/u/-fronting and /æ/-raising in Toronto Families

Erin Hall and Ruth Maddeaux*

1 Introduction

Labov (2001: 415) proposes that children first acquire the language patterns of their female caregivers, and later undergo "vernacular re-organization". Earlier research suggests that with both stable variation and changes in progress, children initially match adult constraints on use (Labov 1989, Roberts 1997, Smith, Durham and Richards 2013, Smith 2017). In the case of variables undergoing change, this faithful reproduction is followed by incrementation, as children advance the change beyond the adult level (Labov 2001, 2007). We examine these processes in children who are acquiring both stable variation and changes in progress in their speech community. Comparing children and their parents directly, we investigate whether transmission and incrementation effects can be found in two vowel variables in Canadian English: /u/-fronting and /æ/-raising.

1.1 Transmission and Incrementation Model

We take as a starting point of inquiry Labov's (2001, 2007) model of transmission and incrementation: a theoretical account offering an explanation for how generational change takes place. In this model, children initially replicate their female caregiver's variable system via the process of transmission. For variables that are stable in the community, this faithful reproduction is followed by learning to associate more social information with the relevant variants. For variables undergoing change, children next undergo the influence of the change over the course of childhood and adolescence, advancing the elements of the system that are variable by increasing their "frequency, extent, scope, or specificity" (Labov 2007: 346). This process is termed incrementation, and results from children perceiving age-related and other social differences in how forms are produced and shifting their behavior towards their preferred targets. For female-led changes, girls are expected to follow this incrementation pattern after age four, leading to an adolescent peak in apparent time before reaching a point of stabilization at around age 17. Boys, on the other hand, should not show the same pattern for changes associated with female speakers. These processes result in the incrementation of a change from one generation to the next, and account for the gender effects seen in female-led changes (Labov 2001).

1.2 The Acquisition of Variation and Change

In studies of stable variation, children have generally been found to match their parents' phonological and grammatical constraints on use from a young age (Labov 1989, Kerswill 1996, Roberts 1997, Kerswill and Williams 2000), supporting the notion of faithful transmission. However, some internal conditioning can take longer to master than others (Labov 1989, Roberts 1997), and stylistic constraints may not emerge until later (Roberts 1997, Smith et al. 2007, 2013). In most studies, children appear to match their parents' patterns by age six or seven.

In cases of change in progress, there is evidence that children increment changes over the course of childhood, as predicted by Labov's (2001, 2007) model. In Smith's (2017) work with families in Buckie, Scotland, pre-adolescents (ages nine and up) were found to be more advanced in several changes in progress than both their adult caregivers and younger children (ages three to four). Tagliamonte and D'Arcy (2009) show that pre-adolescents have lower rates of use of a number of innovative forms than adolescents. Taken together, these results are in line with the predicted adolescent peak, providing evidence that incrementation effects increase over the childhood years and

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then taper off in adulthood.

However, some research suggests that children may uncover potential sites of change even earlier, on initial transmission. In investigating the tensing of short /a/ in South Philadelphia, Roberts and Labov (1995) found that three-year-olds showed increased tensing compared to parents, as well as generalization to new words. Four-year-olds continue to tense more than adults, but not to generalize to new words. Labov (2001: 428) terms this a case of "directional transmission", concluding that children had absorbed the direction of change from their parents and older peers and were advancing it further along the same trajectory. Labov appears to consider this a different process from incrementation, noting that /a/-tensing is not related to any social factors other than age.

Outside of the sociolinguistic variation literature, related questions about children have been asked from the point of view of how mechanical processes of acquisition can drive language change. One influential proposal in the diachronic literature is that children's errors or re-analyses in language learning are a source of innovation (e.g., Kiparsky 1974, Lightfoot 1979). Recent work by Cournane (2014, 2015) provides empirical support for this theory, showing that child learning biases align with the direction of historical change in modals. Cournane (2014, 2015) argues that children play a role in the incrementation of modal *must* from root to epistemic meanings, overgenerating the newer interpretation at age five.

