Could I have a French accent in my native English? American English L1 phonetic drift in French L2 environments

by

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Abstract

While it is well known that a speaker's native language heavily influences the sound system of their second language, previous research has tentatively suggested that a speaker's second language can also shift their native language even at the earliest stages. This study examined whether the vowel system for American English-speaking novice learners enrolled in a study abroad program in Paris with no prior experience in French could drift as a result of exposure to French. Production of American English vowels was found to be unaffected by the acquisition of French vowels over a 6-week period. However, experienced American English-speaking late learners of French compared to novice learners demonstrated tendencies of French influences on American English production, reproducing findings from previous studies. Taken together, these results demonstrate a trend that the extent of a first language phonetic system's response to pressures from a second language phonetic system varies as a function of time spent studying the second language and of the quantity of input during this time, with increased amounts of time and of input signifying higher likelihood to change. The ramification of these findings for language development, linguistic experience, and cognitive models of speech perception and production will be discussed.

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1. Introduction

Deriving from the critical period hypothesis, a common assumption in language acquisition research is that first language phonetic and phonotactic structures are immutable within a speaker. As a speaker ages past a certain point, often after the onset of puberty, their language learning ability undergoes an observable shift that thereafter causes a speaker to produce a notable foreign accent in a non-native language. In terms of phonetics and phonotactics, certain phonemes and phonotactic combinations become more difficult to produce and perceive if they are not part of L1. This limitation makes up one part of the assumption that an L1 is essentially unchanging after a certain age in a speaker's life.

However, research has generally shown that phonetic and phonotactic categories are to some extent malleable and compete with each other in the global phonetic space of a given speaker. For example, in English second language environments for highly proficient L1 speakers of German, English phonotactic probabilities can be mastered and produced, but German L1 phonotactic constraints still inhibit L2 perception within learners (Weber and Cutler, 2006). That is, established categories of phonemes and clusters in a given speaker's L1 tend to inhibit the representation of native-like L2 categories at varying degrees on the phonetic level. Importantly, the ability of a first language phonetic category to shift in some way is in fact present for some categories, contrary to the assumed invariance of L1. Other studies like those in the work of Flege (1987, 2003) suggest a similar, subtle malleability in L1 categories as a result of experience with an L2. Taken together, this research has contributed to the development of a defined phenomenon in contrast to L1 invariance, referred to hereafter as "phonetic drift," as originally indicated in the work of Chang (2012).

Explicitly stated, phonetic drift occurs when a given speaker's L2 encroaches upon L1 phonetic categories, subsequently evoking a shift in the production of L1 phonetic categories. Chang (2012, 2013) argues that this influence is pervasive and can shape speech production in L1 broadly, even from minimal contact. Chang (2012) investigated phonetic drift in novice American English L1 learners of Korean as L2 by assessing their consonant and vowel productions of American English and Korean bi-weekly for the first 5 weeks of immersive second language study in Korea. The study then compared their productions to standard productions in each language in hopes of observing an instance of phonetic categories drifting. Results demonstrated that a given American English speaker's entire vowel space experiences a generalized acoustic shift in category tendencies and frequencies towards the vowel categories of Korean after immediate contact with Korean in an immersive language environment. Minute consonantal shifts were also observed in the results as the VOTs of American English voiceless stops lengthened significantly, causing American English voiceless stops to deviate from the norms of American English. These VOTs appeared to move in the direction of Korean aspirated stops, which also lengthened significantly, arguably "over-aspirating" to differentiate themselves from the lengthening VOT of American English voiceless stops (Chang, 2012).

Longer contact between a person’s L1 and L2 also shows lasting effects in native American English learners of French in terms of VOT for coronal stop productions and high vowel productions (Flege, 1987), demonstrating specific phonetic shifts in consonant and vowel production between French and American English. Learners with an average of 11.7 years of living in Paris and French-speaking spouses produced American English /t/ with considerably shorter, French-like, VOT values than American English monolinguals. Results in this study even indicated that VOT values were still shortened but "less pronounced" for groups of

individuals with less immersive experience with French (Flege, 1987). In addition to consonant productions, Flege (1987) investigated production differences for American English /u/, French /u/, and French /y/ in the same groups of native speakers of American English with varying levels of experience in French. Results for F2 analysis indicated that the extent to which speakers approximated French /y/, a completely new phoneme for L1 American English learners, depended on linguistic experience, but the approximation was only significantly different in speakers with little experience. In contrast to French /y/ productions, French /u/ productions developed in a gradient manner. Speakers with very little L2 experience tended to confuse French /u/ and French /y/ while speakers with a moderate level of L2 experience tended to interchange American English /u/ and French /u/ with a preference for American English /u/ F2 values. Only speakers with over 10 years of immersion experience in French tended to approximate the French /u/ norm, yet with an approximation that was still different from monolingual French /u/ norms. Essentially, the production of a correct French norm depended on linguistic experience in the L2 and production never fully reached the L2 phonetic category norm despite this experience. Still, a category shift in some form occurred for both consonant and vowel productions as a result of L2 experience.

Similarly, a study of a single bilingual speaker of American English and Brazilian Portuguese demonstrated the malleability of consonant categories by recording productions in each language before and after two to four months spent in each respective language community (Sancier and Fowler, 1997). Native listeners of each language were asked whether they could tell which productions from recordings before and after time spent in a different language community sounded accented. Results revealed that VOT lengths for coronal stop productions had shifted to accommodate the dominant language in the speaker's environment. Native

listeners judged their respective language tokens from the bilingual speaker as more accented in cases where the speaker had just spent a period of time in the opposite language community. Despite the defined VOT lengths for the languages in isolation, the speaker's VOT adapted to simulate the immersive language VOT lengths in both languages. Thus, an L1 category is not only pressured to shift into a new category, it can also consistently shift between categories.

The present study will examine these instances of phonetic drift in the context of L1 American English early learners of French. Hoping to elicit results similar to Chang (2012), the focus of this study will include a temporal analysis of phonetic drift in complete novice learners before and after 6 weeks of exposure to French as L2. A global analysis of the vowel space like that in Chang (2012) will also provide an indication of the widespread nature of phonetic drift in American English by incorporating the entire American English vowel space of these early learners.

Results and findings of the present study are organized as follows. Section 2 provides a deeper explanation of the inspiration for the specific question of this study and a discussion of predictive models. Section 3 describes the methods and procedure of the study. Section 4 presents the statistical results of phonetic drift in terms of time and in terms of vowel space movement. Section 5 explains the implications of the results in the context of previous research and the predictive models. Section 6 is a summary of findings and suggests ways to continue research on phonetic drift.

2. Background

2.1 Phonetic drift in-depth

Further detail from the results of Levy and Strange (2008) suggest that rounding is a complicating factor in the production and perception of French high vowels by L1 American English speakers. Native American English-speaking participants in this experiment had the most difficulty distinguishing between French /u/ and /y/ in a perceptual task. The French high vowels /u/ and /y/ both possess rounding as a distinctive feature, differ only in backness, and create minimal pairs in French, e.g., /ty/ (“you,” inf.) versus /tu/ (“all,” masc. sing.). Thus, a special necessity arises for learners to maximize the distance between these two sounds to best convey and interpret meaning to and from native speakers. Acoustically speaking, front rounded vowels have lower formant frequencies as well due to lip rounding as it increases the length of the vocal tract and subsequently lowers front cavity resonances. With this sensitivity to maximizing differences in mind, native L1 American English speakers could become more sensitive to their productions (i.e. lower F2) of the American English vowel /u/ in approximating French /u/, which has a relatively low value of F2, needed for the contrast with French /y/. Out of a residual necessity to do so in French and in an immersive environment where phonetic categories are constantly under the pressure of an L2, native American English early learners' production of the American English /u/ may subsequently lower in its F2 value, signifying the phonetic drift of /u/ in American English L1 speech production because of the L2 environment and specific pressures on speech.

This line of reasoning was disconfirmed by the results in Flege (1987), where native American English speakers with little immersive experience tended to pronounce French /u/ with *higher* F2 values after contact with French as their L2, subsequently assimilating the two vowel

categories of each language to the native category. That is, they pronounced the French /u/ closer to American English /u/ than the reverse. Ultimately, a minimal pair created in French with the high vowels /u/ and /y/ did progressively demonstrate observable shifts in French /u/ production as well as F1 frequencies in American English /u/ production for native L1 American English speakers. Still, it is important to note that these results do not significantly tease out the pressures an L1 would experience from the dominant L2. This effect is not generalized to other categories within the language because of the focus on high vowels in this study, making it difficult to understand the breadth of category movements such as these. The movements are also unspecified as F1 and F2 were both affected in unpredictable and separate ways for each high vowel. Moreover, all learners were in acquisition stages past 9 months of experience with French as L2, neglecting earlier stages of acquisition. Simply put, the vowel categories observed remained distinct and the prospect of pressures like the necessity to maintain distinct categories did not seem to significantly shift L1 categories in ways that could support phonetic drift, potentially due to a limited selection of vowels and broad time scales of acquisition in the learners observed. Thus, while both Levy and Strange (2008) and Flege (1987) evaluate the interaction of L1 and L2 for perception and production respectively in early and late learners, little evidence is given in either study for shorter time frames in which any of these effects could potentially occur in the vowel space nor are any changes considered on a global scale.

However, these two details were applied in Chang (2012) and yielded significant results. Chang selected true novice learners in their first stages of acquisition as a subject group and larger vowel spaces that were more representative of the respective target languages, American English and Korean, on the whole. It is possible that a phenomenon like phonetic drift occurs very quickly after immersive contact with a language and solidifies weeks later to a phonetic

categorical structure much like that of the native speaker prior to immersive contact, but with the possibility of minute, lasting changes. Chang (2012) reports that native American English speakers' L1 vowel production was restructured (i.e. values of F1 and F2 shifted toward L2 norms) after only 5 weeks in a Korean L2 environment, demonstrating a quick response within L1-L2 interaction and providing evidence for some L1 reorganization. This would explain the null results in Flege (1987) as the smallest time frame among participant groups between the beginning of L2 experience and time of testing was 9-months. A phonetic drift effect would have already passed and solidified in the most inexperienced group of Flege (1987). Moreover, this effect was generalized across the entire vowel space, as Chang examined beyond a small set of vowels, unlike the small selection of high vowel minimal pairs in Flege (1987).

