [ʔɑq.ˈtʰuʔ mɛl.ˈlo.tʰɑʔ dʒɛ]. Also, later in *Star Trek: Deep Space 9*, we were introduced to the Klingon General, Martok, (*martaq* [ˈmɑr.tɑq]), whose name received initial, rather than final stress. These observations—which make up some of the input that learners of this constructed language hear—suggest that there is evidence for speakers to create lexical stress on any given lexeme that falls into the proper noun category, rather than assigning stress according to the arbitrary phonological rules of the language. However, one other explanation should also be considered – the role of cognates in L2 production.

Klingon does have some cognates that it shares with English, such as *leSpal*, the name for a stringed instrument (*i.e.,* the Les Paul guitar). But most of the English cognates in Klingon are proper nouns: *qa'naDa'* ([qʰɑʔ.nɑ.ɖɑʔ]) for 'Canada' or *noregh* ([no.rɛɣ]) for 'Norway'. Carroll & Windsor (2015), investigating factors that impede target L2 production in first-exposure learners of German, found that cognate forms, proper nouns in that study as well, were a significant predictor of non-target-like productions. Results such as those in Carroll & Windsor, and in the data examined in this study, suggest that cognate forms facilitate transfer effects rather than target-like pronunciation. This is perhaps the reason why *noregh* 'Norway' was realized by a speaker in this study as [ˈno.rɛɣ], with an English-like trochaic stress, rather than the expected [no.ˈrɛɣ] with iambic stress. It should also be noted that the speaker who produced the unexpected stress on *noregh* 'Norway' agrees that this was a production error, and not the lexical stress of this word in Klingon.

The idea that previously established Klingon proper nouns—which were first introduced by English writers of the *Star Trek* series—created cognates with the later-developed Klingon names for speakers of the invented language is conjecture. However, the fact that names of countries like Canada and Norway are rendered in Klingon as phonological adaptations of the English pronunciations, undoubtedly makes them cognates for L1-English speakers of Klingon. Therefore, the observation that proper nouns—many of which have English cognates in the data set examined here—display unexpected stress patterns in roughly half of the tokens examined, provides further support to the results of Carroll & Windsor (2015): That cognate forms impede target-like L2 pronunciations.

The discussion in this section on the over-application of a [ʔ] stress rule and the role of cognates in L2 production allows us to account for roughly half of the unexpected stresses observed in the data set (27 of 52). For the remaining instances of unexpected

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[7] Koloth and Mara's names were first heard in the episode "Trouble with Tribbles," which originally aired on Dec. 29, 1967; and, Kahless' name was first heard in the episode "The Savage Curtain," which originally aired on Mar. 7, 1969.

stress, we could find no commonalities that allowed them to be grouped into meaningful categories.

5.   Discussion and further questions

The study reported in this article examined the realization of stress on 320 tokens by seven advanced learners of the constructed language, Klingon. Although the rules of stress assignment in Klingon are arbitrary, and not substantially motivated or generalizable across different morphosyntactic domains, target-like stress was observed on 244 of the 320 tokens examined (76.25% accuracy). We found that the unexpected stress of a further 24 tokens could be explained by appealing to information structure to stress suffixes indicating things like emphasis or negation. Considering the role of information structure, this put speakers' accuracy up to 83.75%, with no statistical difference between speakers (p = 0.96). Therefore, all speakers realized target-like stress significantly above chance.

In examining where unexpected stresses were realized (in a total of 52 tokens of the overall 320 tokens), 13 instances of non-target-like stress could be attributed to the over-application of coda-[ʔ] attracting stress. A further 14 instances of unexpected stress were attributed to cognate forms found in proper nouns (e.g., for *noregh* 'Norway', which was reliably produced with English-like trochaic stress, rather than the expected target-like iambic stress).

The observations from this study support three conclusions: i. The arbitrary stress system of Klingon can successfully be acquired, and can be said to have been acquired by all speakers who provided data for this study; ii. A complexity bias advantage facilitates L2 acquisition; and, iii. Cognate forms impede target-like L2 production.

The first conclusion is supported by the fact that target-like production was observed in 83.75% of tokens, showing that all speakers were performing significantly above chance. The second conclusion relies on several factors. The stress system of Klingon is unnatural (*i.e.,* it does not provide a substantive bias advantage for L2 acquisition). Further, stress assignment rules cannot be generalized across morphosyntactic domains; there are different rules for stress assignment in nouns and verbs, therefore it does not provide a domain generalization bias advantage for L2 acquisition. However, Klingon phonological patterns provide evidence for a simplex representational system since there is no reason to suggest that speakers need to acquire representations for moraic timing units or metrical feet. This final observation suggests that Klingon does provide a complexity bias advantage for L2 acquisition since it is representationally simple, and the rules for stress assignment are regular and well attested in the input (with the possible exception of proper nouns). Therefore, this provides evidence that a complexity bias, in near isolation from other learning biases, facilitates L2 acquisition as evidenced in the production data examined in this study. These first two conclusions support the position of Moreton & Pater (2012) who argue that simplex representations facilitate learning and phonetic unnaturalness does not impede learning (contra Hayes *et al.* 2009 and White 2014 who argue that unnatural phonological constraints can only be weakly learned). Finally, based on the observation that the largest grouping of unexpected stress in the present study was found in proper nouns, we suggest that these results support the findings of Carroll & Windsor (2015) – that cognate forms impede target-like pronunciation in the L2.

The data examined in this study come from seven advanced learners of Klingon. As stated above, we found that the speakers in this study have successfully acquired the arbitrary stress system of that language, as evidenced in their production data from spontaneous conversation. However, there are questions that cannot be answered with the present data. Moreton & Pater (2012) argue that sensitivity to patterns increases with sleep, and so studies on artificial phonology are needed on a longer time scale so that more subtle effects can be noticed, compared to previous studies. The study presented here examines a late stage of L2 phonological acquisition. It is not known how quickly the patterns examined here are acquired. If target-like stress realization is not evidenced in the initial stages of acquisition, this might explain why the studies presented in Hayes *et al.* (2009) and White (2014) found that unnatural patterns can only be weakly learned. Perhaps, as Moreton & Pater (2012) suggest, studies such as Hayes *et al.* (2009) and White (2014) need to be replicated over a larger time scale to see if the acquisition of unnatural phonological patterns improves over time.

Finally, to support the conjecture that cognate forms are responsible for stress realization in proper nouns being observed only at chance, we suggest that this study should be replicated using advanced L2 learners of Klingon with different L1s. The speakers in this study all report English as their L1 making some of the Klingon proper nouns cognates with their English counterparts. If, however, this study were replicated with speakers whose L1 is not English, the same cognate status of these proper nouns may not exist.

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