

Introducing the Melodic Transcription (MeT) Scale for Language Documentation and Application

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1. Introduction

The Melodic Transcription (MeT) scale is a perceptual scale developed to contribute to the documentation of pitch movement in the Blackfoot language and to support the teaching and learning of Blackfoot prosody. This scale was developed as part of an online tool, Melodic Transcription in Language Documentation and Application (MeTILDA), which is an ongoing collaborative project among the co-authors: a linguist, a musicologist, a computer scientist, and a community stakeholder. The MeT scale is based on the semitone scale, an existing scale used in music and linguistics. The semitone scale is logarithmic and based on the fundamental frequencies within human auditory perception. However, the way this scale is implemented in music and linguistics differs, and each implementation has advantages in addressing the Blackfoot community's needs. These advantages have been combined to create the MeT scale.

Because community concerns are considered, this project is community-based research (CBR), as pursued by many documentary linguists today (e.g., Bischoff and Jany 2018; McDonnell, Berez-Kroeker, and Holton 2018). Such a project often includes applied approaches, which are significantly lacking among Indigenous language researchers (Penfield and Tucker 2011). Our project addresses this issue and connects linguistic research and language community needs.

This paper introduces the MeT scale for the purpose of language documentation and application. In section 2, the background of the project is outlined, including discussion of the language community, pronunciation study, pedagogy of pitch movement, Blackfoot pitch study, and pronunciation accuracy. Section 3 presents the development of the MeT scale by describing psychoacoustic scales, semitones, and the mechanism of the MeT scale. The conclusion summarizes the project and its implications for the connection between formal linguistics and language reclamation.

2. Background

The MeT scale was developed as part of a project on language documentation and application focused on Blackfoot pitch movement. Blackfoot is an Algonquian language spoken in Canada and the United States (US). Map 1, below, shows the locations of the reserves of the four Blackfoot speaking bands: Siksiká, Aapátóhsipiikani, and Kainai are in Alberta, Canada, and Aamsskáápipiikani is in

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Montana, US.¹ The language is spoken by approximately 2,750 people in Canada (Statistics Canada 2017) and 50 or fewer in the US (Darrell Kipp, personal communication to Miyashita in fall 2011). There are many community efforts to teach the language to children and adults in all four bands.



Map 1. Blackfoot speaking bands in Alberta, Canada, and Montana, United States.²

2.1. Pronunciation Study

Our project focuses on Blackfoot phonetics and phonology, addressing the documentation and application of the language’s pitch movement. The application consists of assisting teaching and learning the language. We have learned that many native speakers insist on accurate pronunciation when instructing learners. Some teachers try to correct students’ pronunciation by having them repeat words ad nauseam, as to teachers the pronunciation is important (Fish 2018). Further, it has been claimed that being able to produce “authentic” pronunciation is a way to honor elders through the spoken language (Bird and Kell 2017). However, achieving accurate pronunciation of a second language is challenging, and pronunciation learning techniques are significantly understudied in Indigenous languages (McIvor 2015). This situation is the same in Blackfoot. While there are a few studies in phonetics and phonology (e.g., Kaneko 1999, 2000; Stacy 2004; Weber 2012; Van der Mark 2002), these studies do not directly extend to pedagogy. However, there has been some recent study of pitch movement in Blackfoot words (Fish and Miyashita 2017, Miyashita and Weber 2020), and study in this area is an important step toward developing pronunciation learning strategies.

Although many Blackfoot language teachers focus on pronunciation, pitch in particular has not been a focus on explicit instruction by many Blackfoot language teachers. This may be because knowledge of pitch movement among native speakers is implicit, despite the fact that Blackfoot pitch is an important factor, as evidenced by contrasting words (e.g., *ákaohkiimiwa* ‘he’s married’ vs. *akáóhkiimiwa* ‘he has many wives’ Frantz, 2017:3). Furthermore, existing linguistics materials are typically impractical for pronunciation teaching and learning. This creates an interesting dichotomy: native-speaker instructors expect learners to produce accurate pronunciation, yet the collective knowledge of Blackfoot sound structure is understudied. Our project includes an investigation of the implicit knowledge of Blackfoot

¹ The term “reservation” is used in the United States and “reserve” in Canada. The antepenultimate high front vowel in Aapátóhsipiikani and Aamsskáápipiikani can be short or long.