A number of studies using artificial language learning paradigms have also investigated how children learn from variable input. When variation is inconsistent, children nearly always overregularize the patterns of use, while adults tend to probability-match (Hudson Kam and Newport 2005, 2009). In cases of predictable variation, children are able to acquire the system, but they show more regularization than adults learning the same artificial language (Samara, Smith, Brown and Wonnacott 2017). Children are well known to show periods of morphological overregularization in natural language acquisition, producing forms such as *taked* for *took* before (re)learning the irregular forms. It remains to be seen if these regularizing tendencies can persist in some cases, resulting in language change, and how such biases might interact with the incrementation process.

The present study aims to examine the processes of transmission and incrementation in children, and their potential relationship with mechanisms of language acquisition, by focusing on two vowel variables that have already been described in adult populations in Toronto: /u/-fronting, a change in progress in the community, and /æ/-raising, a case of stable variation. Vowels in general are a promising area of study in children. They are generally acquired earlier than consonants (Stoel-Gammon and Herrington 1990), but relatively little is known about children's mastery of contextual and social constraints on vowel use. The following section presents the two variables of interest in this study and summarizes the research to date on adult productions of /u/ and /æ/ in Toronto.

2 /u/-fronting and /æ/-raising in Toronto

The clearest case of current vowel change in Canadian English is the fronting of the traditionally high, back vowel /u/, which is an active change across much of North America (Labov, Ash and Boberg 2006). In Canada, most notably in British Columbia and Southern Ontario (including Toronto), /u/-fronting has been described as a possible phonetic response to the reorganization of the front lax vowels known as the Canadian Shift (Boberg 2010, 2011a). Among the most innovative Canadian speakers, the position of /u/ has advanced far enough that it is further front than /æ/ (Boberg 2011a). Boberg (2010) finds a significant effect of age across the country, such that speakers born after 1965 produce a more fronted /u/ than those born after. Females lead this apparent change, a result that is consistent with a typical sociolinguistic change in progress. Boberg (2011a) finds that speakers from Ontario are moderately to extremely innovative in /u/-fronting overall compared to speakers from less urbanized regions of the country.

Whether or not /u/-fronting is occurring as part of a reorganization of the vowel space post-Canadian Shift, it is also heavily motivated by co-articulation. Most research into the varying positions of /u/ divides its conditioning environments into post-coronal and elsewhere, with the consistent finding that /u/ is further front following the coronals. The only exception is in the context of a following /l/, which is described as imposing a ban on /u/-fronting in some dialects (Koops 2010, Labov et al. 2006). In general, /u/ is reported as having an allophonic distribution between post-coronal environments and elsewhere – until such time as the distinction disappears and /u/ is fronted everywhere, which is taken as an indication that the overall change towards a fronted /u/ is complete (Baranowski 2008, Fridland and Bartlett 2006, Koops 2010). In other words, this is a change that is co-articulatorily motivated, being at first highly constrained by environment, with the constraints disappearing as the change advances.

The second noteworthy aspect of the current Toronto vowel inventory is the variability in the position of /æ/. Preceding nasal stops (as in *ban*) and the voiced velar stop /g/ (as in *bag*), /æ/ is raised and to some degree fronted. Note that this raising does not occur before voiceless velars, as in *back*. There is little research reporting a change in progress in any location where pre-velar and nasal /æ/-raising exists, since the majority of research on this variable has focused on phonetic variation without investigating it from a sociolinguistic perspective (e.g., Purnell 2008, De Decker and Nycz 2012, Mielke, Carignan and Thomas 2017). Rosen and Skriver (2015) find that *bag*-raising is increasing in Alberta in apparent time. Roeder, Onosson and D'Arcy (2018) report raising of *bag* and *ban* to similar degrees in Victoria, BC and find no correlation with age or gender, leading to the conclusion that this is a case of stable allophonic variation in the west that has existed for at least 85 years. Most discussions of /æ/ in Ontario assume a stable allophonic system – noting that in this location raising is most advanced for *ban* and less for *bag* – without reporting age or gender effects (Boberg 2008, 2011b; Labov et al. 2006). In Toronto, then, as in Victoria, variation in /æ/ seems to be embedded idiosyncratically among speakers who do not form a cohesive social group in terms of age or sex, suggesting a stable variable system. We follow these authors in predicting stability of this variable, and discuss our age-related findings in more detail in the results section.

