Computationally modelling the morphophonology of Blackfoot

Expediting IGT creation and automating analysis testing

Joel Dunham

46th Algonquian Conference
October 25, 2014
collaborative fieldwork software
Desiderata

• automate the morphological parsing task
• automate the evaluation of analyses
Automate parsing
Automate parsing

nítsspiyi
/nit-ihpiyi/
I-dance
AGR-VAI
Automate evaluation
Automate evaluation

nítsspiyi
/nit-ihpiyi/
I-dance
AGR-VAI

Warning!
The morphological analysis you have specified is incompatible with your morphophonological model.
What I did

• built a parser-building application and integrated it into the OLD

• tested it on Blackfoot
Morphological parser:

a function from surface transcriptions to morphological analyses.
Parser = morphophonology + ranker

<nítsspiyi> → morphophonology
|                | phonology
|                | morphology
|                | morphotactics
|                | lexicon

{ /n-it-ihpiyi/, /nit-ihpiyi/, /nit-ihp-yi-yi/, ...

ranker ( /nit-ihpiyi/, /n-it-ihpiyi/, /nit-ihp-yi-yi/, ... )
Implementation

<nítsspiyi> \rightarrow \text{morphophonology} \rightarrow \{/n-it-ihpiyi/, /nit-ihpiyi/, /nit-ihp-yi-yi/, ...\} \rightarrow \text{ranker} \rightarrow (/nit-ihpiyi/, /n-it-ihpiyi/, /nit-ihp-yi-yi/, ...)

- morphophonology
- phonology
- morphology
- morphotactics
- lexicon

FST

N-gram language model
Specification

Ordered phonological rules

morphophonology

phonology

morphology

morphotactics

lexicon

Extracted from OLD corpora

{n-it-ihpiyi/, /nit-ihpiyi/, /nit-ihp-yi-yi/, ...}

ranker

{nit-ihpiyi/, /n-it-ihpiyi/, /nit-ihp-yi-yi/, ...}
<nitsspiyi>

morphophonology

phonology

morphology

morphotactics

lexicon

- → s / t _ i

ih → s / s _

word → \{AGR-VAI\}

AGR → \{/nit/\}

VAI → \{/ihpiyi/\}

{/nit-ihpiyi/}
Figure 3.4: FST network diagram for "--" -> s || k _ I ;.
FST

/k-I/ → [ksl]

Figure 3.4: FST network diagram for "--" → s || k_ l ;.
Figure 3.4: FST network diagram for \"\" -> s | l k _ I ;
Figure 3.4: FST network diagram for 

```
"-" -> s || k _ I ;
```

/ki-l/ → [ksl]  [ksl] → /ki-l/  [ksl] → /ksl/

FST
Your phonology is a computer program.
Appendix B: Phonological Rules

1. **GEMINATION**
   \[ C_1 \rightarrow C_2 / \_ + C_2 \]

   nitánIt + k + wa \rightarrow nitánIk + wa (7, 15. \rightarrow nitánikka)
   "He told me."

2. **s - INSERTION**
   \[ \emptyset \rightarrow s / I_t \]

   nitánItawa \rightarrow nitánIstawa (7. \rightarrow nitánistawa)
   "I told him."

3. **s - CONNECTION**
   a. \[ \emptyset \rightarrow s / C + s \]

   nit + siksipawa \rightarrow nítssiksipawa
   nit + ssikópii \rightarrow nítssikópii
   "I bit him"
   'I rested'

   b. \[ \emptyset \rightarrow 1 / V(\_)+s, \]

   where s is not part of a suffix.
N-gram language model

Corpus of analyzed words:
{nit-ihpiyi, n-aahk-ihpiyi, nit-it-ihpiyi, ...}

bigram counts:

<table>
<thead>
<tr>
<th>Bigram</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>nit ihpiyi</td>
<td>5</td>
</tr>
<tr>
<td>n aahk</td>
<td>17</td>
</tr>
<tr>
<td>aahk ihpiyi</td>
<td>1</td>
</tr>
<tr>
<td>nit it</td>
<td>106</td>
</tr>
<tr>
<td>it ihpiyi</td>
<td>12</td>
</tr>
<tr>
<td>n it</td>
<td>1</td>
</tr>
</tbody>
</table>

probability estimates:

\[ p(\text{nit-ihpiyi}) > p(\text{n-it-ihpiyi}) \]
morphological parser creator

rewrite rules

lexicon corpus

morphotactics
corpus

N-gram LM
corpus

parser creator

parser
test-driven phonology development (TDD)
rewrite rules
lexicon corpus
morphotactics
corpus
N-gram LM
corpus
collaborative
fieldwork software
morphological parser creator
parser
parser
Blackfoot Dictionary of Stems, Roots, and Affixes

DONALD G. FRANTZ and NORMA JEAN RUSSELL
<table>
<thead>
<tr>
<th>source</th>
<th>form count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blackfoot OLD</td>
<td></td>
</tr>
<tr>
<td>original fieldwork</td>
<td>7,416</td>
</tr>
<tr>
<td>grammar (Frantz, 1991)</td>
<td>1,020</td>
</tr>
<tr>
<td>other sources</td>
<td>467</td>
</tr>
<tr>
<td>dictionary (Frantz and Russell, 1995)</td>
<td>14,805</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>23,708</strong></td>
</tr>
</tbody>
</table>

Table 4.1: Sources of the Blackfoot data set.
Appendix B: Phonological Rules

1. GEMINATION
   \( C_1 \rightarrow C_2 / -C_2 \)

   nitánšt + k + wa \( \rightarrow \) nitánškk + wa (7, 15, \( \rightarrow \) nitáníkk)  
   "He told me."

2. s-INSERTION
   \( \emptyset \rightarrow s / I_t \)

   nitánštawa \( \rightarrow \) nitánštawa (7, \( \rightarrow \) nitánštawa)  
   "I told him."

3. s-CONNECTION
   a. \( \emptyset \rightarrow s / C+ s \)

   nit + siksipawa \( \rightarrow \) nitssiksipawa  
   "I bit him"

   nít + ssikópii \( \rightarrow \) nítssikópii  
   "I rested"

   b. \( \emptyset \rightarrow I / V()+_s, \)

       where \( _s \) is not part of a suffix.

# Phonological Rules (cf. Frantz 1991, pp. 152--155)

1. \( C_1-C_2 \rightarrow C_2C_2 \)

   # Geminatin Original

   # Note that this rule is actually quite contrived since it requires that the
   adjacent plosives be MADE adjacent by a previously applying rule. If they
   were underlyingly adjacent, then the so-called "stop-stop epenthesis" rule
   would insert /oh/ or /i/ between them. Note: geminationGeneral is not being
   used.

   define geminationGeneral [
   [ plosives "-" \( \rightarrow \) p || _ p ] .o.
   [ plosives "-" \( \rightarrow \) t || _ t ] .o.
   [ plosives "-" \( \rightarrow \) k || _ k ] ;
   ]

   define gemination [
   [ a n i s t \( \rightarrow \) a n i k || _ "-" k ] .o.
   [ t \( \rightarrow \) k || _ "-" k ] ;
   ]

2. \( s \rightarrow \) Ist

   # s-Insertion (assumes that "breaking I" is a phoneme)

   # Note: since the dictionary does not use /I/, this rule is not being used.

   # Instead it is assumed that words like waanit 'say to' are represented
   phonemically as /waaništ/ and there are special lexical rules to deal with
   /waaništ-ok/ \( \rightarrow \) [waanik], etc. (see above).

   define sInsertion [..] \( \rightarrow \) s || I _ t ;

3. \( C-s \rightarrow C ss, V()-s \rightarrow V()-is \)

   # s-Connection

   # condition on s-Connection "B": the 's' is not part of a suffix;

   # present implementation: transformation is optional.
t-Affrication

(Frantz 1997, p. 154)

\[
\begin{align*}
t \rightarrow & \quad ts / \_i \\
\approx & \quad - \rightarrow s / t \_i \\
\approx & \quad - \rightarrow s / t \_ \{i, i\}
\end{align*}
\]