² This map was created by Kevin McManigal, a cartographer at the University of Montana.

pitch as well as development of a pronunciation learning technique that helps teachers and learners realize pronunciation characteristics.

2.2. Blackfoot Pitch Movement and Teaching

Pitch movement is not explicitly visualized in writing. For example, take the Blackfoot words for ‘mouse,’ ‘boy,’ and ‘bread’ in (1), which are shown in the most widely used orthography (Frantz 1978). An International Phonetic Alphabet (IPA) transcription is shown beside the orthographic forms. In both, the acute symbol is added to show the “accent,” which indicates the highest pitch of the word. With respect to pitch assignment, linguists interested in finding patterns and analyzing them in a theoretical framework may choose to represent the prominent or accented high-pitched syllable with H* and the remaining non-prominent or low-pitched syllables with Ls; this notation is also included in (1).

(1) <i>káánaisskiinaa</i>	[ká:nes:ki:na:]	‘mouse’	H*LLL
<i>saahkómaapi</i>	[saxkóma:pi]	‘boy’	LH*LL
<i>napayínni</i>	[napajín:i]	‘bread’	LLH*L

While abstraction of pitch characteristics into two levels, whether by accent marking or with H* and L, works well for theoretical study, it does not serve the needs of language teachers and learners. For Blackfoot, many native-speaker teachers are not familiar with the orthography, and among those who did learn the writing system it is common to leave out the accent marker. And while the use of the pitch marking and its implementation seems to help learners’ pronunciation to a certain degree, it is not entirely helpful because the acute symbol indicates only the location of the highest pitch in the word, not the pitch movement throughout the entire word.

Therefore, orthography, IPA, and tonal symbols, alone or in combination, are not helpful to typical language teachers and learners with no linguistics background, who are the key individuals for the community’s language work. For linguistic research with a CBR approach, it is essential for the community’s stakeholders to be involved as team members, so that the research is designed from an early stage around the community’s needs and the project result will bear aspects that are useful to the community’s language revitalization activities. The reason for documenting implicit knowledge of Blackfoot pitch movement is partly because of the necessity identified through a series of conversations among the collaborators.

2.3. Blackfoot Pitch Study

First, existing linguistic resources regarding Blackfoot pitch were reviewed in order to understand the characteristics that have already been documented and to build on existing knowledge. For example, the accented syllable is realized with the highest pitch in a word (Frantz 2017), and fundamental frequency better represents the acoustic correlate of Blackfoot word prominence than intensity (Miyashita 2019). Furthermore, Blackfoot pitch accent is inherent (Uhlenbeck 1938, Frantz 2017). For example, the minimal pair in (2) is the same in terms of their sound sequences except that their pitch movements are different: one has the highest pitch on the first syllable and the other on the second.

(2) <i>ápssiw</i>	‘it’s an arrow’	H*L
<i>apssiw</i>	‘it’s a fig’	LH*

The representation of pitch in the orthography, and especially the notation using two levels of pitch (H and L), gives the impression that the pitch patterns of these two words mirror each other: ‘it’s an arrow’ is high to low, and ‘it’s a fig’ is low to high. However, measurements of the relative pitch of the words’ syllables reveal that their pitch movements are not, in fact, mirrors of one other, as shown in Figure 1, below. On both graphs, the dots indicate the fundamental frequencies (F₀) of the plotted vowels, and the dots are linked with a line. *ápssiw* ‘it’s an arrow’ (on the left) has steep drop, while *apssiw* ‘it’s a fig’ (on the right) has a shallower rise. Thus, for the study of actual pronunciation, using accentual markings alone is not sufficient.