It is important to note though that the most significant results in Chang (2012) involve a global shift in F1, based on subdivisions by gender within the participant groups. The study reports that over time "mean F1 of female learners' English vowels decreased toward the lower mean F1 of female Korean vowels… while mean F2 of female learners' English vowels stayed steady." This mean shift corresponded to a difference of 17 Hz for F1 from the beginning of the time period to the end of the time period, five weeks later. The nature of a shift like this is relatively unclear however as individual vowels of American English were found to have shifted, and may have driven the global shift of 17 Hz, but not every vowel within the vowel space examined had significantly shifted in unison. It is only under a general trend of F1 decreasing that is shown in each vowel, despite varying significance, that the phonetic drift was observed for the learners studied in Chang (2012).

Still, phonetic drift remains intriguing and dynamic according to these general trends observed in Chang (2012) and Flege (1987) and warrants a reexamination under different language contexts.

2.2 Cognitive models

Following the comparisons made in Chang (2012), in the evaluation of L1-L2 interaction, the proceeding study will refer to two cognitive models of speech as the underlying explanation for the actions and pressures of this cross-linguistic interaction. The two models chosen are the Speech Learning Model developed by Flege (1995, 2003) and the Perceptual Assimilation Model-L2 defined by Best and Tyler (2007). The primary difference between these two studies involves the explanation of the interaction between perception and production. The SLM generates a cognitive model of cross-linguistic interactions that directly involves both perception and production in L2 whereas PAM-L2 focuses on the perceptual side of L2 processing. Deriving from a former Perceptual Assimilation Model (see Best et al., 2001 for a review) for the perception of general non-native speech contrasts, the PAM-L2 builds in a component for L2 perception that ultimately informs on L1 phonetic, phonological, and gestural distinctions in the language acquisition environment.

Flege's SLM (1995, p.239) provides evidence for L1-L2 interaction by generating four postulates that describe the nature of L1-L2 interaction and subsequent cognitive representation in the phonetic space of a speaker. First, the mechanisms and processes used in learning the L1 sound system, including category formation, remain intact over the life span, and can be applied to L2 learning. Second, language-specific aspects of speech sounds are specified in long-term memory representations called phonetic categories. Third, phonetic categories established in

childhood for L1 sounds evolve over the life span to reflect the properties of all L1 or L2 phones identified as a realization of each category. Fourth and last, bilinguals strive to maintain contrast between L1 and L2 phonetic categories, which exist in a common phonological space.

Important to these four postulates are a number of mechanisms explaining how and when categories are established or prevented from being established in L2. Two of these mechanisms explain the process of category formation in L1 and L2 phonetic systems: category assimilation and category dissimilation. Category assimilation occurs when a new category fails to be established as an L2 speech sound despite present yet unperceived audible differences between the new category and a similar L1 category. Essentially, an L2 category like French /u/ is assimilated into a similar L1 category like American English /u/ and is unable to form its own distinct category. This is because L1 acquisition systems are postulated to exist throughout life and thus sounds are still capable of being established at any point as an L1 sound despite belonging to an L2 sound system. This mechanism potentially results in a modified L1 category somewhere between the original L1 category and the similar L2 category, but with more preference given to the original L1 category. Conversely, category dissimilation occurs when a new category is established for an L2 sound. Importantly, this process benefits from the dissimilarity between sounds; the less sounds resemble each other, the likelier two separate categories can be maintained. Once created, this new category then forces a distance between the next closest L1 category and itself, based on the idea that bilinguals and language learners attempt to maintain a strong distinction between their two phonetic systems (see Flege et al., 2003 for a full review).

A third mechanism of importance is equivalence classification, which accounts for a speaker's age and how that plays into their ultimate attainment of the language. According to

Flege (1987), "equivalence classification is a basic cognitive mechanism which permits humans to perceive constant categories in the face of the inherent sensory variability found in the many physical exemplars which may instantiate a category." This mechanism allows a young speaker, as young as an infant, to hone in on phonetic systems and specialize to an L1, correctly translating subtle sensory inputs as new categories. However, it is precisely this same mechanism that then prevents older speakers from separating similar L1 and L2 categories as the adults do not have an "effective use of sensory input" and subsequently merge already formed categories rather than create new ones for an L2 (Flege, 1987). Thus, in addition to the categorical mechanisms of assimilation and dissimilation, the age of a speaker has a significant influence on L2 development insofar as it constrains speakers the older they are at the time of acquisition because of a change in the way the language learning mechanism benefits the speaker.
As Chang (2012) puts it, "it is the consequences of linguistic experience, not neurological developments per se, that results in the longitudinal decline in ability to acquire L2 sounds like a native speaker."

Best and Tyler's (2007) PAM-L2 purports that L2 speech perception occurs on the phonetic, phonological, and gestural level, contrary to the information-rich, singular phonetic level of L2 perception and production in the SLM. A simple explanation of how the original PAM works begins with perceptual assimilation, which occurs when a naïve speaker perceives a non-native phoneme as belonging to the next most articulatorily-similar native phoneme, under the influence of their native linguistic background and experience (Best and Tyler, 2007, p.22). If an L2 phoneme is successfully perceived as belonging to a different category than an L1 phoneme, the contrast between the phonemes is maintained. If the L2 phoneme is unsuccessfully perceived and thus assimilated to the L1 phoneme category, the linguistic experience of the

speaker predicts how strongly or weakly the category assimilates to the L1 category, if at all (i.e. it's understood as a good or bad example of a familiar phoneme, or not). This gradient manner in which the phoneme is assimilated is classified in PAM under a number of levels based on the extent of the phoneme's similarity and "goodness of fit" to its perceived category.

PAM-L2 takes these principles and applies them to the L2 perception environment for learners rather than listeners, on phonetic, phonological, and gestural levels and it is at these levels where PAM-L2 diverges most from the SLM. Specifically, the gestural representation suggests that listeners directly receive and learn the gestures they receive from other speakers to arrive at understanding speech. This diverges directly from the cognitive representations of phonetic categories in the SLM by suggesting that listeners are constantly learning and attuning themselves to the physical properties of speech as opposed to relying on the reconciliation of two cognitive representations, one established and one not, of a perceived sound at the phonetic level. Thus, the PAM-L2 arrives at separating the physical acoustic properties of a sound from any indication of cognitive properties like meaning. The phonological level is reserved for the convergence of the phoneme and its lexical information; the phonetic level remains a physical, informative category in the sense that it can provide different exemplars of a phonological representation based on how the sound was produced, what type of speaker it came from, etc.; and the gestural level relies on the physical, acoustic properties of the sound. Then, the interaction and competition of these three levels maps onto the ultimate perception of an L2 sound, its comparative similarity or dissimilarity to an L1 sound, and its good or bad representation of that category.

A final divergence from the SLM concerns the preference for the phonological level over the phonetic, despite interactions between the two in PAM-L2 framework, as the guiding

component of perception. Best and Tyler (2007) propose that the strong phonetic similarity between English [b] and French [p] for American English L1 learners of French as L2 ultimately points to the phonetic and phonological overlap between the two sounds as French /p/ phonetically manifests as French [p], which is perceptually similar to English [b]. Due to this similarity, it's possible a single phonological representation is guiding production and perception, meaning a single phonological category bears information on two different phonemes cross-linguistically. Further, similar L1 American English learners of French "tend to equate the lexical-functional category /r/ across the two languages" despite the strong phonetic differences between English [ɹ] and French [ʁ]. The model uses both of these examples as indications that the phonological level is most influential in L2 perception, contrary to the phonetic centerpiece of the SLM.

However, the SLM and PAM-L2 diverge most significantly for this study on one aspect, production. PAM-L2 is a predictive model on the process of perceiving L2 phonemes in learners whereas the SLM predicts the ways in which reconciliations between the cognitive phonetic categories of L1 and L2 ultimately inform production *and* influence perception of non-native phonemes. Flege (1995, p.239) explains that the phonetic categories of the SLM are representations that link perception and production because the "production of a sound eventually corresponds to the properties represented in its phonetic category representation". Essentially, information from an L1 category that has already been formed allows for the sharing of information with new L2 categories and the creation of new information with similar L2 categories. Relative to the present study, thanks to this sharing of phonetic category space, the SLM explicitly provides a mechanism for not only the influence of an L1 on an L2 as new and similar phonemes are assimilated and dissimilated, but also the effect of an L2 on an L1 for both

production and perception. Specifically, equivalence classification — wherein L1 and L2 categories compete to influence an L1 category — and the fact that bilinguals are predicted to maintain separate phonetic structures for each language demonstrate the ability of an L2 to influence the phonetic category of an L1 (Flege, 1995, p.239), evoking the definition of phonetic drift.

2.3 Research question and rationale

This plethora of evidence on L1 phonetic categories provides the inspiration for the specific question of the present study: do L1 American English vowels begin to drift as a result of influence from French vowels in an immersive L2 environment of French? Special emphasis is placed on the high vowels, as these contrasts have been shown to be particularly difficult for English speakers learning French in past research. We seek to investigate this question with two important expansions from Flege (1987), with the structure of Chang (2012) in mind.

The first expansion concerns the fact that Flege (1987) tested subjects with a minimum of 9 months of French immersion experience and compared them to subjects that had married into French families and primarily spoke French as an L2 for an extended amount of time, i.e., heavy L2 use individuals. Attention will be given to L2 speakers with varied amounts of French experience, but with specific regard to the subjects with and without French experience, at late and early states of L2 acquisition, respectively. Instead of 9-months of experience as a starting point, the representation of this group for this specific study will be formed of students tested twice over the course of their study in France, before and after the first 6 weeks of immersion. These groups were chosen to test the idea in Chang (2012) that phonetic drift within American English L1 vowel space occurs much sooner than previously shown. This line of reasoning

additionally proposes that phonetic drift levels off or possibly disappears after this short time frame, explaining the insignificant results of late learner participants in Flege (1987).

