The Acquisition of Metrical Opacity: A Longitudinal Case Study from Northern East Cree

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1. Introduction

The phonological systems of the world's languages differ from one another on a number of counts, for example with regard to their segmental inventories. The same holds true at the level of rhythm and prosodic prominence; among other details, languages may differ in how they assign rhythm to syllable groupings (e.g. so-called iambic versus trochaic systems) as well as in related characteristics such as syllable weight, which may affect the status of a syllable with respect to its being stressed, stressable or unstressable. Other phenomena often found in the description of metrical systems include extrametricality, whereby given phonological units, be they segments, syllables or even larger units such as the foot, may be excluded from the computation of stress altogether (e.g. Hayes 1995). To further complicate matters, conditions such as extrametricality may also be suppressed in case their application would make a word unstressable and, therefore, phonologically ungrammatical. For example, in languages with syllable extrametricality, the only syllable in a monosyllabic word cannot be excluded from stress parsing (by virtue of extrametricality) if the language requires each word to be stressed.

Languages with invariant metrical systems, for example ones which consistently assign syllable prominence to word/phrase-initial/final positions, are relatively easy to describe. Conversely, languages such as English that display alternating stress patterns, i.e. alternations between strong (stressed) and weak (unstressed) syllables, which involve a number of analytical considerations, may also display further complications, depending on a number of phonological and morphological considerations. The different stress patterns found between the morphologically-related words *eLECtric* versus *elecTRIcity*, for example, suffice to illustrate such complications. Such languages thus offer interesting benchmarks for the testing of competing theories of phonology and lexical representation. This is especially true in the context of language acquisition.

In this paper, we discuss two general approaches to lexical representation, namely the generative approach (e.g. Hayes 1995 and references therein) versus the exemplar-based approach (e.g. Bybee 2001). These two approaches to lexical representation vary in a number of fundamental ways, chief among which is the notion of derivation between lexical and output (phonetic) forms. On the one hand, the generative approach typically favours a simple lexicon associated with a set of interacting rules or constraints that govern the shape of outputs, such that *electric* and *electricity* are grammatically derived from a single root form. On the other hand, the exemplar-based approach rejects the underlying/surface dichotomy and instead posits that all the grammatical forms associated with a given lexeme are stored in the lexicon; *electric* and *electricity* are thus represented in two separate entries in the lexicon, themselves related by segmental and/or semantic similarities. In this approach, speakers' intuitions or 'knowledge' about morphological relatedness do not involve the sharing of a single root by different grammatically-derived forms. Instead, such intuitions are seen as the result of segmental and semantic generalizations across the lexicon.

While each available version of these competing approaches has been developed based on evidence coming primarily from adult languages, their validity must also be assessed from the perspective of first (and/or later) language acquisition. These two approaches indeed make significantly different predictions with regard to how the learner builds his/her lexicon. Within the generative approach, words are represented as semi-autonomous levels of prosodic and melodic specifications (e.g. Selkirk 1980; Itô 1986). Among other predictions, we thus expect potential (over-)generalizations of the most transparent aspects of the system during acquisition. Idiosyncratic or more abstract properties of lexical representations should be acquired progressively, on a word-by-word basis. Conversely, within the exemplar-based approach, words are represented as memorized acoustic traces (e.g. Bybee 2001). Early word representations are predicted to contain at least the most salient properties of the memorized exemplars. Also, generalizations across the lexicon can only happen once a minimal set of lexical items is acquired.

In the sections that follow, we tackle this theoretical debate with acquisition data from one learner of Northern East Cree (henceforth, NE Cree), an Algonquian language spoken in the James Bay region of Northern Québec.[1] Building on the key observation that children are typically faithful to stressed syllables in early words, regardless of the phonetic correlates of stress of the target language (e.g. Fikkert 1994; Demuth 1995; Pater 1997; Freitas 1997; Rose 2000; Ota 2003), we focus on the development of stress (pitch accent).

We begin with a description of the NE Cree phonological system. We then turn to our investigation, and introduce the child language data relevant to addressing the above debate. In our ensuing discussion, we argue that the developmental patterns observed generally support the generative view. As we will see, the child appears to grammatically flatten the various intricacies of the target system into a single analysis, thereby leaving aside patterns of syllable prominence whose manifestation in early speech forms should be expected under the exemplar-based approach.