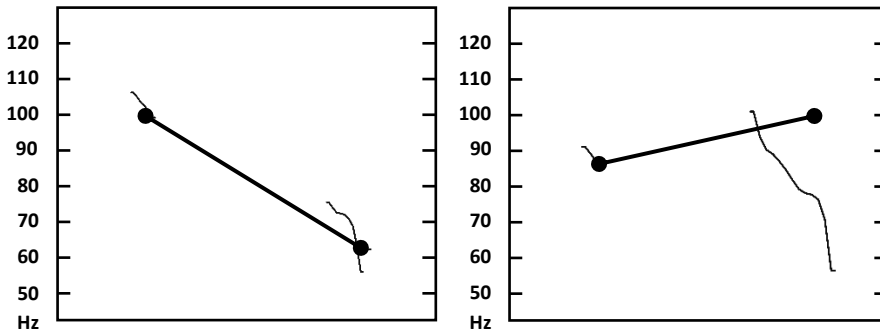


Figure 1. Pitch movement of *ápsšiw* ‘it’s an arrow’ (left) and *apššiw* ‘it’s a fig’ (right).

The curved lines in Figure 1 depict the tracked pitch contour. The pitch track on the right indicates the drastic drop in pitch from the accented, highest point of the vowel due to the language’s low boundary tone at the end of a word (Miyashita and Weber 2020). In addition, there is underlyingly another vowel, as the word’s reference form is *apššiw-wa*, with the suffix *-wa* indicating 3rd person singular; this vowel serves as the landing site of the low boundary tone. While the vowel of the suffix is dropped as vowel devoicing or dropping commonly occurs in Blackfoot (Gick et al. 2012, Prins 2019), the dropping pitch contour may be a remnant of the devoiced vowel, though further analysis is necessary for confirmation.

2.4. Pronunciation Accuracy and Pitch Movement

Perceiving Blackfoot pitch movement and producing it correctly are not intuitive tasks for second language learners whose first language is English. This is an important consideration, because many learners of the language within the community are English speakers. We have made an interesting observation regarding second language learners’ pronunciation with respect to correct pitch accent location and sound accuracy. Table 1, below, reflects two aspects of pronunciation of the word *saahkómaapi* ‘boy’ by nine learners, A~I. One aspect is whether the learner correctly located the highest pitch (pitch accent) on the second syllable, and the other is an accuracy score as rated by a native speaker. The speaker was directed to evaluate the learners’ production only on “intonation.”³ The scale for the accuracy score is 1 (least native-like pronunciation) to 7 (most native-like).

	A	B	C	D	E	F	G	H	I
Accent on σ_2	✓	✓	✓	✓?	✓		✓		
Score (1-7)	6	6	6	6	4	4	3	2	2

Table 1. Blackfoot learners’ prosodic accuracy.

Five of the nine learners correctly located the highest pitch on the second syllable, but not all of them scored high marks for the accuracy of their pitch movement.⁴ Among the nine learners, 6 was the highest score for intonation accuracy, and 2 was the lowest score. All four learners who received a score of 6 also correctly located the pitch accent; this is to be expected if pitch accent location is the determining element for native-like pronunciation. Learners F, H, and I did not produce the word with the correct accent location, and they did not receive accuracy scores higher than 4. Interestingly, Learners E and G did not receive the highest accuracy score (6, here) despite locating the accent correctly.

While the central topic of this paper is not second language acquisition, we briefly outline the characteristics of Learners A and E’s productions to make a point about focusing on pitch movement in

³ The speaker was directed to score two things for each word, the overall pronunciation and the intonation, to reinforce that the latter should reflect only the intonation (i.e., pitch movement).

⁴ Learner D’s highest pitch was on the nasal consonant between the second and the third syllables. In this utterance, the pitch on the second vowel rises, and that on the third syllable falls. Perceptually (to the linguist author), the second syllable with the rising pitch contour is the highest. The question mark for Learner D indicates the slight difference in the accent location.

language teaching and learning.⁵ Both learners accurately located the highest pitch on the second syllable, yet for pitch movement accuracy, student A scored 6 and student E scored 4. This means that locating the pitch accent on the correct syllable is not the only determining factor for intonation accuracy. How the pitch movement might be interacting with other elements of pronunciation is discussed below.