In summary, there are two areas of interest in the vowel inventory of Toronto English speakers. The first is a change in progress: the fronting of /u/. The second is a probable instance of idiosyncratic stable variation: the raising of pre-voiced velar /æ/. Both have the potential to result in allophony, with one variant produced in a restricted environment, and the other produced elsewhere. Both are instances of variation at the phonetics/phonology interface – they are both motivated by co-articulation to some degree, and as a result are both candidates for phonologization of their respective phonetic motivations, resulting in the loss of contextual conditioning.

This paper investigates the production of these two vowels among Toronto families by comparing parents and children. Specifically, we ask: what are the patterns in children's productions of /u/ and /æ/ between ages four and 12? Do young children initially replicate their parents' systems, or change some aspects of the input upon transmission? How and when does incrementation – and/or overgeneralization – take place? Do the acquisition patterns differ for different kinds of variation: stable variation vs. a change in progress?

3 Methodology

A production study elicited the two variables from typically-developing, monolingual English-speaking children from the Greater Toronto Area, and their parents. We focus on children ages four to 12 in order to examine the full course of development over childhood. While most other studies focus either on initial acquisition or the (pre-)adolescent periods, we targeted the ages in between as well, in order to gain a more complete picture of the transmission and incrementation processes.

3.1 Speakers

We include data from 24 children, and from at least one parent of each child; in total, 19 families participated. The children fall into three age categories spanning from four to 12. While the children are balanced in terms of age and sex, the parents who participated are predominantly female. We also include data from 16 Toronto-native adults who are not parents, as a control population. The breakdown of speakers is given in Table 1.

	Children			**Parents**	**Adults**
	4–6	7–9	10–12	35–49	18–40
Female	4	4	4	18	8
Male	4	4	4	2	8

Table 1: Speakers included in study.

3.2 Materials

We designed two novel tasks, a picture naming task and a word reading task, to elicit the two vowels of interest. Although this method may sacrifice some ecological validity compared to spontaneous speech samples, it is preferred in this case because it allows for control over the various constraints affecting each variable, such as phonological context. We can manipulate the elicitation contexts in order to focus on the particular loci of variation, while also minimizing the amount of data collection required from each child. A picture naming game was used by Roberts and Labov (1995) to elicit vowels from young children in Philadelphia; like these authors, we view picture-based elicitation as an adaptation of the word list method frequently used in adult studies of phonological variation.

To create the two tasks, we compiled a word list of 106 common, monosyllabic words featuring all of the stressed vowels of Canadian English in a variety of allophonic environments. Twenty-seven words containing /æ/ and 18 containing /u/ were included in a variety of contexts to examine raising and fronting, respectively, and the remaining 61 words were added to complete the vowel space and aid in vowel normalization. The words were split into two lists: one list administered via picture elicitation and one reading list.

For the picture elicitation task, pictures representing 56 target words were obtained from the OpenClipArt website and arranged in random order in a PowerPoint presentation. The target word for each picture was elicited via sentence completion; see Figure 1 for two sample prompts.

Prompt: *This is a…* (Expected answer: *cat*)	Prompt: *This face isn't happy, it's…* (Expected answer: *sad*)
	

Figure 1: Sample picture elicitation task item.

Child and parent participants recited each target word twice. In addition to the picture list, children aged seven and up and parents also completed a supplementary reading task: a list of 50 words presented via PowerPoint, with one word per slide, with each word recited twice. Adults who were not parents (i.e., the control group) read a similar word list containing 89 words.

Parents and children were recorded on a Zoom H4 recorder with an external Audio-Technica l AT831b lavalier microphone; control group adults were recorded in a soundproof booth using an AudioTechnica AT3035 microphone. During the child's session, the caregiver completed a written background questionnaire to elicit demographic information about the family.