The secondary expansion of the present study concerns testing the American English vowel space beyond the French high vowels in Flege (1987) to evaluate phonetic drift in the entire American English vowel space illustrated in Chang (2012) in native American English-speaking learners of French. The analysis in Flege (1987) ignored two important elements: American English /i/ and F1. American English /i/ made up part of the stimuli set, yet it was ignored to preserve "lexical similarity." Following the global shift in Chang (2012), it's possible that the F2 movements in American English /u/ were complemented by a shift in at least one other vowel category like American English /i/. However, the comparison of the two vowels was not analyzed, subsequently rendering a phenomenon like phonetic drift unobservable because of the small focus on a single vowel category. Further, F1 was not reported on in the discussion despite significant changes in the production of American English /u/ for the most experienced group, the same group with the most significant changes for F2. Chang (2012) reports that this generalized phonetic drift occurs over time as a global decrease in F1 for American English learners' vowel space while individual vowels are also reported to move along F2. Thus, the lack of consideration for both F1 and F2 and for multiple vowels in the target L1 necessitates a reexamination of phonetic drift in native American English learners of French as the analysis in Flege (1987) was not sufficient.

This reexamination will be carried out as a modified replication of the study in Chang (2012) in an attempt to extend those findings to another language, French. We predict that L1 American English learners of French will attempt to assimilate the categories of their American English vowel space towards the categories of the ambient L2 French. Particularly in the case of

high vowels, we expect to see that American English /i/ and American English /u/ decrease equally in F2 toward the phonetic norms of French /i/ and French /u/ and to maximize distance in the high vowel space with the introduction of a new vowel category, French /y/. Further, we expect other American English vowel categories to assimilate to the next closest French vowel category. Then, based on the productions of the group of late learners in Flege (1987), we predict a strong difference in phonetic category productions between early learners and late learners, with the early learners more accurately approximating French phonetic category norms, demonstrating that phonetic drift is impermanent and highly acute.

3. Methods

3.1 Participants

A sample of 23 speakers formed the participant group for this study. 16 participants were native speakers of American English and were classified as monolingual speakers by means of a linguistic background survey administered at the time of testing. Of the 16 native speakers of American English, 11 participants (8 female, 3 male; mean age of 19 years, range of 18-21) were students with no significant exposure to French prior to the present study, beginning a semester abroad at New York University in Paris (NYUP) for the fall of 2014. The remaining 5 speakers of American English (3 female, 2 male; mean age of 40 years, range of 28-56) volunteered for the study after receiving email correspondence about the opportunity. These 5 participants had significant exposure to the French language prior to the testing period and were instructors at NYUP or American friends of instructors at NYUP. Detailed definitions of significant exposure were determined by means of a linguistic background survey prior to testing, but generally these participants were expected to have had at least 5 years of immersion experience with French as a criterion for participation in the study. All of these subjects met this criterion. The final 7 participants (6 female, 1 male; mean age of 19, range of 19-20) were native speakers of French and formed the representative control sample of French for this study. These participants were gathered from students at the Institut universitaire de technologie Paris Descartes who participated in a weekly language workshop with NYUP students. All individuals were paid for their participation.

Four groups were designed to ensure accurate coverage of the research question at hand. The 11 American English speaking participants with no significant exposure to French were selected for Group A. These same 11 participants were gathered a second time to form Group B.

For the purposes of clarity, these two groups of participants are often referred to as "inexperienced learners" in this study. Group A participants were tested once at the beginning of the study abroad period after the first week of arrival. The same students were then tested a second time six weeks later, but were then labeled as Group B. 7 out of 11 participants had significant exposure a language other than American English or French (most often intermediate to advanced level Spanish study). American English dialect varied for participants. Details on American English dialect and linguistic background can be found in Appendix A.

Group C is comprised of 5 speakers, qualified as “long-term residents” in this study, with significant prior exposure to French. For the purposes of clarity, this group of participants is often referred to as "experienced learners" in this study. These individuals have had at least 5 years of immersive contact with French by living in the country and using it for a job, at home, or for school. Two participants were also married to a native French speaker. All participants were native speakers of American English. 3 out of 5 participants had minimal exposure to a language other than American English or French (most often basic to intermediate Spanish study). American English dialect varied for participants.

Group D is comprised of 7 native French speakers. None were qualified as being fluent in American English by means of a survey administered at the time of testing. 5 participants had significant exposure to a language other than American English or French. French dialect did not vary for participants.

At the time of data collection, Group A participants were beginning a semester abroad, living in Paris, France for a period of 14 weeks, and starting an immersive course in Elementary French with native speakers while taking at least two other courses in English. Each week, participants had 6 total hours of class in French with their instructor (1.5 hours per day, Monday-

Thursday). This time in class constituted a majority of contact with the language according to surveys administered to Group B. Participants reported speaking English with their friends and other Parisians during 90 percent of their time spent outside of the classroom after 6 weeks in Paris. Additionally, of the small percentage of interactions in French outside of the classroom, an even smaller percentage was with a native speaker of the language. Thus, English heavily dominated the language environment outside of the classroom in the 6-week time frame despite immersion.

Group C speakers had a wide range of exposure to French (14 years, 14 years, 17 years, 22 years, 48 years, mean of 23 years). 4 participants reported using French for their job and at home. All participants had begun learning French in a classroom environment, but ultimately reported learning the language from immersive exposure in a job setting or with routine visits to France prior to moving to Paris. Three participants were instructors at NYUP, one participant ran a tour business and had authored cookbooks in French, and one participant was an American student studying travel journalism in Paris.

3.3 Stimuli

The stimuli for the French condition and the American English condition consisted of 6 tokens of 10 French vowels and 6 tokens of 9 American English vowels, respectively. Each token was contained within a word with a CVC sequence and this word was then embedded in the middle of a phrase. For example, the French word "poche," meaning, "pocket," contains the vowel /ɔ/, between the consonants /p/ and /ʃ/, written phonetically as [pɔʃ]. This word was then embedded in the middle of the phrase, "son chapeau a une poche secrète" in order to best mimic an instance of natural speech production. In some instances, the CVC pattern was maintained

across a word boundary instead of within a single word due to the constraints of where certain words can occur in each language. However, as a rule, vowels were never in initial or final positions either in phrases or in words and all vowels were flanked on both sides by either a stop or a fricative, regardless of whether the CVC sequence was within a word or contained a word boundary (e.g., “I’ll have *two* cups” or "she *sits* on the sofa"). In American English stimuli, affricates were also used. This contextual environment allowed for the simplest segmentation and the least interference from coarticulation for each vowel. In the full data set, the chosen vowels often had a direct counterpart between the languages i.e. French /i/ and American English /i/ while other vowels unique to each language like French /ø/ and American English /ʊ/ were chosen to ensure coverage of the whole vowel space. All stimuli were checked with multiple native speakers prior to their usage in the experiments. One American English stimulus was removed from data analysis, "one doe at the lake," as it was later found to be in violation of the CVC pattern. Appendix B contains a table of all stimuli materials.

3.2 Procedure

Each speaker participated in a series of production tasks. The French condition concerned the production of French while the English condition focused on the production of American English. Instructions were given verbally in the speaker’s native language and the same experimenter (the author) ran all experiments. For each experiment, participants first filled out a survey on their linguistic background and were allowed to ask clarification questions. They then performed a reading task in which they read aloud each of the phrases presented to them. To accommodate the early learners in Group A that did not yet know how to read French, an additional sound sample of the phrase was provided. Participants were instructed to listen to the

sample to get an idea of how to pronounce the phrase presented. All participants in Group A, B, and C were required to listen to the sample at least once but no more than three times to keep the procedure consistent across groups. For Groups A and B, the French condition and the American English condition were run once per session and only one session was held per participant. The two sessions, one for Group A and one for Group B, were run six weeks apart starting on the second week of the semester. Sessions began with Group A after one week of French classes in Paris. For Group C, the French condition and the American English condition were run once per session and only one session was held per participant. For Group D, just the French condition was run, as it was not necessary to the specific question of the study to collect data on French learners of American English. Only one session was held per participant in Group D.

For each participant, the French condition was presented first, followed by the American English condition (where applicable). Within each experiment, stimuli were manually presented in the form of PowerPoint presentations on an early 2011 Apple Macbook Pro laptop computer. Subjects were asked to advance the slides themselves after pronouncing each phrase. After one PowerPoint ended, the experimenter would switch to the next within-language PowerPoint according to the random order generated for the specific participant. The order of PowerPoint presentations was randomized with a random number generator, effectively randomizing the blocks of stimuli, to eliminate the possibility of order effects, but all French PowerPoints were always completed prior to the English ones. Experiments were run in a quiet room at the NYUP building. Recordings were taken with a TASCAM DR-40 4-track Handheld Digital Audio Recorder with a built-in condenser microphone that was positioned on a table 6 to 8 inches away from the participant's chin. Sampling rate was set to either 48k or 96k in mono. Files created

were in WAV 24-bit format. Most participants finished the survey and all tasks within 30 minutes.

3.4 Acoustic analysis

The acoustic analysis of the study examined F1 and F2 measurements taken from manually segmented recordings in the Praat waveform editor. Tokens were the target vowel in each of the 114 phrases reported in the stimuli section and in Appendix B. Tokens were segmented in each file from the onset of the vowel to the offset as formant frequencies were measured from the midpoints of each vowel. Vowel onsets were selected based on the clearest beginning of F1 and F2 and the clearest ending of F1 and F2. Some segmenting boundaries were not right at the edge of the vowel interval due to glottalization, ambient noises, or unclear onsets. As a result, all trials where the midpoint of the vowel was too compromised or the entire vowel could not be accurately measured were excluded from the statistical analysis in the Results section. In all cases of a mistracked formant in Praat, the original segmentation was examined, corrected, and measured again, if possible.

Once the F1 and F2 midpoints were extracted using a Praat script, the list of all tokens was again checked for outliers and anomalies. Spectrograms and formant measurements from the script were also matched in a number of cases to determine that the script had extracted all of the information correctly. The F1 and F2 midpoint formant values were normalized using the Nearey1 formula implemented in the R package NORM (Nearey 1977, Kendall and Thomas, 2014). This normalization technique was chosen because it was shown to be one of the best performing ones for comparing across speakers with different vocal tract properties by Adank et al. (2004), who compared a number of different normalization techniques on the same dataset of

Dutch vowels. This method is appropriate since the entire vowel space of the speakers in both languages had been measured.