The graphs in Figure 2, below, show the pitch value shifts of the same word, *saahkómaapi* ‘boy,’ produced by a native speaker, Learner A, and Learner E. The x-axis is shown in hertz (Hz), and the y-axis indicates syllables, from first to fourth. The pitch values of the plotted vowels are connected by straight lines, showing the shifts up and down in pitch throughout the utterances. Comparing the pitch movements, Learner A’s graph looks more like the native speaker’s, with the difference being the pitch range. On the other hand, the relative pitch movement produced by Learner E shows an obvious difference, with shallower pitch drops from the second syllable to the third, creating a word melody distinct from that of the native speaker and Learner A. Our interpretation of this observation, combined with Learner A’s higher score for accurate intonation, is that pitch movement throughout the word is one of the determining factors of native-like pronunciation, and learners must acquire reasonably accurate relative pitch movement in addition to correctly locating the accent in a word.

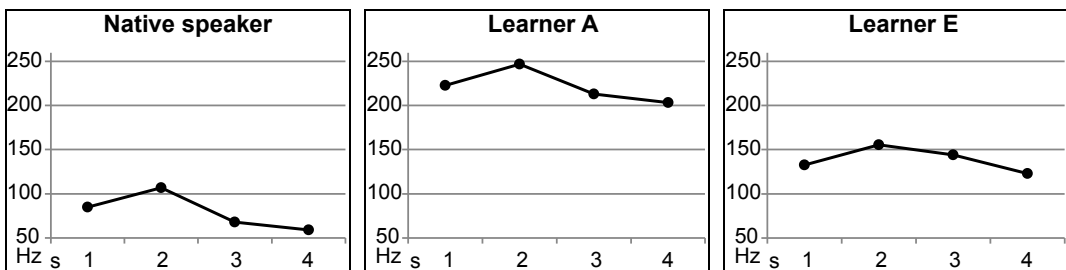


Figure 2. Plotted vowel pitches in *saahkómaapi* ‘boy’ of a native speaker and Learners A and E.

With respect to teaching suprasegmentals (e.g., stress, rhythm, and intonation), Anderson-Hsieh points out that “visual feedback combined with the auditory feedback ... is more effective than auditory feedback alone” (1994, 6). To help students learn accurate pitch movement, we developed a visual guide called Pitch Art, referring to pitch movement as “word melody” (Fish and Miyashita 2017). These word melodies are based on previous research that found that words with the same number of syllables and the same accent location have similar relative pitch movements. The Pitch Art images were utilized in Blackfoot language classes at the University of Montana during class meetings when word melody was instructed (Fish 2018, Bird and Miyashita 2018). Example Pitch Art images are shown in Figure 3.

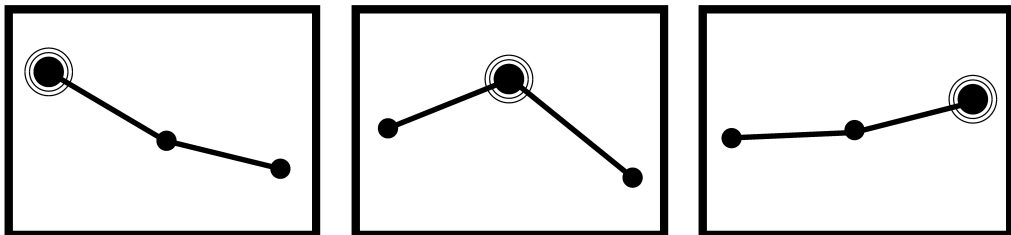


Figure 3. Examples of Pitch Art for three-syllable words with accent on the first, second, and third syllable, respectively.

⁵ Of course, pitch movement and accent location are not the only determining factors for sound accuracy. Despite the fact that the native speaker evaluator was directed to evaluate the pronunciations only based on pitch movement, multiple variables may have interacted with his decision-making processes. This paper does not further examine these issues, since they are beyond the scope of this study. See Fish and Miyashita (2021) for a related study.

3. Development of the MeT scale

In developing Pitch Art, the use of a psychoacoustic scale was considered. This section describes psychoacoustic scales in general, the semitone scale commonly used in tonal linguistics, and the modified scale used in this project: the Melodic Transcription (MeT) scale.