3.3 Vowel Extraction and Measurement

Acoustic analysis was conducted using the speech analysis software Praat (Boersma and Weenink 2019) and the alignment and formant extraction tools FAVE-align and FAVE-extract (Rosenfelder et al. 2014). Measurements of F1 and F2 were taken at the 35% point of each vowel and normalized using the Lobanov (1971) method in the vowel normalization and plotting suite NORM (Thomas and Kendall 2007) to factor out differences between speakers due to physiological differences in the vocal tract, allowing for reasonable comparison across speakers.

4 Results

Figure 2 displays the vowel space for all speakers involved in the study. The words illustrate the vowels in particular phonological contexts; for example, *ban* represents multiple words in which /æ/ precedes a nasal (*jam, tan, sang*, etc.), *tooth* is /u/ following all coronal and palatal consonants,[1]

[1] Despite palatals being considered part of the "elsewhere" condition in previous studies, preliminary analyses indicated that they patterned more closely with coronals. As a result, palatals and coronals are grouped together as the *tooth* context for the remainder of the analysis.

pool is /u/ following any onset but preceding /l/, and *boot* is /u/ following labial and velar consonants, or, "elsewhere".

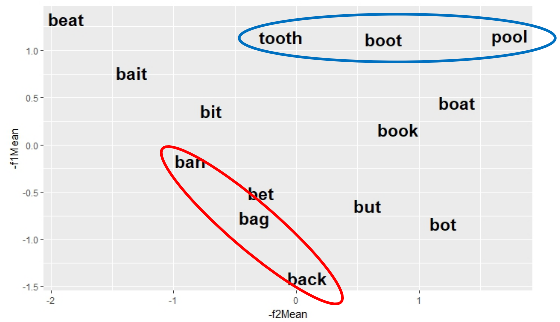

Figure 2: Vowel space for all adults and children.

Linear mixed effects analyses using *lme4* (Bates et al. 2015) in R (R Core Team 2013) test the effects of phonological context, age, gender, and interactions between them, on the normalized F1 of /æ/ and the normalized F2 of /u/. Children are divided into three age groups: 4–6, 7–9, and 10–12. Preliminary statistical analysis revealed no significant differences between the two groups of adults; therefore, parents and non-parents are both included in the adult group.

4.1 /u/-fronting Results

Table 2 gives the results of the mixed effects regression.

Random effects					
Groups	Name	Variance	Std. Dev.		
Speaker	(Intercept)	0.02903	0.1704		
Residual		0.26198	0.5118		
Number of objects: 1862; Speakers: 60					
Fixed effects					
	Estimate	Std. Error	Df	t Value	p Value
(Intercept)	0.15459	0.03902	83.600	3.962	0.000156 ***
Context (vs tooth)					
Boot	-0.94244	0.03311	1797.100	-28.465	< 2e-16 ***
Pool	-1.86312	0.04282	1796.800	-43.515	< 2e-16 ***
Age (vs adults)					
4–6yo	-0.01602	0.10114	153.600	-0.158	0.874326
7–9yo	0.01314	0.08502	81.200	0.155	0.877549
10–12yo	0.02602	0.08513	81.700	0.306	0.760619
Gender (vs female)					
male	-0.09642	0.05526	56.900	-1.745	0.086373 .
Interactions					
boot: 4–6yo	0.59528	0.10234	1797.900	5.817	7.09e-09 ***
pool: 4–6yo	0.23405	0.12963	1799.800	1.806	0.071154 .
boot: 7–9yo	0.25409	0.07434	1796.500	3.418	0.000645 ***
pool: 7–9yo	-0.06107	0.09727	1796.900	-0.628	0.530194
boot: 10–12yo	0.17940	0.07459	1796.400	2.405	0.016269 *
pool: 10–12yo	-0.08381	0.09939	1798.700	-0.843	0.399182

Table 2: Mixed effects logistic regression for F2 of /u/.

There is a strong main effect of context, as expected: *tooth* is significantly further forward than *boot* (or, "elsewhere") and *pool* (ps<0.0001). In the *boot* condition, all of the children are significantly further forward than the adults: the effect is strongest in the youngest children, followed by the middle age group, followed by the oldest. This confirms that /u/-fronting in the elsewhere condition – that is, not following coronals/palatals, or preceding /l/ – is a change in progress. A separate model including age as a continuous factor reveals a significant main effect of age (p=0.008), confirming that the overall position of /u/ is fronting in apparent time. Gender has only a marginal effect, in the expected direction: female speakers are further front than male speakers.