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[1] NE Cree is a subdialect of East Cree, along with neighbouring Southern East Cree. It is a member of the Cree-Montagnais-Naskapi (CMN) dialect continuum, which is a Central Algonquian language (MacKenzie 1980).

2. The NE Cree phonological system: an overview

Algonquian languages are polysynthetic and, as such, often yield relatively lengthy and morphologically complex word forms, which the child must decode in the course of acquisition. In addition to this, the NE Cree segmental and prosodic systems display a number of intricate properties, which we describe in the following subsections.

2.1 Vowel inventory

The vowels and diphthongs of NE Cree are divided into 'long' versus 'short'. Synchronically, long vowels can be as short in duration as the short vowels, and so the contrast in vowel length is not a reliable cue to the two categories of vowels. Instead, vowel quality is a more reliable cue to long versus short status: as shown in (1) and (2), most long vowels are tense, and all short vowels are lax.

(1) Vowels

Long		Short	
î [i(:)]	*û* [u(:), o(:)]	*i* [ɪ, ɨ, ə]	*u* [ʊ]
â [ɛ(:), æ(:), a(:)]		*a* [ɪ, ɛ, ɨ, ə, ʌ]	

(2) Diphthongs (long): *âw* [ɑw], *aw* [aw], *wâw* [(ʷ)ɒ(ʷ),(ʷ)ɔ(ʷ)], *wâ* [wɑ], *îw* [iu], *iw* [ɪw, uː, oː], *uy* [ʊj], *wî* [wi], *wîw* [wiw]

The long versus short distinction is phonologically active in NE Cree. It is relevant for the process of Initial Change (morphologically-conditioned ablaut), where long /â/ becomes [ijâ] while, in contrast, short /a/ becomes [â] (MacKenzie 1980:187). Long vowels also attract pitch accent, and cannot undergo syncope, while short vowels, in contrast, are lax and can undergo syncope (see below).

2.2 Pitch accent

NE Cree displays an abstract metrical system whose analysis is challenging even for the linguist (e.g. Dyck et al. 2006; Wood 2006; Swain 2009). NE Cree words have one pitch accent per citation form. Accent falls on one of the last three syllables in long words and, typically, the rightmost stressable syllable is accented. However, some departures from the latter observations, which are discussed below, suggest that accent might be lexically idiosyncratic in some instances.

There are two types of accent, final (3a) and non-final (3b). Final accent (3a) is morphologically conditioned. In contrast, non-final accent (3b) is the default pattern for words in isolation and in context. (Syllable boundaries are indicated by periods in the orthographic representation and by spaces in the transcriptions.)

(3) Pitch accent
  a. Final
    chî.mân-h [tʃiː ˈmaːnʰ] 'boats (plural inanimate suffix)'
    ûh.kum-h [uːh ˈkʊmʰ] 'someone's grandmother (obviative suffix)'
  b. Non-final
    chî.mân [ˈtʃiː maːn] 'boat'
    nuh.kum [ˈnʊh kʊm] 'my grand-mother'

Words with final accent all end with a suffix, spelled as <-*h*> and realized with heavy aspiration. Historically, it derives from plural inanimate and (the homophonous) obviative **-a*, as well as from other suffixes. (All word-final short vowels are deleted in NE Cree through a regular sound change; MacKenzie 1980: 119-123.)

Non-final accent either falls on the penult or the antepenult. If the penult or antepenult is long (4), the rules of accent placement are clear: the penult is accented when it is long (4a); in contrast, the antepenult is accented when it is long and the penult is short (4b). (L, S, and F stand for long, short, and final syllables respectively.)

(4) Non-final accent, long penult or antepenult
  a. Penult (…LˈLF): *kâh.kâ.chiw* [kaːh ˈka tʃuː] 'raven'
  b. Antepenult (…ˈLSF): *pû.tâ.chi.kin* [puː ˈtaː tʃɪ kɪn] 'mouth organ'

However, if both the penult and antepenult are short, the rules of accent placement are unclear. As shown in (5), words with identical syllable structure (LSSF) can be accented on either the penult (5a) or the antepenult (5b). The variation shown in (5) is not free: the word in (5a) must have penultimate accent, and the word in (5b) requires antepenultimate accent.