3.5 Statistical analysis

Formant frequency measurements in both experiments were analyzed with mixed-effects linear regression using the lme4 package in R (Bates, Maechler, et al., 2014). All regression models had fixed effects of Vowel and Group, and included random intercepts for Word and Participant. Initial analyses include Groups A, B, and C: novice learners in the first week, novice learners in the sixth week, and late learners, respectively. Later analyses break down Group C by age to explore results further. In these late analyses, the variable Group includes the following sub-groups: A, B, CE1, CE2, CF1, CF2, and D. In these subdivisions, "E" signifies American English and "F" signifies French while "1" signifies younger participants and "2" signifies older participants, e.g., CF1 is the French vowel space of younger participants in Group C. Since the lme4 package does not return p-values for linear regressions, we follow the standard practice for using the t-statistic to determine whether the fixed factors are significant contributors to the model or not (Gelman and Hill, 2006); if it is above 2 or below -2, then the factor is considered significant.

4. Results

4.1 Phonetic drift in vowel production

The first regression model examined F1 in American English, with baseline values of Group A and /a/ for reference vowel. Results for this model show that over time, there was no significant change in F1, either among the NYUP learner group from week 1 to week 6 or between these speakers and Group C. There was no significant effect of Group B as compared to Group A (β = -0.00, t = -0.61) or of Group C (β = -0.00, t = -0.09). There was one, single interaction between Group and Vowel, only in Group C (/æ/: β = -0.17, t = -3.79).

The results for F2 in American English show that there is no significant effect of Group B as compared to Group A (β = -0.004, t = -0.41), but Group C is significantly different for F2 (β = 0.07, t = 3.181). In addition, there are four interactions between Group and Vowel, all for Group C (/i/: β = -0.18, t = -3.95, /oʊ/: β = -0.12, t = -3.29; /ʊ/: β = -0.09, t = -3.03; /u/ β = -0.21, t = -4.18). The results for F1 and F2 are shown in the vowel plot for American English phonemes for all three groups in Figure 1.

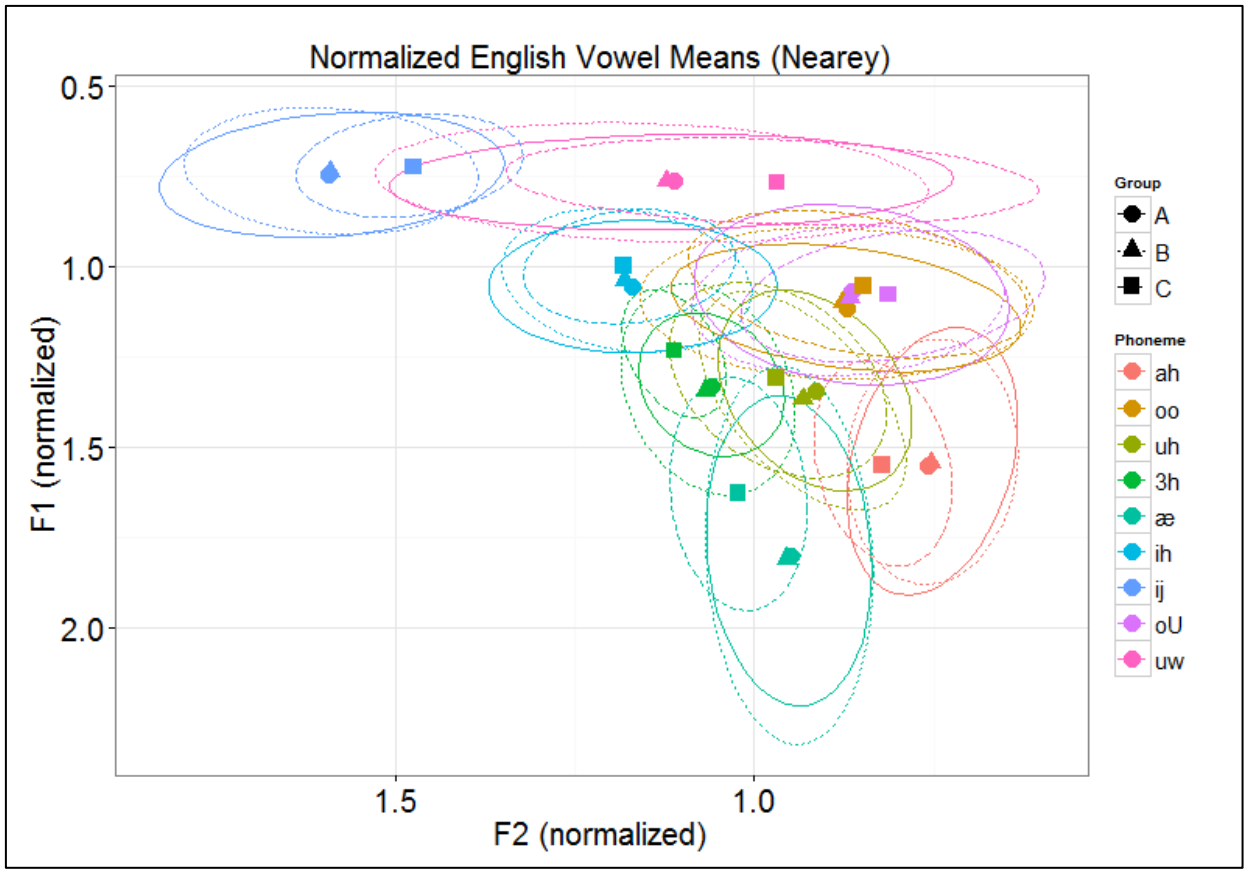

Figure 1. A scatterplot of normalized means of American English vowels in Groups A, B, and C. (a) Groups A and B do not differ significantly. (b) Group C is significantly different from Groups A and B. Vowel key: ah – /ɑ/; oo – /ʊ/; uh – /ʌ/; 3h – /ɛ/; æ – /æ/; ih – /ɪ/; ij – /i/; oU – /oʊ/; uw – /u/.

In order to further examine the high vowels, which were both the focus in Flege (1987) and the source of the interactions for the analysis of F2, further refined comparisons were done by examining the effect of group in separate regressions for each of the high vowels of French and English. Group D was the baseline for French models and Group A for English models. For French vowels /i/, /y/, and /u/, Groups A and B are is significantly different from Group D, but Group C is not significantly different from Group D (/i/: Group A ($\beta = 0.16$, $t = 3.55$), Group B ($\beta = 0.18$, $t = 4.02$), Group C ($\beta = 0.08$, $t = 1.43$); /y/: Group A ($\beta = -0.12$, $t = -2.4$), Group B ($\beta = -0.12$, $t = -2.5$), Group C ($\beta = 0.02$, $t = 0.39$); /u/: Group A ($\beta = 0.18$, $t = 3.23$), Group B ($\beta =$

0.18, t = 3.32), Group C (β = 0.11, t = 1.64). The analysis of American English /i/ and /u/ and showed that only Group C was significantly different from Group A (/i/: Group B (β = -0.00, t = -0.30), Group C (β = -0.12, t = -2.53); /u/: Group B (β = 0.01, t = 0.54), Group C (β = -0.14, t = -3.065). Figures 2 and 3 display these findings.

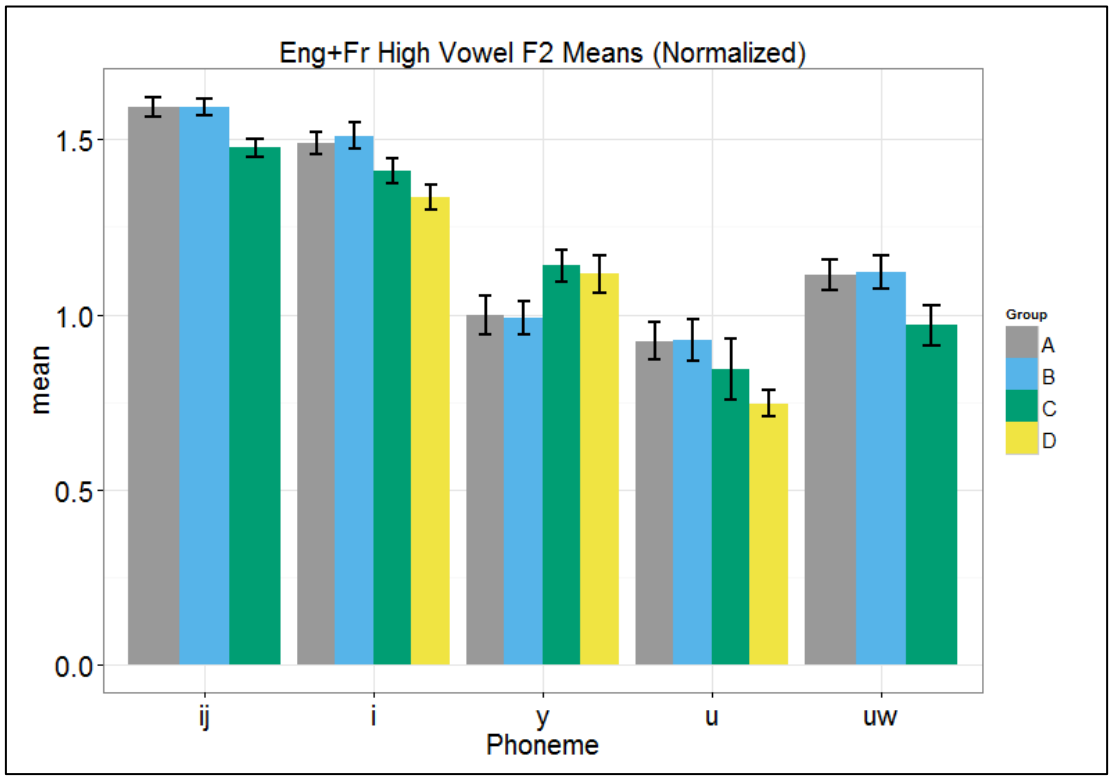

Figure 2. A bar graph of normalized means of American English and French high vowels in Groups A, B, and C. (a) Group A and B are not significantly different across all high vowels. (b) Group C is significantly different from Groups A and B for the phonemes /i/, /y/, and /u/. Vowel key: Vowel key: ij – American English /i/; i – French /i/; y – French /y/; u – French /u/; uw – American English /u/.