"-" \rightarrow s \mid t \_ [i \mid i]
Breaking

- $\rightarrow$ s / k _ l

/nit-áak-itsiniki/ $\rightarrow$ nitáakitsiniki  /nit-áak-łpii/ $\rightarrow$ nitáaksipii

"-" $\rightarrow$ s || k _ [ i | í ]

/nit-áak-itsiniki/ $\leftrightarrow$ *nitáaksitsiniki nitáakitsiniki  /nit-áak-ipii/ $\leftrightarrow$ *nitáakipii
“become O”  
(Frantz 1997, p. 80)

define becomeO [  
[ i -> o  \|  plosives "-" _ mitáá ] .o.  
[ ma -> o  \|  plosives "-" _ [ míí | nítsí ] ] .o.  
[ is (->) o  \|  "-" _ ttoán ] ];
“3mm” verbs

nitsíko’po  ikó’po mma
nit-iko’po  iko’po-wa
“I’m very scared.”  “He’s very scared.”

define 3mm [
[ [ .. ] -> mm | | [ .#. | "-" ] ] [ 
  i k o ' p o |
  i k s i s á i k i k i |
  i k s i s t o ' s i |
  i m i |
  i n á á m m |
  i n n o ' s i |
  i p a h k s i m i |
  y o o h s i n i i n a |
  ...
] _ "-" [ w a | y i | y i n i ] [ "-" | .#. ] ]
Past tense initial change

nitókska’si
/nit-okska’si/
I-run
‘I ran’

nitsííkska’si
/nit-okska’si/
I-run
‘I ran’

nitsííyoohtoaawa
/nit-yoohto-aa-wa/
I-hear-DIR-3SG
‘I heard her’

nitóóhkoawa
/nit-yoohko-aa-wa/
I-await-DIR-3SG
‘I waited for her’
test-driven phonology development (TDD)

# Tests from Phonological Rules Appendix B of Frantz's Grammar

#
#test nit-waanist-ok-wa -> nitaanikka
#test nit-waanist-aa-wa -> nitaanistaawa
#test nit-siksip-aa-wa -> nitssiksipaawa
#test nit-siksip-aa-wa -> nitssiksipaawa
#test nit-áak-yo'kaa -> nitáakso'kaa
#test nit-ssikópii -> nitsssisikópii
#test á-sínaaki-wa -> áísínaakiwa
#test n-ikáá-ssikópii -> nikáíssikópii
#test káta'-simi-wa -> kátai'simiwa
#test áak-oto-apinnii-wa -> áakotaapinniwa
#test áak-oto-apinnii-wa -> áakotapinniwa
coalescence
semivowel loss
gemination
s-connection
y-reduction
breaking
o-replacement
ih-loss
presibilation
sss-shortening
semivowel drop
vowel shortening
t-affrication
postsibilation
i-absorption
desyllabification
glottal metathesis
vowel epenthesis
glottal reduction
glottal loss
glottal assimilation
accent spread
i-loss
Phonology summary

- 42 ordered rules
- 18 lexically conditioned phonological alternations
- 24 general phonological rules
- 127/127 tests pass (but overgenerates)
# Phonological Rules (cf. Frantz 1991, pp. 152--155)

1. C1-C2 -> C2C2
   # Gemination Original
   # Note that this rule is actually quite contrived since it requires that the
   # adjacent plosives be MADE adjacent by a previously applying rule. If they
   # were underlyingly adjacent, then the so-called "stop-stop epenthesis" rule
   # would insert /oh/ or /i/ between them. Note: geminationGeneral is not being
   # used.

   define geminationGeneral [  
     [ plosives "-" -> p || _ _ p ] .o.  
     [ plosives "-" -> t || _ _ t ] .o.  
     [ plosives "-" -> k || _ _ k ] ];

   define gemination [  
     [ anist -> anik || _ "-" k ] .o.  
   ]