(5) Non-final accent
  a. Penult (LSˈSF): *pîh.tu.si.nân* [piːh tʰ ˈsɪn naːn] 'ammunition pouch'
  b. Antepenult (LˈSSF): *pâ.yi.ku.shâp* [pa ˈjɪ kʷ ʃæpʰ] 'eleven'

In summary, accent in some words might be lexicalized, minimally for a subset of nouns with a short penult and antepenult. However, it is clear that the NE Cree accent placement is partly determined by quantity sensitivity ((4); and (4) versus (5)), and by extrametricality ((3a) versus (3b)). NE Cree thus displays an abstract metrical system whose analysis poses its own challenges, not least among which is final extrametricality, suppressed in case it yields sub-minimal or unstressable words (e.g. one-syllable words). Also, an analysis based on issues such as syllable weight is required to determine which of the three rightmost syllables is accented in long words. Finally, the language displays a number of idiosyncratic metrical patterns which further complicate the overall evidence available to the learner.

Presumably, the simplest way to acquire such a system should be through a highly suppletive lexicon, one in which each word form would be memorized with its own pitch contour. However, as we will see, the child instead displays word productions that reflect the most basic aspects of the target system. Before we turn to the relevant data, we provide an overview of our research project on the first language development of NE Cree and briefly describe our empirical approach.

3. The database

3.1 The Chisasibi Child Language Acquisition Study

The database is comprised of approximately 120 video recordings made between 2004 and 2007 (30 months) within the context of the Chisasibi Child Language Acquisition Study (CCLAS).[2] There were five participants in total, two in the younger cohort (A), and three in the older cohort (B). At the start of the study, cohort A were aged between 1;8 and 2 yrs, and cohort B were aged between 3;10 and 4 yrs. When recording ended, the oldest participants of each group were aged, respectively, 4;6 yrs and 6;6 yrs. CCLAS was thus able to gather data on four and a half of the major language learning years (1;8 to 4;6 yrs) in a 30-month period. Participants were video-recorded in familiar surroundings (usually their home) at approximately two to three week intervals, with each session lasting on average 30 minutes.[3] In all of the recordings participants interacted in a naturalistic manner with the (then) project coordinator, Darlene Bearskin, a native speaker of NE Cree. She engaged the children in activities conducive to language production, such as looking at pictures or playing with toys, but did not attempt to elicit specific linguistic structures.[4] While the majority of Cree people in Chisasibi speak English as a second language, Cree remains very much the primary community language. Participants were chosen from families self-reporting as principally Cree-speaking in the home. To date, CCLAS is the first in-depth naturalistic acquisition study for an Algonquian language. The study focuses on production only. The data discussed below come from the first child of our A cohort, a girl code-named A1.

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[3] Many Cree families maintain a traditional lifestyle, spending periods of time out on the land, for which reason participants were not always available for bimonthly recording. Participant A1, on whom the present study is based, was however available for regular recording for most of the 30-month period.

[4] In order to facilitate the analysis of data, Ms. Bearskin repeated the target form(s) for any child utterances she felt might be hard for other researchers to identify. This was especially important in the case of the younger participants whose productions more often fall short of the target.