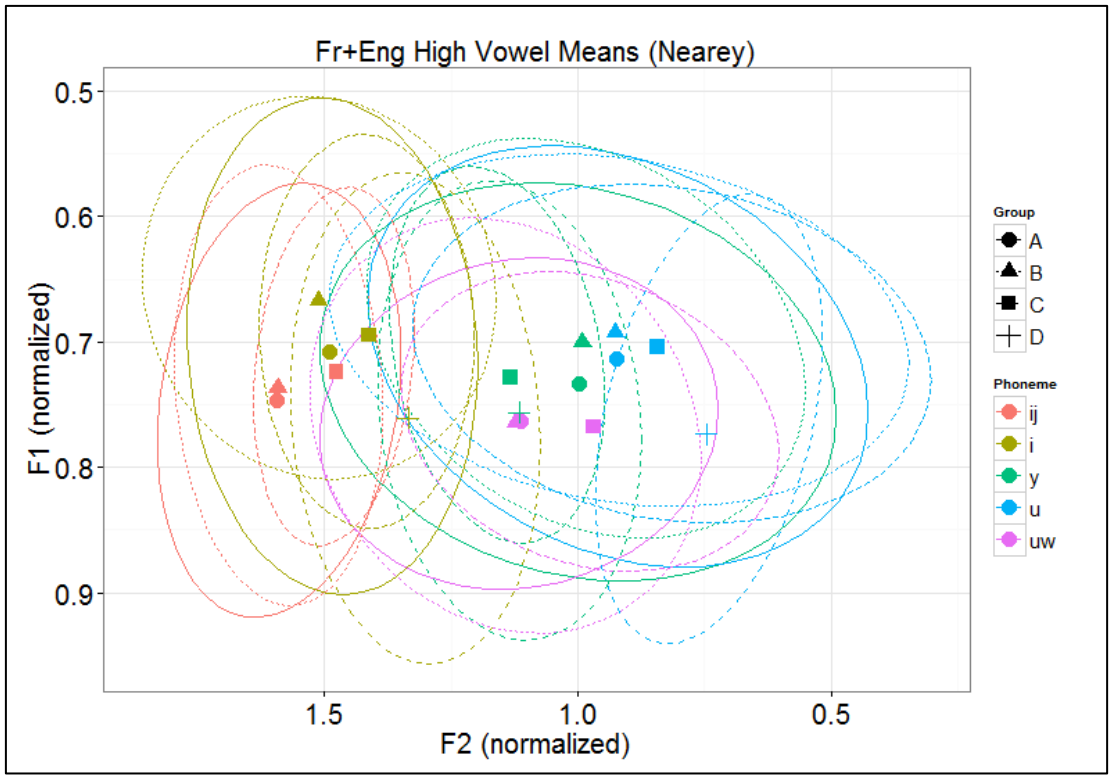

Figure 3. A scatterplot of normalized means of American English and French high vowels in Groups A, B, and C. (a) Group A and B are not significantly different across all high vowels. (b) Group C is significantly different from Groups A and B for the phonemes /i/, /y/, and /u/. Vowel key: Vowel key: ij – American English /i/; i – French /i/; y – French /y/; u – French /u/; uw – American English /u/.

Despite a slight rise in F2 for both French /u/ and American English /u/, differences were not significant. F2 also rose for French /i/ in Group B, but was still not significantly different from its Group A counterpart. For the phonetic drift to occur, we would expect to at least see a significant decrease in American English /i/ towards French /i/ and a separate significant decrease in F2 for American English /u/ towards French /u/. Thus, accounting for the effects of time with the inherent difference between Groups A and B, no significant differences were found between American English high vowels and the entire American English vowel space after 6 weeks of immersion.

It is also worth noting that Groups A and B tended to produce only French /y/ in a way that was significantly different from Groups C and D. This follows some predictions that novice L1 American English learners of French often encounter difficulties with the distinction of French /y/ and French /u/ (Levy and Strange, 2008), reinforcing their place as inexperienced learners as Group C was not shown to have this difference in productions of French /y/. In fact, in Figure 3, it seems Groups A and B tended to produce their French /u/ and French /y/ relatively close to one another while Group C produced the same two sounds farther apart from each other, and closer to the French native speakers in Group D. French /i/ for Group C is also closer to the French category in Group D than Groups A and B, but ultimately did not reach significance.

In short, Group C is consistently below measurements of Group A in Figure 2, signifying a movement backward for multiple categories, and a trend of shifts toward the French category of /u/ and the French category of /i/. These movements are also represented in the location of Group C means in Figure 1 where Group C means are slightly more back (i.e. lower in F2) in comparison to Group A. Due to the multiple significant interactions for Group C, further analyses were conducted in order to investigate the nature of these Group C differences.

4.2 Group C age analyses

Further analyses of the interactions in Group C were conducted in order to account for possible biological age effects that translate to differences due to language change. A given speaker's biological age could contribute to dialectical differences as younger speakers may pronounce vowels differently due to the changing linguistic landscape of the language over time. For example, sociolinguistic research has shown that change over time in the production of vowels can change the mean midpoint formant values for younger speakers as compared to older

speakers (Labov 2010). Group C was split into four subgroups and these subgroups were used in subsequent analyses. The subgroups are CE1, CE2, CF1, and CF2. Group C1 contained the three youngest subjects of Group C while Group C2 contained the two older subjects of Group C. "E" signified American English and "F" signified French. Examination of the geographic information provided in the demographic data suggest that there were no substantial differences among the speakers, so it is unlikely that American English dialect is affecting the results. Many of the speakers in Groups A and C share their American English dialect and thus comparisons between the groups are fairly assessing the same dialect. Finally, only Group A was used for further comparisons, as it was not found to be significantly different from Group B in the original analysis.

The first regression model applied to the subgroups examined groups CE1, CE2, CF1, and CF2 for F2 for all high vowels. Using English /i/ as a reference vowel, results showed that for the main effect of Group there were no significant effects, and no interactions between Group and Vowel. However, there are significant main effects of Vowel as compared to English /i/: French /y/ ($\beta = -0.32, t = -4.88$), English /u/ ($\beta = -0.5, t = -7.55$), and French /u/ ($\beta = -0.61, t = -8.94$). Tukey post-hoc comparisons confirmed the significant effects, collapsing across groups: French /y/ to English /i/ ($\beta = -0.32, p < 0.001$), English /u/ to English /i/ ($\beta = -0.5, p < 0.001$), French /u/ to English /i/ ($\beta = -0.61, p < 0.001$), French /y/ to French /i/ ($\beta = -0.31, p < 0.001$), English /u/ to French /i/ ($\beta = -0.48, p < 0.001$), and French /u/ to French /y/ ($\beta = -0.59, p < 0.001$). The post-hoc comparisons for French /i/ to English /i/ ($\beta = -0.61, p = 0.9993$), English /u/ to French /y/ ($\beta = -0.61, p = 0.0708$), and French /u/ to English /u/ ($\beta = -0.61, p = 0.4603$) were did not reach significance. These results are illustrated in Figure 4.

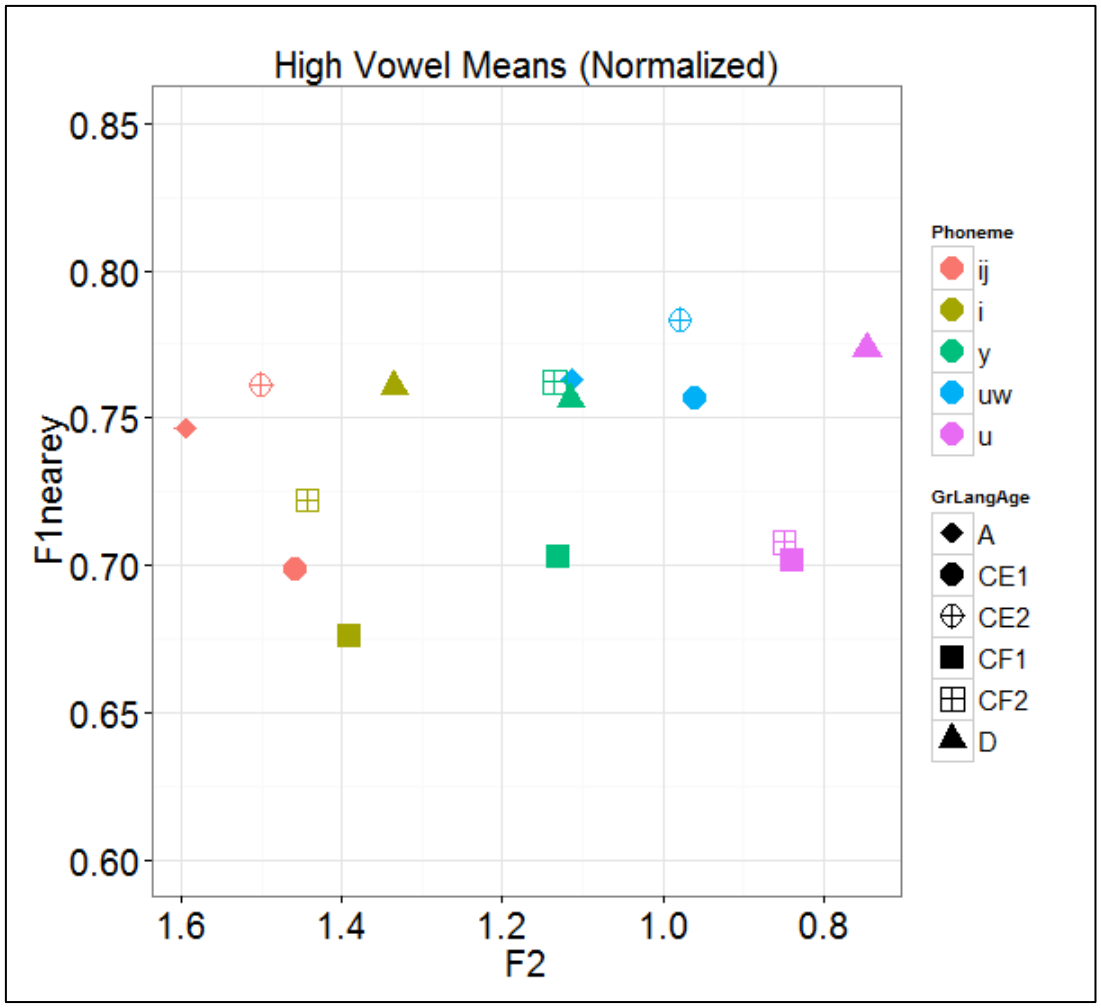

Figure 4. A scatterplot of normalized means of American English and French high vowels in subgroups A, CE1, CE2, CF1, CF2, and D. (a) Subgroups CE1, CE2, CF1, and CF2 are not significantly different from one another. (b) American English /u/, French /u/, and French /y/ were found to be different from each other when collapsed across subgroups. Vowel key: Vowel key: ij – American English /i/; i – French /i/; y – French /y/; u – French /u/; uw – American English /u/.