3.1. Psychoacoustic scales

Those who are familiar with musical pitch or the physics of sound may skip this section, which provides a brief explanation of psychoacoustic scales. The purpose of psychoacoustic scales is “to provide steps which correspond to equal perceptual intervals” (Nolan 2003, 771). To illustrate this concept, this section uses the example of the pitch movements of a native speaker and Learner A (who scored a 6 in the pitch accuracy evaluation) pronouncing the same word referenced in the previous section, *saahkómaapi* ‘boy.’ On the left in Figure 4, below, the dots represent syllables plotted by fundamental frequencies in Hz. The pitch track in the lower range is by the native speaker, an elderly male with a deep voice, and the track in the higher range is by Learner A, a female in her early 20s at the time of recording. The pitch shifts on this chart look almost identical. However, their relative pitch movements do not sound the same. This is because Hz, a unit of measure that represents sound wave cycles per second (CPS), does not match with how humans perceive sound. A scale or unit that matches with the human perception is called a “psychoacoustic scale.” When we normalize the fundamental frequencies of the two speakers’ utterances and use a psychoacoustic scale, the word melodies look different, as shown on the right in Figure 4. This graph uses semitones, a type of psychoacoustic scale that is also used in music, making these two pitch movements look more distinct and matching with how they sound to human ears. The range of the native speaker’s pronunciation is wider (approximately 10 semitones) than that of Learner A (approximately 4 semitones).

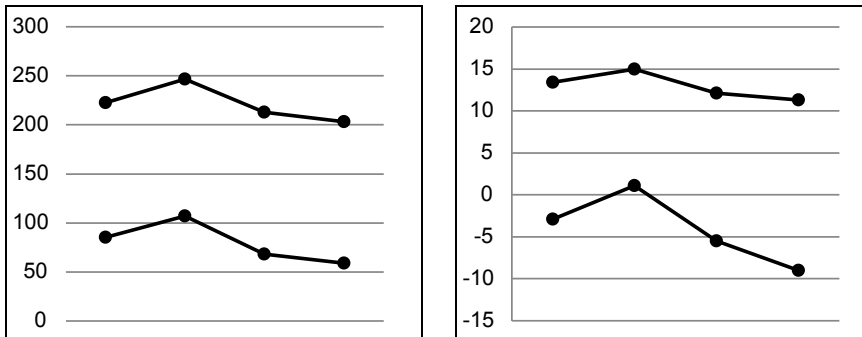


Figure 4. Pitch movements plotted at each vowel, shown in Hz (left) and semitones (right).

3.2. Semitones

We are using a semitone scale as the basis of our project for two reasons. First, according to the linguistics literature, the semitone scale best reflects human perception (Nolan 2003, Zhang 2018). Nolan’s examination of four psychoacoustic scales—semitones, Bark scale, mel scale, and ERB-rate scale—concluded that semitones and the ERB-rate scale best reflect the participants’ intuitions about intonational range (c.f. Rietveld and Chen 2006).⁶ The musical semitone scale is well known; it is used widely in the study of prosody and tonology (Wong and Diehl 2003). However, while the semitone scale has been used by many researchers in the study of pitch, tone, and intonation in dominant languages such as Mandarin, Cantonese, and languages in Africa, to our knowledge, the use of Hz is pervasive in research in the Indigenous languages of North America, including Blackfoot.

We also considered the familiarity of the semitone scale to our target population. Since the concept of semitones is used in music, semitone divisions are familiar to many people cross-culturally. A

⁶ Rietveld and Chen (2006) did not find semitones and ERB-rate as the best scales when examining pitch register; in contrast, Nolan (2003) looked at pitch span.

semitone scale is generally understood as a logarithmic frequency scale in which one octave consists of 12 semitones. For example, on a piano, the distance between one pitch and the closest adjacent pitch (i.e., white or black key) is one semitone. The semitone is commonly encountered in Western tonal music, which makes it a familiar reference for many people.

However, the way semitones have been utilized in linguistics is quite different from their use in music. In linguistics, semitones are typically used in descriptions of tonal languages and intonation studies, and the values of measured tones are shown using semitone distances from a reference point. For example, Praat offers options of 1, 100, 200, and 440 Hz for a reference point in showing pitch tracks (Boersma and Weenink 2013). So, while a musical tone is referred to with a specific name, in linguistics the label for a tone varies depending on the reference point. Table 2, below, shows five music semitones from A₂ to C₃-sharp and their corresponding values in Hz as well as semitones with reference points at 100 and 200Hz, as examples of the same tones referred to in multiple ways: if a tone measured as 110Hz, it is always referenced as A₂ in music, but in linguistics, it is 1.7 when the reference point is 100Hz and -10.3 when the reference point is 200Hz. For community-based documentation, having a single name for each tone would be most accessible.