3.2 Data recording and transcription

The video recordings were made using a tripod-mounted mini DV camcorder and tapes and a stationary (i.e., not attached to the child) microphone. The recordings were then processed by the research team at Memorial University by means of the following stages. IMPORT: Each file (video recording) is imported into *Phon*, the software used to handle all the CCLAS data. TAGGING: A student team member watches each recording and attempts to create one record per child utterance, electronically tagging bursts of child speech. (The adult side of the conversation always remains accessible, but is not tagged as a record.) Each record consists of a number of fields (e.g. orthography, IPA actual, IPA target, morphology, English translation, notes on context) and is linked to the relevant segment of video recording. TRANSCRIPTION: A narrow transcription of the child language is made under double-blind conditions. Transcribers, most of whom are native English speakers, follow project guidelines to ensure as much symbolic consistency as possible in the database. Certain phonological properties of Cree regularly pose a challenge for the English speaker; for example, voice is not a contrastive feature for obstruents. For this reason we made the (arbitrary) decision to regularly transcribe obstruent stops with their voiceless counterparts only. The quality of this set of sounds is subsequently verified either by native speakers or by computer (acoustic) analyses. We follow the same checking procedure for identifying stress, since the correlates of stress in Cree differ from those of English. VALIDATION: For each session, the two independently made transcriptions are checked against each other and a single transcription is arrived at. Where necessary, discrepancies between the two transcriptions are settled through the use of acoustic analysis. To this point, there are no English translations of the data. RECORD INTEGRITY CHECK: A Cree speaker checks that the records created by the (non-Cree-speaking) researcher have captured no more and no less than a single child utterance; adjustments are made where necessary. ORAL COMMENTARY: This stage is so called because the entire procedure is audio recorded; information is subsequently added to *Phon.* A Cree speaker watches the entire video recording and provides commentary on (minimally): (i) Cree-to-English translation, for all child language, and for relevant portions of adult language; (ii) elaboration on contextual information; (iii) verification of target forms; and (iv) comment on any innovative language use (lexical or structural). DATA ENTRY: The information provided by the oral commentary is then entered into the relevant field for each *Phon* record. A broad IPA transcription is made for the targets, but the adult language is not otherwise transcribed into IPA. CREE ORTHOGRAPHY: Each child utterance is represented in Cree orthography (reconstructed from the IPA target). MORPHOLOGICAL ANALYSIS: For each child utterance, and for its corresponding target, word boundaries and syntactic categories are identified and, at the level of morphology, morpheme glosses are provided. (IPA fields preserve the phonological phrasing of the utterances.) The data are now amenable to analysis at the levels of phonology, morphology, or syntax.

4. The data from child A1
4.1 Mastery of the phonetic cues

As we allude to above, previous research on the acquisition of phonetic cues of stress (most of which describe English learners) shows that children acquire stress cues early in the course of language development (e.g. Kehoe et al. 1995). Research on English-learning children's productions also shows that young children have difficulty reducing unstressed syllables at the onset of acquisition (e.g. Allen & Hawkins 1980; Schwartz et al. 1996; Pollock et al. 1993).

Both of these findings are supported by A1's productions. Acoustic analysis demonstrates her target-like use of pitch to mark stress (Swain 2009: chapter 5). Additionally, her ability to weaken unstressed syllables improves markedly over time. For example, A1's rate of unstressed syllable deletion increases by 33% from age 2;02.02 to 4;01.30.

These results indicate that the child had no issue with the phonetic perception or production of pitch accent contours in her produced word forms. However, as we discuss in the next section, the child displays a systematic pattern of errors, often accenting syllables in positions that are clearly ungrammatical from an adult perspective but which reveal a basic yet incomplete understanding of the target metrical system.

4.2 Mastery of stress patterns
4.2.1 Word-final stress

One of the most striking observations to be made about A1's stress productions is that she produces correct stress with a high degree of consistency when it is on the final syllable in the target language, as can be seen in (6).

(6) Percentage of accuracy with word-final stress

Age	Attempts	Errors	Target-like stress
2;02.02	14	1	92.9%
2;08.28	47	0	100%
3;04.09	14	0	100%
3;06.23	16	0	100%
4;01.30	32	0	100%

As shown in (6), only one example of incorrect placement of final stress is attested in the entire A1 corpus, and this one example is from a relatively early developmental stage. Some examples of words with final stress are given in (7).

(7) Examples of words with final stress

Orthography	Translation	Target IPA	IPA Actual	Age
chipiha	close it	[tə'ba]	[ə'ba]	2;02.2
ihtâyû	s/he is there	[da'jo]	[dæ'na]	2;02.2
châkwân	someone who...	[tə'gʌn]	[dʌ'no]	2;02.2
tâpâ	no	[də'bæ]	['bʊ]	2;08.28
pichihtin	it falls down	[bɪts'tɪn]	['dʒʊn]	2;08.28

4.2.2 Penultimate stress

Although A1 acquired word final stress early on, her rate of accuracy in producing forms with penultimate stress reveal that these present a greater learning challenge. As shown in (8), A1's overall accuracy with penultimate stress is generally much lower.