The second regression model for the subgroups was fitted to subgroup CF and group D in order to assess the significant differences in F2 for the French high vowel space reported above for subgroups CF1 and CF2. Using French /i/ as a reference vowel and CF1 as the reference group, results from this model showed that for the main effect of Group, Group D ($\beta = -0.06$, $t = -1.43$) was not significantly different from subgroup CF1, and subgroup CF2 ($\beta = 0.05$, $t = 1.03$) was not significantly different from subgroup CF1. In addition, no interactions were found for

subgroup CF2 and Group D. However, there is a significant effect for Vowel as compared to French /i/: /y/ (β = -0.24, t = -4.32) and /u/ (β = -0.55, t = -9.77). These results are illustrated in Figure 5.

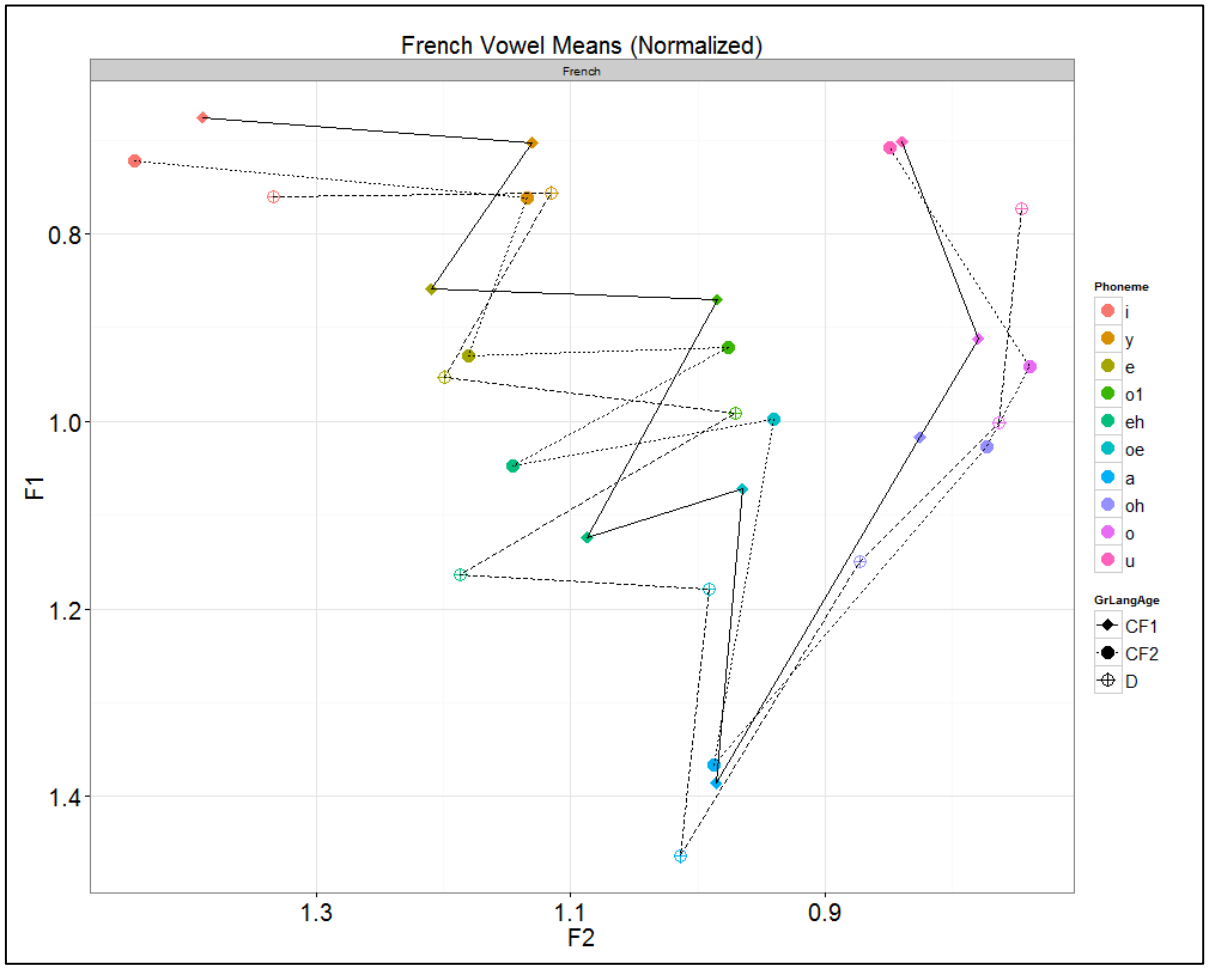

Figure 5. A scatterplot of normalized means of all vowel tokens in French for subgroups CF1 and CF2, and Group D. Vowel key: i – /i/; y – /y/; e – /e/; o1 – /ø/; eh – /ɛ/; oe – /œ/; a – /a/; oh – / ɔ /; o – /o/; u – /u/.

A third regression model for the subgroups was fitted to subgroup CE and group A in order to assess the significant differences in F2 in the American English high vowel space for subgroups CE1 and CE2. Using American English /i/ as a reference vowel and Group A as the reference group, results from this model showed that for the main effect of Group, Group A was

not significantly different from subgroup CE2 (β = -0.09, t = -1.64), but Group A was significantly different from subgroup CE1 (β = -0.14, t = -2.8). In addition, no interactions were found between subgroups CE1 and CE2, and Group D. However, for Vowel, there is a significant difference between /u/ and /i/ in American English (β = -0.48, t = -8.79). These results are illustrated in Figure 6.

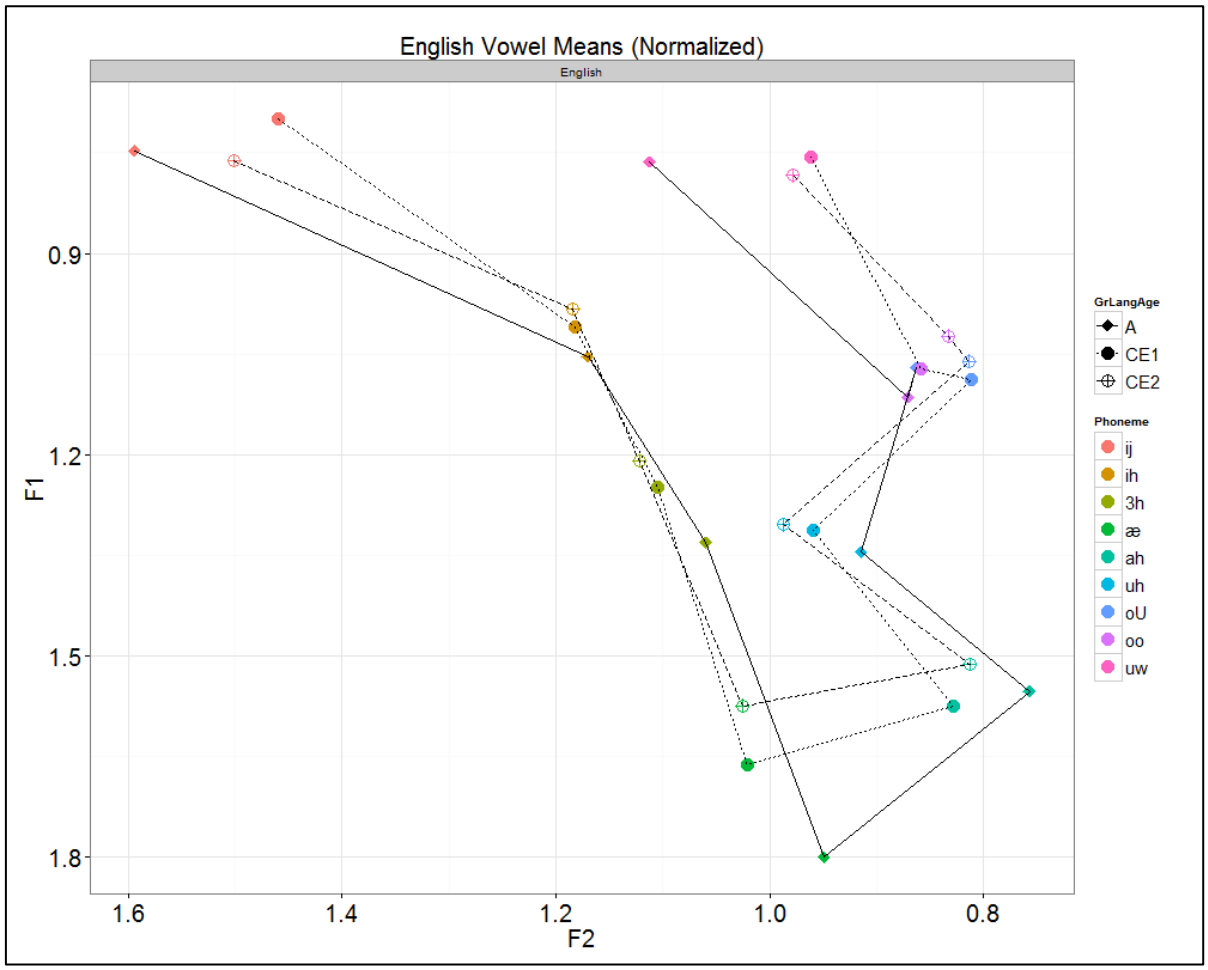

Figure 6. A scatterplot of normalized means of all vowel tokens in American English and French for subgroups CE1 and CE2, and Group D. Vowel key: ah – /ɑ/; oo – /ʊ/; uh – /ʌ/; 3h – /ɛ/; æ – /æ/; ih – /ɪ/; ij – /i/; oU – /oʊ/; uw – /u/.