Figure 3 illustrates these findings by showing the vowel space for all speakers, with /u/ separated by condition and age group.

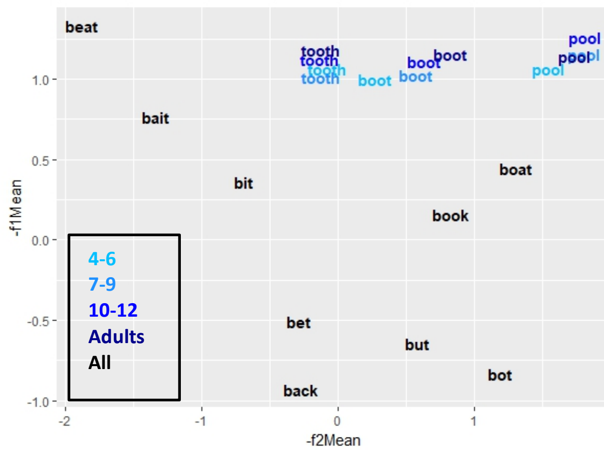

Figure 3: /u/ by age group + environment.

In the coronal/palatal environment, there is no difference among the age groups. In this condition, /u/ appears to have fronted as far as it will. In the pre-/l/ context, the youngest children are marginally further front, but there is no significant difference among the groups. The area of interest, then, is in the elsewhere condition. This is the environment that is not traditionally considered to facilitate fronting, like post-coronal, but also does not preclude fronting, like pre-/l/. Here is where children are extending the /u/-fronting change to new environments, as indicated by the regression model.

The transmission and incrementation model predicts that the 4–6-year-olds will match their parents' system most closely. The 10–12-year-olds should be more advanced than younger children, building to the adolescent peak. Our results for /u/-fronting do not follow the expected incrementation pattern. Instead, we find the opposite: the youngest children are most advanced in the change, followed by the middle age group, and then by the oldest. We return to this in the discussion.

4.2 /æ/-raising Results

The mixed effects regression testing the effects of the same factors on the normalized F1 of /æ/ are given in Table 3. For everyone, pre-voiced velar (*bag*) and pre-nasal (*ban*) /æ/ are higher than elsewhere (ps<0.0001), confirming that /æ/-raising is highly allophonic. There is a main effect of age only for the 7–9-year olds, who have lower *back* than adults. The interactions between age group and context show that younger children have exaggerated raising, especially in *ban*. In *bag,* only the 7–9-year-olds are significantly higher than the adults. The 10–12-year-olds are not significantly different from adults in either environment. A separate model with age as a continuous factor revealed no significant main effect of age (p=0.31), confirming that /æ/ is not raising overall in apparent time. Gender is also not significant, indicating that this variation is not associated with the gender effects that would be expected for a sociolinguistically meaningful change.

Random effects					
Groups	Name	Variance	Std. Dev.		
Speaker	(Intercept)	0.005811	0.07623		
Residual		0.199918	0.44712		
Number of objects: 2744; Speakers: 60					
Fixed effects					
	Estimate	Std. Error	Df	t Value	p Value
(Intercept)	1.384e+00	2.054e-02	7.960e+01	67.376	< 2e-16 ***
Context (vs *back*)					
bag	-6.143e-01	3.495e-02	2.681e+03	-17.575	< 2e-16 ***
ban	-1.142e+00	2.357e-02	2.680e+03	-48.449	< 2e-16 ***
Age (vs adults)					
4–6yo	9.834e-02	5.883e-02	1.933e+02	1.672	0.0962 .
7–9yo	1.180e-01	4.502e-02	8.080e+01	2.620	0.0105 *
10–12yo	3.139e-03	4.475e-02	7.900e+01	0.070	0.9443
Gender (vs female)					
male	1.795e-03	2.916e-02	5.190e+01	0.062	0.9511
Interactions					
bag: 4–6yo	1.152e-01	1.016e-01	2.686e+03	1.133	0.2572
ban: 4–6yo	-5.917e-01	9.313e-02	2.702e+03	-6.353	2.47e-10 ***
bag: 7–9yo	-3.099e-01	7.907e-02	2.678e+03	-3.919	9.12e-05 ***
ban: 7–9yo	-5.164e-01	5.328e-02	2.678e+03	-9.691	< 2e-16 ***
bag: 10–12yo	1.175e-02	7.894e-02	2.679e+03	0.149	0.8816
ban: 10–12yo	1.172e-02	5.280e-02	2.678e+03	0.222	0.8240