(8) Percentage of accuracy in words with penultimate stress

Age	Attempts	Errors	Target-like stress	Shifted to final stress
2;02.02	24	9	62.5%	9/9
2;08.28	35	14	60%	14/14
3;04.09	41	19	53.7%	17/17
3;06.23	33	11	66.7%	10/10
4;01.30	39	6	84.6%	6/6

At age 2;02.02 A1 accurately produces penultimate stress at a rate of only 62.5%. By age 4;01.30, this rate increases to 84.6%. This increase suggests that A1 has only progressively, but not quite completely, acquired penultimate stress over a relatively long time period (2 years). Note also that there is a dip in performance at age 3;04.09, which we discuss further below. Furthermore, when A1's realization of target penultimate stress is incorrect she most frequently shifts stress rightward to the final syllable. Examples of this stress shift are given in (9).

(9) Examples of penultimate-to-final stress shift

Orthography	Translation	Target IPA	IPA Actual	Age
iyâwâu	have it	['jawo]	[ʔo'ʔo]	2;02.02
chûchû	breast feed	['dʒodʒo]	[do'dʒo]	2;02.02/ 2;08.28
nâtâ	over there	['nadɑ]	[dɛp'tɛ̃]	2;02.02/ 2;08.28
kûhkûm	Grandma	['gʊkum]	[gʊ'go]	2;02.02
pîpîsh	little baby	['bibiʃ]	[bi'biʃ]	2;08.28
chîhtû	it works	['dʒido]	[dʒi'jo]	2;08.28
kîkî	it hurts	['gigi]	[gɪ'gi]	2;08.28
mîmîu	sleep	['mimjaw]	[mi'mi]	2;08.28

4.2.3 Antepenultimate stress

Compared to her performance on penultimate and final stress, A1's rate of accuracy with antepenultimate stress is very low, as can be seen in (10).

(10) Percentage of accuracy in words with antepenultimate stress

Age	Attempts	Errors	Target-like stress	Shifted to final stress
2;02.02	7	6	14.3%	6/6
2;08.28	12	6	50%	7/7
3;04.09	16	12	25%	12/12
3;06.23	32	5	84.4%	4/5
4;01.30	12	3	75%	3/3

Initially, at age 2;02.02, A1 only produces one of seven such stress patterns correctly. By 3;06.23, however, she attains target antepenultimate stress in the majority of forms.

The table in (10) also shows an increase in performance at age 2;08.28. A1's performance however drops noticeably at age 3;04.09 before it resumes its upward trend in subsequent sessions. The increase in accuracy at age 2;08.28 can be partially attributed to the fact that three of the six correct productions of antepenultimate stress are attempts at the same lexical item: *pwâchikî* 'boogieman'. As for the seemingly large drop in A1's accuracy at age 3;04.09, recall from the preceding subsection that it also affected target words with penultimate stress. We provide further discussion of this observation in the following subsection.

Similar to the pattern observed in A1's errors with penultimate stress, she also almost consistently shifts antepenultimate stress to the final syllable as shown in (11) (where vowel syncope in target forms is indicated by "_").

(11) Examples of antepenultimate-to-final stress shift

Orthography	Translation	Target IPA	IPA Actual	Age
mânitâh	like that	[ˈmæn_də]	[ənˈdʌ]	2;02.2
âkutâh	right there	[ˈagoda]	[ɛˈde]	2;02.2
pwâchikî	boogieman	[ˈbʌdʒəgi]	[dibˈdi]	2;02.2
ituhtâu	it goes	[ˈi_dɛn]	[dæˈda]	2;08.28
pîtihwâu	put it in pocket	[ˈbit^{h}_o]	[ˈdo]	2;08.28
minitûsh	insect	[ˈmin_doʃ]	[miˈnoʃ]	2;08.28

As we can see from these examples, the child displays a fairly systematic pattern of errors in her production of target words with non-final prominence. She also displays a gradual improvement through time, as she gains knowledge of the more intricate aspects of stress in words whose metrical patterning is more abstract due to factors such as syllable weight, the related process of vowel syncope, and extrametricality.