These results are ultimately consistent with the differences between Groups A and B, and Group C found in Section 4.1. However, subdividing Group C by language and by age provided

evidence of minute differences within the conglomerate Group C. Since the members of Group C represent a range of individuals with a range of experience, it seems these results emulate the multiple group distinctions in Flege (1987) that ultimately demonstrated a gradient of high vowel productions. Additionally, subgroup CE1, a group matched in age and dialect to Group A, behaved similarly with CE2, demonstrating that age and language were not significant to the difference between Groups A and C. The following discussion section will delve into the ramifications of these findings in the context of linguistic experience and external factors that influence language development and phonetic drift in these speakers. The cognitive models of the SLM and PAM-L2 will also be revisited with these findings in mind.

5. Discussion

This study reported no instance of phonetic drift in vowels in L1 as a consequence of immediate contact with an L2. Contrary to predictions in the present study and Chang (2012), no categorical adjustments in the phonetic space of L1 were made early on in L2 development. However, extended contact with L2 demonstrated some initial effects on the phonetic space of L1. The following discussion concerns the implications of these findings for linguistic experience and phonetic drift, and the cognitive ramifications of language development and speech production and perception.

5.1 Phonetic drift

This study examined the American English vowel space for phonetic drift on two different fronts: temporal change and global spectral change. Temporally speaking, phonetic drift of American English vowels after immediate contact with French as L2 did not occur. Early learners in fact showed no difference in their pronunciation of American English vowels after 6 weeks of immersion in a French-speaking environment. F1 and F2 were found to be unchanged after this time period for these novice learners. However, experienced learners conformed to temporal predictions insofar as they exhibited tendencies of phonetic drift in later periods of learning beyond the first 6 weeks of contact. This was manifest in the fact that for F1, American English /æ/ significantly shifted its position relative to American English norms, and for F2, American English high vowels /i/ and /u/ and mid vowels /oʊ/ and /ʊ/ significantly shifted positions relative to American English norms. Experienced learners that had passed periods of immersion well beyond 6 weeks showed that time as a function of their combined experiences did generate some effects in productions. Still, the global vowel space for these participants, and

thus the possibility of phonetic drift as defined in this study and Chang (2012), remained virtually unchanged and was not significantly different overall from American English norms, just like the global vowel space of Groups A and B.

Our predictions on global vowel movement expected that all vowels in the American English vowel space would experience the same type of shift in F1 or F2. That is, all vowels would increase or decrease in F1 in complete unison, or increase or decrease in F2 in complete unison. In these findings, it was instead that F1 and F2 remained unchanged for all vowels after the first 6 weeks of learning for inexperienced learners as seen in the vowel means plotted virtually on top of each other for Groups A and B in Figure 1. These unison movements for F1 and F2 were also not observed in all vowels of American English for Group C. Instead, F1 and F2 shifted under specific but not all vowels in the experienced learners of Group C and these shifts were not always in the same direction. Some vowels increased in F2, some vowels decreased in F2, and one vowel even decreased in F1, as seen in the individual vowels of subgroups CE1 and CE2 as compared to Group A in Figure 6. Therefore, the shifts are limited to specific vowels in experienced learners and no group, inexperienced or experienced, produced a unified, global shift in productions of American English vowels.

This finding suggests that there is a subtle nuance to the definition of phonetic drift in Chang (2012) that may be overestimated by the results of the study. It seems that one type of phonetic drift should concern movements in unison in F1 or F2 from *all* target vowels in an L1 according to Chang (2012, 2013). The results of Chang (2012) certainly demonstrated a general, globalized shift in F1 that is in line with this definition, but only *some* specific vowel movements in American English categories carried the shift; not all vowels of the target L1 shifted. In contrast to Chang (2012), specific vowel category shifts occurred in the *experienced* learners of

Group C in the present study. These specific movements were also unable to carry a generalized shift in the global vowel space in this group. Consequently, phonetic drift like that observed in Chang (2012) was not borne out in the results of the present study, nor is it very clear which vowels need to move in order to evoke a global phonetic drift for French and for Korean. On the other hand, movements similar to the general hypothesis of phonetic drift as L1 category movement due to L2 input were present in an experienced group of learners of French in Group C. Therefore, phonetic drift may operate on many levels and is not only limited to global shifts and immediate contact in inexperienced learners. It is at least certain that the generalized shift in Chang (2012) and specific vowel movement in the present study demonstrate that L2 phonetic systems still do begin to influence L1 phonetic systems. Furthermore, it is precisely for these differing instances of phonetic drift that the definition of the phenomenon remains an open question.

5.2 Linguistic experience

Due to the fact that Group C experienced some effects, it now appears that the linguistic background of participants could paint a clearer picture of how some vowels were shown to drift in experienced learners and how phonetic drift can manifest. Prior to the explanation of individual vowel movements in Group C, it should be noted that the interpretation of the shifts in individual vowels is limited; the small number of participants in the group with individual vowel movement, Group C, is not large enough to easily generalize to the population of L1 American English-speaking late learners of French as L2 at large. Also prior to this discussion of individual vowels, we must consider the linguistic background of the inexperienced learners.

In Flege (2003), the authors explained that input from only native speakers could facilitate the formation of native-like categories. For the inexperienced learners of Group A and B, the input from non-native speakers that were friends of the participant or other instructors at NYUP that were non-native speakers of French, but all speaking in French to the participant, may have negatively contributed to the linguistic development of these novice learners. Instructors' vowel categories may not have been entirely native-like in production and other early learners would not have had sufficiently native-like categories from the start. In fact, these same peers speaking American English to the participants may have reinforced American English categories, prohibiting the pressures of the L2 from affecting American English vowels. Taken with the fact that self-reported rates of speaking French outside of the classroom environment with native speakers were on average less than 10% of the time and the fact that participants were only in class 6 hours per week, the quantity of native input and general language experience seems to be too insufficient to effectively place pressure on L1 categories. Furthermore, the inexperienced learners of Groups A and B reported that they did not have jobs that required French, nor significant others with whom they communicated in French, nor consistent contact with friends that were native speakers, and they did not live with native French-speaking host families. It is therefore assumed that because of this lack of experience beyond the classroom, Groups A and B were unable to reach a point in their language development where phonetic drift could occur.

This lack of experience is similar to the inexperienced listeners in Chang (2012), who received 6 hours of class time per week, but were otherwise using their L1 American English with friends and while out and about in the L2 environment. However, contrary to the absence of phonetic drift in inexperienced learners of French, the American English vowel space of

inexperienced learners of Korean did drift. Therefore, the linguistic background and experience in L2 of participants doesn't seem to explain why no phonetic drift was found in inexperienced learners of French as the groups of inexperienced learners in the present study and in Chang (2012) are matched on a number of levels. At this point, it is possible that the inherent differences between French and Korean, linguistic and metalinguistic, are contributing to the difference in likelihood of phonetic drift in these two studies.

In Chang (2012), the American English vowel space and Korean vowel space are plotted on top of each other and are revealed to be very different in acoustic measures; Korean has less vowels than American English and appears to be more spread out in all directions. On the other hand, French has an abundant set of vowels relative to Korean, making the options of category movement much more numerous. There are simply more vowels to compare to one another with much smaller differences between each vowel in American English and in French and thus more options to substitute and subsume into a native category (see Figure 7). Consequently, since the target groups of participants in either study are matched in terms of linguistic experience, age, dialect, etc., it could simply be that French is not different enough from American English to evoke any sort of change in L1 vowel categories after immediate contact.

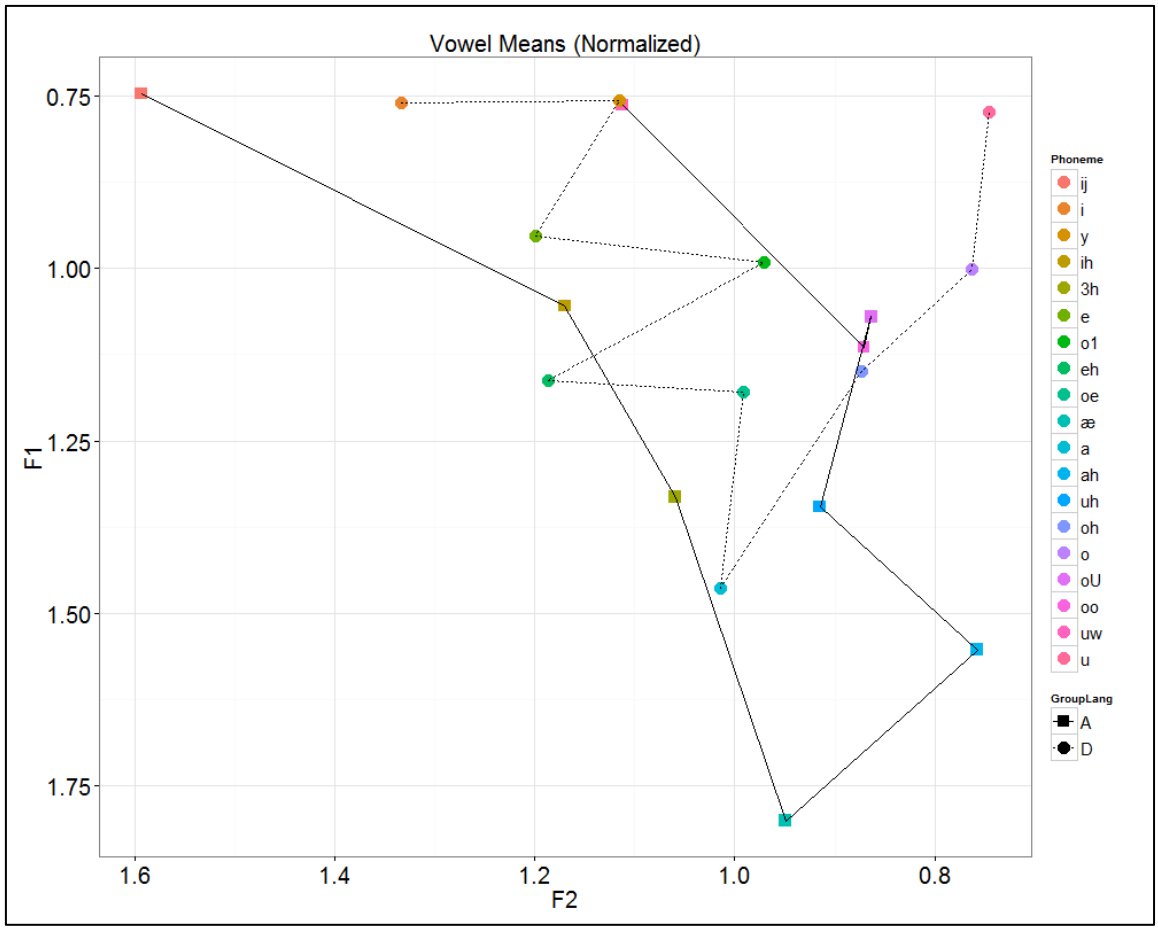

Figure 7. A scatterplot of normalized means of all vowel tokens in American English and French for Groups A and D. Vowel key: ah – /ɑ/; oo – /ʊ/; uh – /ʌ/; 3h – /ɛ/; æ – /æ/; ih – /ɪ/; ij – /i/; oU – /oʊ/; uw – /u/; i – /i/; y – /y/; e – /e/; o1 – /ø/; eh – /ɛ/; oe – /œ/; a – /a/; oh – /ɔ/; o – /o/; u – /u/.