Table 3: Mixed effects logistic regression for F1 of /æ/.

Figure 4 shows each age group's positions for /æ/ by environment.

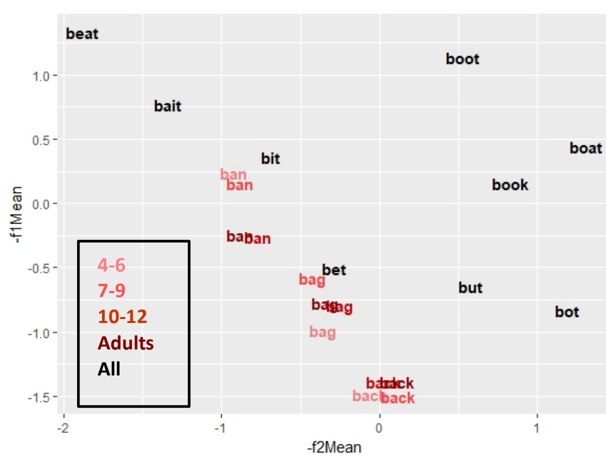

Figure 4: /æ/ by age group + environment.

The contexts that have significant differences are both traditionally raising; in the non-raising environment, *back*, children do not show higher /æ/ than adults. In other words, the children are not extending the variation to new environments, like they are for /u/. As indicated by the regression model, young children overshoot the adult target for *ban*, while the middle group overshoots both *ban* and *bag*, and older children match the adults' positions for /æ/ in all environments. The lack of consistent patterning by age in *ban* and *bag* suggests that /æ/-raising is likely not a change in progress in Toronto, and instead is a case of stable, contextual, somewhat idiosyncratic variation. There are no clear incrementation effects, neither of the traditionally expected kind, nor of the kind displayed in the /u/ results.

Given these findings, the next step in investigating the acquisition of /æ/ is to compare parents and children directly.

4.3 /æ/ Patterns by Family

Figure 5 shows the position of /æ/ for three separate families.