2. It -> Ist
   # s-Insertion (assumes that "breaking I" is a phoneme)
   # Note: since the dictionary does not use /I/, this rule is not being used.
   # Instead it is assumed that words like waanIt 'say to' are represented
   # phonemically as /waanist/ and there are special lexical rules to deal with
   # /waanist-ok/ -> [waanikk], etc. (see above).

   define sInsertion [ ] . . . -> s || I _ t ;

3. C-s -> Css, V(')-s -> V('-)is
   # s-Connection
   # condition on s-Connection "B": the 's' is not part of a suffix;
   # present implementation: transformation is optional.
<table>
<thead>
<tr>
<th>shape</th>
<th>imitááá</th>
</tr>
</thead>
<tbody>
<tr>
<td>gloss</td>
<td>dog</td>
</tr>
<tr>
<td>category</td>
<td>nan</td>
</tr>
</tbody>
</table>
# Lexicon

5,095 morphemes

<table>
<thead>
<tr>
<th>category</th>
<th>count</th>
<th>category</th>
<th>count</th>
</tr>
</thead>
<tbody>
<tr>
<td>vai</td>
<td>1,280</td>
<td>agra</td>
<td>10</td>
</tr>
<tr>
<td>nin</td>
<td>857</td>
<td>drt</td>
<td>7</td>
</tr>
<tr>
<td>nan</td>
<td>847</td>
<td>mod</td>
<td>7</td>
</tr>
<tr>
<td>vta</td>
<td>604</td>
<td>PN</td>
<td>6</td>
</tr>
<tr>
<td>adt</td>
<td>432</td>
<td>num</td>
<td>6</td>
</tr>
<tr>
<td>vti</td>
<td>408</td>
<td>prev</td>
<td>4</td>
</tr>
<tr>
<td>vii</td>
<td>305</td>
<td>pro</td>
<td>4</td>
</tr>
<tr>
<td>vrt</td>
<td>79</td>
<td>stp</td>
<td>4</td>
</tr>
<tr>
<td>oth</td>
<td>57</td>
<td>whq</td>
<td>4</td>
</tr>
<tr>
<td>fin</td>
<td>52</td>
<td>ten</td>
<td>3</td>
</tr>
<tr>
<td>nar</td>
<td>44</td>
<td>asp</td>
<td>3</td>
</tr>
<tr>
<td>agrb</td>
<td>28</td>
<td>nir</td>
<td>2</td>
</tr>
<tr>
<td>med</td>
<td>19</td>
<td>dim</td>
<td>1</td>
</tr>
<tr>
<td>thm</td>
<td>10</td>
<td>o</td>
<td>1</td>
</tr>
</tbody>
</table>