4.2.4 Additional evidence from MLUs

The acquisition of NE Cree complex word structure, and by extension the prosodic aspects of the word, is in many ways comparable to the development of syntax in less morphologically complex languages such as English. Given this, we expect to see some relationship between performance in stress production and other aspects of grammatical productivity. In this respect, we have noticed a dip in performance in words with both penultimate and antepenultimate stress at age 3;04.09. As Swain (2009) observes, this dip actually correlates with a noticeable increase in the child's Mean Length of Utterance (MLU) if compared with the previous recording session, as in (12).

(12) A1's Mean Length of Utterance

Age	MLU
2;02.02	1.3
2;08.28	1.31
3;04.09	1.78
3;06.23	1.81
4;01.30	1.96

As hypothesized by Swain (2009: 60), the additional processing involved in producing the more morpho-syntactically complex utterances attested during that session may have partially hindered A1's ability to cope with prosodic parsing at that moment. This is consistent with the general view that U-shaped developmental curves coincide with changes in grammatical organization or processing, especially for forms that display irregular grammatical patterning (e.g. Marcus et al. 1992; see also Rumelhart & McClelland 1986 for a connectionist simulation of similar observations). Swain's hypothesis is further supported by Terry (2010), who shows from his study of morphological development in A1's productions that the child indeed begins to produce inflectional patterns exactly at this age, her productive vocabulary being generally uninflected before 3;04.09. Such evidence is certainly suggestive of the formal relationships that exist between morphological and prosodic structure in NE Cree.

We discuss the broader implications of this study in the context of the theoretical debate outlined in the introduction in the next section.

5. Discussion

Perhaps the most central observation about the stress shifts observed in the data is that they appear to be manifestations of a system that defaults to the final syllable as the locus for pitch accent. Interestingly, this over-application of final prominence reflects the most basic properties of the target metrical system, that is, rightmost prominence at the level of both the foot and the word (as described in section 2). From this basic stress pattern, A1 gradually acquires the more abstract aspects of the target prosodic system.

These results suggest an early grammatical bias in stress productions. This observation is in fact similar to that made by Fikkert (1994) who documents a pattern of stress shift displayed by Dutch learners. These children preserve both syllables of disyllabic words with final stress but systematically produce these forms with stress on the initial syllable (e.g. child Robin's production of *gitaar* /χiːˈtaːr/ → [ˈsiːtaː] 'guitar'). As Fikkert argues, these productions are conditioned by the predominant, trochaic stress pattern that exists in the target language, which yields an over-application of initial stress to all disyllabic forms. Fikkert's analysis is motivated by the metrical properties of the target language, the systematicity of the pattern, which regularizes away lexical exceptions, and by the broad consensus (e.g. Morgan 1996, Jusczyk 1997) that children make strong generalizations about the predominant stress patterns of their target languages. Such facts argue against simple misperception of the finally-stressed target forms. (See, e.g., Kehoe 1998 and Pater 2004 for related discussions.)

Both the NE Cree primary evidence discussed in this paper and the related, aforementioned findings by Fikkert (1994) thus argue in favour of a grammar-based approach to phonological representation and processing. We do not construe this to mean, however, that A1 has effectively learned all of the relevant metrical properties of NE Cree by the time of the last recording period covered by this study. For example, since no pattern of antepenultimate-to-penultimate stress shift appears in the data, we are left with no evidence for a generalization about the (iambic) foot form parameter, independent from extrametricality, during the period observed. We, instead, make the more careful claim that A1 was, throughout the study, in the process of understanding the overall system, in effect revising her stress patterns in a gradual fashion, on a word-by-word basis. Both the over-application of final stress and the gradual learning of the other target patterns are entirely predictable in an approach that favours grammatical stress parsing (as opposed to pattern memorization only), given that each NE Cree word with non-final stress comes with its own, sometimes abstract, combination of metrical characteristics.

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