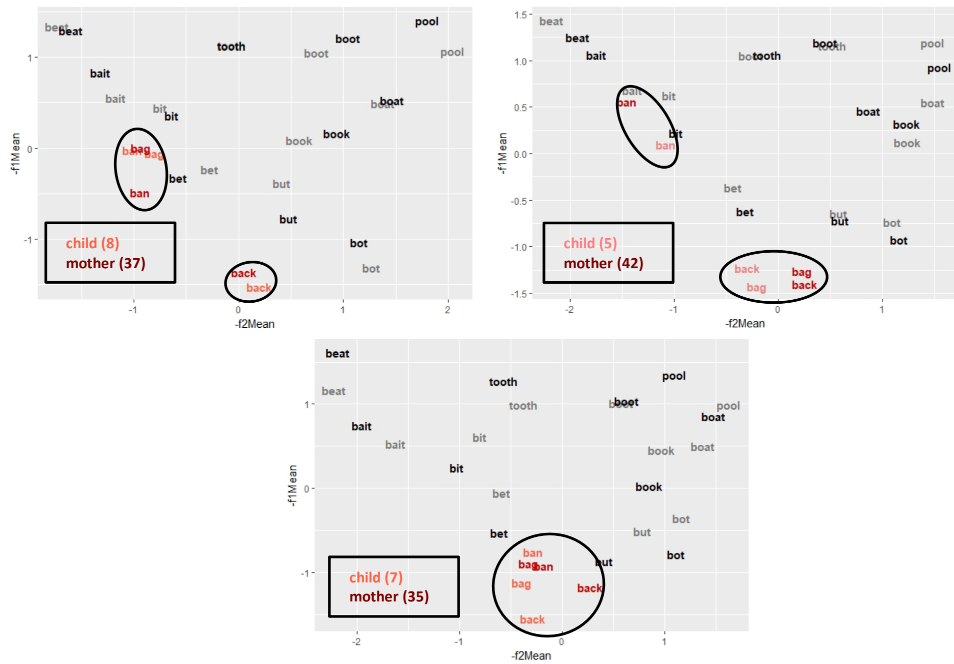

Figure 5: /æ/ by parent and child.

In the first family, the parent raises both *ban* and *bag* considerably higher than *back*. The second raises only *ban*, while *bag* is in the same low position as *back*. The third raises neither *ban* nor *bag* higher than *back*. In each case, the child faithfully reproduces the parent's pattern. Though we show only three families here, these are representative of the pattern we find across all 19 families in the study. There are no cases where a child raises in a given context where the parent doesn't also raise.

5 Discussion

To summarize, in the case of a sound change (/u/-fronting), children participate in extending the change as early as four years old. They front more overall, and in more environments. It is not the case that they faithfully acquire their parents' patterns first. By age 10, they settle into a pattern that is not as exaggerated, but will still advance the change in the community.

What we cannot tell from this apparent time result is what has transpired among these children in real time. It is possible that each age group has not adjusted their placement of /u/ since acquisition, and will retain their current position through to adulthood. If this is the case, we would not see any adolescent peak, because the younger children will have been more advanced than the older children since early childhood. This scenario would mean no incrementation at the individual level, but would still result in community-level change.

A second possibility is that when these 10–12-year-olds were four, they were also as far fronted as the current 4–6-year-olds, and then gradually retreated closer to the adult placement. This would represent reverse-incrementation at the individual level, but, assuming the children's end result was still further front than the adults, would still advance the change at the community level. We suggest this could be seen as a kind of overgeneralization in the acquisition process, like we often see in morphological acquisition. It could be thought of as a "two steps forward, one step back" approach: children initially overshoot the fronting change, but eventually retreat toward the adult norm – however, crucially, settling further forward than their parents, so that they still advance the change.

In the case of stable variation (/æ/-raising), younger children may inconsistently overshoot in raising environments, but do not extend the raising to new environments. Older children are statistically identical to their parents, matching their idiosyncratic raising patterns. With respect to the development of this variation, this may be a case of a "two steps forward, two steps back" approach: rather than ending up further ahead and advancing the change, as children do for /u/, they stabilize in the same range as their parents, maintaining the contextual variation. Compared to previous studies of stable variation in which children tend to match their parents' production patterns by age six or seven (e.g., Labov 1989, Roberts 1997), these results suggest that 7–9-year-olds may still be learning some aspects of the variable system.

5.1 Incrementation: overgeneralization?

This apparent time study does not seem to show evidence for childhood incrementation: we find that younger children are more advanced in the change than older children, which is the opposite of what the incrementation model predicts. However, we do find a pattern consistent with overgeneralization. Recall that Roberts and Labov (1995) demonstrate that three-year-olds extended /æ/-tensing (which in Philadelphia was in a state of change) to new words, but four-year-olds did not, increasing only the level of tensing. We find a similar pattern in our changing variable: children first overgeneralize fronting to new environments, and then retreat, but still end up ahead of their parents. In the case of /æ/-raising, we find a different pattern that instead maintains stable variation: children initially exaggerate the raising, but do not extend to new environments; by age 10, they match their parents' allophonic system identically.

Conceptually speaking, comparing the extension of a vowel change to a new phonological context to overgeneralization in the traditional morphological sense, such as saying *taked* for *took*, requires further theoretical and empirical exploration. We argue that alongside our theories of childhood transmission and incrementation, we need to explore how the general acquisition phenomenon of overgeneralizing can apply to sound change.

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Department of Linguistics
University of Toronto
Toronto, ON, Canada
e.hall@mail.utoronto.ca
ruth.maddeaux@mail.utoronto.ca