agra = \{/nit-/, /kit-/, ...\}

agrb = \{/-hpinnaan/, /-hpoaawa/, ...\}

thm = \{/-yii/, /-o/, /-aa/, ...\}
Lexicon

vai → \{ /ihpiyi/, /okska’si/, /itsiniki/, \ldots \} 

nan → \{ /imitáá/, /aakíí/, /ponoká/, \ldots \} 

agra → \{ /nit/, /kit/, \ldots \} 

num → \{ /wa/, /yi/, /iksi/, /istsi/, \ldots \}
Morphotactics

Nitsiitsinoaayaawa
nit-iit-ino-aa-yi-aawa
1-loc-see-dir-3pl-pro

word → agra-prev-vta-thm-agrb-oth
<table>
<thead>
<tr>
<th>category string</th>
<th>count</th>
</tr>
</thead>
<tbody>
<tr>
<td>drt-num</td>
<td>1169</td>
</tr>
<tr>
<td>nan</td>
<td>348</td>
</tr>
<tr>
<td>und</td>
<td>335</td>
</tr>
<tr>
<td>nan-num</td>
<td>189</td>
</tr>
<tr>
<td>vii</td>
<td>152</td>
</tr>
<tr>
<td>nin-num</td>
<td>148</td>
</tr>
<tr>
<td>drt-agrb</td>
<td>143</td>
</tr>
<tr>
<td>agra-vai</td>
<td>132</td>
</tr>
<tr>
<td>nin</td>
<td>108</td>
</tr>
<tr>
<td>drt-o</td>
<td>99</td>
</tr>
<tr>
<td>adt-fin</td>
<td>89</td>
</tr>
<tr>
<td>drt-o-num</td>
<td>87</td>
</tr>
<tr>
<td>adt-vai</td>
<td>80</td>
</tr>
<tr>
<td>agra-nar-num</td>
<td>74</td>
</tr>
<tr>
<td>vrt-fin</td>
<td>71</td>
</tr>
<tr>
<td>drt-fin</td>
<td>60</td>
</tr>
<tr>
<td>drt</td>
<td>59</td>
</tr>
<tr>
<td>vai-agrb</td>
<td>58</td>
</tr>
<tr>
<td>asp-vai</td>
<td>58</td>
</tr>
<tr>
<td>agra-nar</td>
<td>57</td>
</tr>
<tr>
<td>agra-pro</td>
<td>56</td>
</tr>
</tbody>
</table>

Table 3.6: 20 most common category strings of well analyzed words in the Blackfoot data set.
Morphology

word → \{ agra-vai, nan-num, ...\}

morphotactics

vai → \{ /ihpiyi/, /okska’si/, /itsiniki/, ... \}

lexicon

nan → \{ /imitáá/, /aakíí/, /ponoká/, ... \}

agra → \{ /nit/, /kit/, ... \}

num → \{ /wa/, /yi/, /iksi/, /istsi/, ... \}

*imitáístsi

overgenerated
3,245 gold standard analyzed word types
LM training & testing

- 5 iterations
- 90% training set (2,920 words)
- 10% test set (325 words)
- trigrams (modified Kneser-Ney smoothing)
- 5,917 trigram counts
<table>
<thead>
<tr>
<th>trigram simple</th>
<th>trigram unambiguous</th>
<th>count</th>
</tr>
</thead>
<tbody>
<tr>
<td>yi-aawa#</td>
<td>yi</td>
<td>3PL</td>
</tr>
<tr>
<td>ok-wa#</td>
<td>ok</td>
<td>INV</td>
</tr>
<tr>
<td>yii-wa#</td>
<td>yii</td>
<td>DIR</td>
</tr>
<tr>
<td>#nit-á</td>
<td>&lt;s&gt; nit</td>
<td>1</td>
</tr>
<tr>
<td>aa-wa#</td>
<td>aa</td>
<td>DIR</td>
</tr>
<tr>
<td>#nit-áak</td>
<td>&lt;s&gt; nit</td>
<td>1</td>
</tr>
<tr>
<td>#nit-iik</td>
<td>&lt;s&gt; nit</td>
<td>1</td>
</tr>
<tr>
<td>hp-wa#</td>
<td>hp</td>
<td>DIR</td>
</tr>
<tr>
<td>inaa-mm#</td>
<td>inaa</td>
<td>appear.as</td>
</tr>
<tr>
<td>#it-á</td>
<td>&lt;s&gt; it</td>
<td>LOC</td>
</tr>
<tr>
<td>hp-yi#</td>
<td>hp</td>
<td>NOM</td>
</tr>
<tr>
<td>a’p-yi#</td>
<td>a’p</td>
<td>be</td>
</tr>
<tr>
<td>#nit-it</td>
<td>&lt;s&gt; nit</td>
<td>1</td>
</tr>
<tr>
<td>#ii-ohpok</td>
<td>&lt;s&gt; ii</td>
<td>PAST</td>
</tr>
<tr>
<td>m-yii-wa</td>
<td>m</td>
<td>TA</td>
</tr>
<tr>
<td>m-wa#</td>
<td>m</td>
<td>DIR</td>
</tr>
<tr>
<td>mm-yi-aawa</td>
<td>mm</td>
<td>3mm</td>
</tr>
<tr>
<td>m-yii#</td>
<td>m</td>
<td>TA</td>
</tr>
<tr>
<td>inaa-mm-yi</td>
<td>inaa</td>
<td>appear.as</td>
</tr>
<tr>
<td>#nit-ino</td>
<td>&lt;s&gt; nit</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 3.7: 20 most frequent trigrams in one of Parser 1’s training LMs.
### Results