Music notes	A ₂	A [#] ₂	B ₂	C ₃	C ₃ [#]
F0 (Hz)	110	116.5	123.5	130.8	138.6
St 100	1.7	2.6	3.6	4.6	5.6
St 200	-10.3	-9.4	-8.4	-7.4	-6.4

Table 2. Various referencing methods for the same tones.

Another difference between the use of semitones in music and linguistics is how they are represented visually. Music uses a staff with notes to represent changes in semitones. To a trained musician, the system communicates differences in pitch, but its practical use for non-musicians is limited. For instance, a succession of rising semitone pitches like A-flat (A^b), A-natural (Aⁿ), and A-sharp (A[#]) would all be represented on the same staff line, as shown in Figure 5. Understanding this graphic notation requires training, and the notation is not an absolute match with perception.

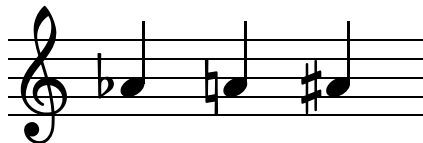


Figure 5. A^b, Aⁿ, and A[#] on a treble clef staff.

The image in Figure 6 shows the same sequence of A^b, Aⁿ, and A[#] on a graph similar to one used in the tonal study of languages. The rising of these semitones is visually represented, matching perception, and this better serves the needs of language teachers and learners. However, in this form there are no names for individual semitones, as in music.

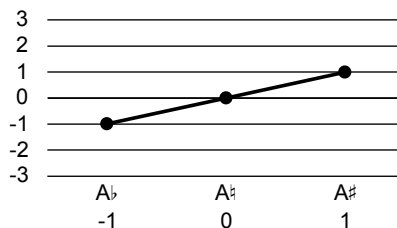


Figure 6. A^b, Aⁿ, and A[#] on a semitone graph.

4. Conclusion

This paper described the development of the Melodic Transcription scale. The MeT scale aims to represent pitch movement in a way that matches with human perception, incorporating the advantageous elements of semitone use in music and linguistics. Each tone in this scale has a unique name, as in music, and tone sequences are represented on a graph, as in linguistics. Also, the interval between adjacent tones is smaller than a quarter-tone interval and larger than a cent. As briefly mentioned in the introduction, the MeT scale was developed as part of the community-based applied project of an online tool, MeTILDA (Lee 2019) (<https://metilda.herokuapp.com/>). The current stage of MeTILDA can create Pitch Art images in one platform, whereas their creation previously involved at least three separate applications. The MeT scale is incorporated in the production of Pitch Art, and we aim for the tool to be user friendly in order to contribute to community stakeholders' activities as well as the documentation of Blackfoot in terms of pitch movement.

The use of MeTILDA and the MeT scale can go beyond Blackfoot; it can be used for other languages' teaching and learning, especially when the language's prosody and native-like pronunciation is characterized by pitch movement rather than strong-weak syllable alternation. Also, since an interval between adjacent MeT tones is smaller than the interval between semitones or even quarter-tones, the system can be applied to song transcriptions that require a tone scale finer than a quarter-tone system. For that matter, the MeT scale can also be used by communities to document their own songs.

The goals of typical formal linguistic research are rarely in line with language communities' language revitalization efforts. Since many linguists rely on language structure examples from Indigenous languages for their theoretical studies, it is typically the case that language communities serve linguistics research, and reciprocity in these relationships is quite low. This is an unfortunate and ironic reality, given that the National Science Foundation requires research proposals to include broader impacts, defined as "the potential to benefit society and contribute to the achievement of specific, desired societal outcomes" (National Science Foundation 2020, III-2). Considering the issue of connecting linguistic research with work on language reclamation, we believe that it is essential for language researchers and community stakeholders to work together. We also believe that our applied project serves to connect linguistic research and language community needs, and we aim to serve both academic and non-academic communities. Finally, we hope that by making a perceptual scale that is accessible to both researchers and community members, our project will serve as an example of research that embodies reciprocity.

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