<table>
<thead>
<tr>
<th>Method</th>
<th>14%</th>
</tr>
</thead>
<tbody>
<tr>
<td>success</td>
<td>14%</td>
</tr>
<tr>
<td>F-score</td>
<td>0.32</td>
</tr>
<tr>
<td>precision</td>
<td>0.53</td>
</tr>
<tr>
<td>recall</td>
<td>0.23</td>
</tr>
<tr>
<td>phonology</td>
<td>21%</td>
</tr>
<tr>
<td>LM</td>
<td>72%</td>
</tr>
</tbody>
</table>

**Precision**

$$\text{precision} = \frac{\text{# correctly guessed morphemes}}{\text{# guessed morphemes}}$$

**Recall**

$$\text{recall} = \frac{\text{# correctly guessed morphemes}}{\text{# correct morphemes}}$$
Results

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>success</td>
<td>14%</td>
</tr>
<tr>
<td>F-score</td>
<td>0.32</td>
</tr>
<tr>
<td>precision</td>
<td>0.53</td>
</tr>
<tr>
<td>recall</td>
<td>0.23</td>
</tr>
<tr>
<td>phonology</td>
<td>21%</td>
</tr>
<tr>
<td>LM</td>
<td>72%</td>
</tr>
</tbody>
</table>

\[
\text{precision} = \frac{\text{# correctly guessed morphemes}}{\text{# guessed morphemes}}
\]

\[
\text{recall} = \frac{\text{# correctly guessed morphemes}}{\text{# correct morphemes}}
\]
Phonology failures

28% due to pitch accent marking

<table>
<thead>
<tr>
<th>underlying</th>
<th>/ohpommaa-wa/</th>
</tr>
</thead>
<tbody>
<tr>
<td>correct</td>
<td>&lt;iihpómmaawa&gt;</td>
</tr>
<tr>
<td>phonology</td>
<td>&lt;iihpommaawa&gt;</td>
</tr>
</tbody>
</table>

many due to length contrasts

<table>
<thead>
<tr>
<th>underlying</th>
<th>/nit-iik-waakomimm-ok-yini/</th>
</tr>
</thead>
<tbody>
<tr>
<td>correct</td>
<td>&lt;nitsiaka komimmokini&gt;</td>
</tr>
<tr>
<td>phonology</td>
<td>&lt;nitsiiikaak komimmokini&gt;</td>
</tr>
</tbody>
</table>
Provisional solution

Obliterate accent marking and length distinctions

```plaintext
define noAccentedVowels á -> a , í -> i , ó -> o ;

define shorten [ 
  p+ @-> p ,
  t+ @-> t ,
  k+ @-> k ,
  m+ @-> m ,
  n+ @-> n ,
  s+ @-> s ,
  a+ @-> a ,
  i+ @-> i ,
  o+ @-> o ] ;
```
## Results

<table>
<thead>
<tr>
<th></th>
<th>p1</th>
<th>p2</th>
</tr>
</thead>
<tbody>
<tr>
<td>success</td>
<td>14%</td>
<td>17%</td>
</tr>
<tr>
<td>F-score</td>
<td>0.32</td>
<td>0.40</td>
</tr>
<tr>
<td>precision</td>
<td>0.53</td>
<td>0.40</td>
</tr>
<tr>
<td>recall</td>
<td>0.23</td>
<td>0.39</td>
</tr>
<tr>
<td>phonology</td>
<td>21%</td>
<td>60%</td>
</tr>
<tr>
<td>LM</td>
<td>72%</td>
<td>28%</td>
</tr>
</tbody>
</table>
Conclusions

• parser as effective fieldwork tool
• gaps in morphophonological analysis of grammar & dictionary
• parser creator assists with building parsers and testing analyses
Effective parser

• 17% overall success rate
• 88% parse suggest rate with F-score of 0.4
• 60% morphophonology success rate
• To do: GUI to suggest partially correct analyses for user editing
Gaps in standard analysis

- exhaustive list of allomorphic alternations
- pitch accent (and syllabification)
- rigorous prescriptive orthography
Gaps in standard analysis

- exhaustive list of allomorphic alternations
- pitch accent (and syllabification)
- rigorous prescriptive orthography
Gaps in standard analysis

• exhaustive list of allomorphic alternations
• pitch accent (and syllabification)
• rigorous prescriptive orthography
Gaps in standard analysis

- exhaustive list of allomorphic alternations
- pitch accent (and syllabification)
- orthographic variation
Parser-building features

- parser-building functionality incorporated into a collaborative database
- Test-driven phonology development
Next steps

- GUI suggests IGT analyses during data entry
- GUI for the parser creator
- Improve Blackfoot models
  - more accurate morphology
  - pitch accent generalizations
  - exhaustive allomorphy
- Model other Algonquian/FN languages
‘Thank you’
References


Blackfoot orthography

1) [nítsːpiji] <nítsspiyi> /nit-ihpiyi/
2a) [anːʔoxk] <annohk> /annohk/
2b) <ann'(o)hk>

<table>
<thead>
<tr>
<th>Orthography</th>
<th>IPA</th>
</tr>
</thead>
<tbody>
<tr>
<td>labial</td>
<td>coronal</td>
</tr>
<tr>
<td>stops</td>
<td>p pp</td>
</tr>
<tr>
<td>fricatives</td>
<td>s ss</td>
</tr>
<tr>
<td>nasals</td>
<td>m mm</td>
</tr>
<tr>
<td>glides</td>
<td>w</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>labial</th>
<th>coronal</th>
<th>dorsal</th>
<th>glottal</th>
</tr>
</thead>
<tbody>
<tr>
<td>stops</td>
<td>p pː</td>
<td>t tː</td>
<td>k kː</td>
</tr>
<tr>
<td>fricatives</td>
<td>s sː</td>
<td>h</td>
<td></td>
</tr>
<tr>
<td>nasals</td>
<td>m mː</td>
<td>n nː</td>
<td></td>
</tr>
<tr>
<td>glides</td>
<td>w</td>
<td>j</td>
<td></td>
</tr>
<tr>
<td>language</td>
<td>forms</td>
<td>texts</td>
<td>audio</td>
</tr>
<tr>
<td>------------------------</td>
<td>-------</td>
<td>-------</td>
<td>-------</td>
</tr>
<tr>
<td>Blackfoot (bla)</td>
<td>8,847</td>
<td>171</td>
<td>2,057</td>
</tr>
<tr>
<td>Nata (ntk)</td>
<td>3,219</td>
<td>32</td>
<td>0</td>
</tr>
<tr>
<td>Gitksan (git)</td>
<td>2,174</td>
<td>6</td>
<td>36</td>
</tr>
<tr>
<td>Okanagan (oka)</td>
<td>1,798</td>
<td>39</td>
<td>87</td>
</tr>
<tr>
<td>Tlingit (tli)</td>
<td>1,521</td>
<td>32</td>
<td>107</td>
</tr>
<tr>
<td>Plains Cree (crk)</td>
<td>686</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>Ktunaxa (kut)</td>
<td>467</td>
<td>33</td>
<td>112</td>
</tr>
<tr>
<td>Coeur d’Alene (crd)</td>
<td>377</td>
<td>0</td>
<td>199</td>
</tr>
<tr>
<td>Kwak’wala (kwk)</td>
<td>98</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>TOTAL</td>
<td>19,187</td>
<td>324</td>
<td>2,599</td>
</tr>
</tbody>
</table>

Table 2.1: Data in OLD applications (Feb 14, 2014)