Furthermore, on a metalinguistic level, inexperienced learners of French may not perceive French to be that different from American English relative to the perceived difference of Korean from American English. Thus, when early learners begin to acquire the language, they may already be inattentive to the differences between French and American English that need to be perceived in order to evoke phonetic drift. In a motivated learner of Korean in an immersive language program, the attention given to subtle differences would be exponentially higher relative to the inexperienced learners of French and may encourage the possibility of phonetic drift. Taken together, the acoustic qualities of the input and the attitudes informing the language

learning process and subsequently the perception of L2 may have contributed to an inhibition of phonetic drift in the inexperienced learners of Groups A and B. For experienced learners in Group C, however, some drifting effects for individual vowels were observed. This group possesses considerably larger linguistic experience in L2, heavier motivations for using L2, and a likelihood that a metalinguistic factor such as the perception of language difficulty has been reduced. This suggests that the above linguistic and metalinguistic factors that inhibit category movements in Groups A and B may be resolved later on in the language learning process.

In a deeper look at these vowel movements, experienced learners' American English high, mid, and low vowel manipulation seems to have been influenced by a phonetic drift-like pressure as a function of their linguistic experience. To quickly recap, both American English /i/ and /u/ demonstrate a decrease in F2 for Group C as a whole (see Figures 1 and 2). This is consistent with a shift toward the norms of the French high vowel /i/ and /u/ counterparts observed in this study. It is also contrary to the singular observation of category movement in American English /u/ in Flege (1987). The movement of American English /i/ was ignored to preserve "lexical similarity" and the study reported its findings only on American English /u/. In the present study, both high vowels were shown to move in a complementary fashion, and in a predictable way that is consistent with the shifting toward L2 norms. Although no global phonetic drift was observed in the experienced learners, the movement was not isolated to the American English vowel /u/, nor was it isolated to high vowels.

This trend of a decrease in F2 and a shift toward the French norm was also present for the mid vowels /oʊ/ and /ʊ/ (see Figure 1). However, in this instance, only one vowel, American English /oʊ/ had a direct counterpart, French /o/. The mid vowel /ʊ/ is not clearly moving toward a particular counterpart and may just be following the trend. As acknowledged above, there are

simply more French vowels to categorize for American English learners and this may neutralize some of the possibility of phonetic drift, relative to the learners of Korean in Chang (2012). Lastly, American English /æ/ demonstrated a significant decrease in F1 (see Figure 1). While not intended to directly match French /a/, it is possible that American English learners treat French /a/ as a counterpart to American English /æ/. The presence of two low vowels in the American English vowel space (/a/ and /ɑ/) provides an opportunity for assimilation to or dissimilation from multiple categories when incorporating French /a/ into the phonetic space of a speaker. Since F1 decreased and it is shown in Figure 6 that American English /æ/ appears to be moving closer to French /a/, the closer category to French /a/ is American English /æ/, not American English /ɑ/. Due to this closeness, this F1 shift of American English /æ/, toward French /a/, provides more minute evidence of a tendency of L1 American English categories to shift toward L2 French category norms.

Returning to the subdivided data for American English high vowels /i/ and /u/ in Group C (Figure 6), we see that subgroups CE1 and CE2 are grouped together with lower F2 values than Group A. This is expected as Group C tended to not differ from Group D in their productions, suggesting their L2 French productions are close to French norms. Importantly though, Group A and subgroup CE1 are relatively the same in age and in dialect, meaning that at the start, without considering linguistic experience in L2, we would expect these groups to produce American English in a similar manner. Simply put, the notable difference between these groups is limited to linguistic experience. However, Group A and subgroup CE1 are significantly different from one another and, since CE1 and CE2 are not significantly different from one another, the conglomerate Group C appears to be producing American English high vowels in a different way as a function of their conglomerate linguistic experience as opposed to their biological age and

dialectical differences. Thus, movements still occurred despite the existence of relatively similar learners in the inexperienced groups and experienced groups, suggesting that the biological age and dialect do not seem to inhibit specific vowel movements in experienced learners of French.

Moreover, multiple participants in Group C use French in a "heavy" sense: they speak it at home, for their job, and have been doing so for an extended amount of time. The others use French in a "light" sense: they use it at work only when necessary, it is not spoken at home, and they fluctuate between periods of heavy usage and no usage at all. Further, the magnitude of previous experience varied greatly from one individual to the next in Group C, somewhat emulating the group divisions in Flege (1987). This is important to note because the differing groups of experienced learners in Flege (1987) were shown to have a gradient distribution of high vowel productions. That is, the more experience an individual had, the closer to a French norm their productions of American English vowels were. Then, when compared to the novice learners, the evidence suggested that time as a function of linguistic experience may have provided an environment where L1 phonetic systems are in some way affected by L2 phonetic systems. Regardless of usage, experienced learners in Group C are just that — experienced — in comparison to those without experience in Group A and B. Consequently, due to the similarity in our results and the results of Flege (1987), it is further likely that a meaningful element of L1 phonetic category manipulation is the level and magnitude of experience in L2.

It is still necessary to consider that with all specific vowel movements taken at face value and with the low subject count in mind, it may be more plausible that normal speaker variability is contributing to these minute differences between individual vowels for Group C. However, when a direct or close counterpart is available in French, these specific American English vowels tended to predictably drift toward the given L2 counterpart or next closest counterpart,

suggesting that the L2 may have an influence on L1 categories as a result of linguistic experience. Furthermore, the L1 American English vowel space of L1 American English learners of French could approach the global phonetic drift observed in Chang (2012), as it goes beyond single high vowel movement in Flege (1987) and toward a quantity of specific movements that motivated the generalized shift in Chang (2012). However, it is best to keep in mind that the definition of phonetic drift remains contentious since it is unclear in both the present study and Chang (2012) how a proportion of shifted and unshifted vowels could evoke a global phonetic drift, especially if the movements in F1 and F2 for each individual vowel are not in unison. It is also best to acknowledge that French and Korean present very different challenges to L1 American English learners and the way in which this could affect the likelihood of phonetic drift is indistinctly borne out in these results. Overall, as a result of linguistic experience in French as L2, phonetic categories in experienced speakers still display a tendency to shift away from American English norms, and a tendency to shift toward the direct counterpart or next closest French norm at least on the level of individual vowels. Furthermore, the contrast in results between Chang (2012), the present study, and the possibility of any studies focusing on different language pairs with different pressures are unable to explicitly define phonetic drift and thus the mechanism that evokes the phenomenon is still up for consideration.

5.3 *Cognitive models revisited*

In terms to the SLM, the lack of phonetic drift in Groups A and B, and the fact that the American English vowel space remained unchanged in these groups, make it unlikely that any predicted form of category dissimilation occurred to create a new category in the L2, or, importantly, that any category assimilation occurred to create a merged, shifted category in L1.

That is, if French vowels were categorized properly, we would expect to see certain vowel norms of French influencing the vowel productions of American English, but it appears that no relationship was necessarily established between vowels categories in American English and French in inexperienced learners. However, some of the individual vowel movements in Chang (2012) could be categorized as assimilatory in nature in so far as American English vowel categories seemed to shift as a result of L2 Korean contact signifying a merged L1 category and suggesting that the mechanisms of the SLM do operate within the process of phonetic drift. Therefore, it is not clear as to why these vowels or any vowels were susceptible to phonetic drift in relation to those that did not shift nor is it clear why the same shifts did not occur between American English and French.

One possible explanation for this is that certain category assimilations and dissimilations in an L2 Korean environment have thresholds that need to be reached in the time of immediate contact in order to evoke phonetic drift. For some of the vowel categories in Chang (2012), this threshold was met and some shift occurred. Conversely, the assimilation and dissimilation thresholds in the inexperienced learners of French in Flege (1987) and the present study were not met and thus no shift occurred. In fact, in Flege (1987), the movement of American English /u/ towards the French /y/ norm suggests that the correct threshold was not even approached and instead learners' likelihood to merge the categories may have been superseded by perceptual difficulties with French as L2 (see Levy and Strange, 2008). Thus, it appears that the nuances of the relationship between French and American English could be inhibiting the mechanisms of the SLM. Inevitably, the mechanisms of the SLM are motivated by the amount and type of L2 input a given speaker receives to compare to a native category (see Flege, 2003), and thus the amount of input necessary to each individual vowel's threshold of assimilation and dissimilation

varies among language pairs. Therefore, the relationship between French and American English in inexperienced learners was not given an occasion in the immediate contact of the first 6 weeks of L2 French immersion to evoke phonetic drift due to interaction between their unique linguistic characteristics. In terms of the SLM, the relationships between American English and French vowels have their own thresholds for category assimilation and dissimilation and subsequently possess their own time scale and environment in which phonetic drift can occur. This also relies on the fact that the categories are being distinguished in the first place. If metalinguistic information or perceptual difficulties unique to learners of French could be inhibiting the vowel categorization at the start of the L2 acquisition process, no categorization could occur.

Returning to Levy and Strange (2008), the French /y/ - /u/ distinction is difficult for L1 American English speakers. In a perceptual task, as compared to other vowel pairs like French /i/ - /u/ and French /y/ - /œ/, where linguistic background did contribute to more success in distinguishing certain pairs, novice and experienced learners were equally as bad at distinguishing French /y/ - /u/, showing that specific vowel pair is significantly difficult to distinguish for L1 American English speakers, regardless of linguistic experience. In terms of PAM-L2, the perceptual behavior of learners suggests that French /y/ and French /u/ are either categorized as poor examples of the same category (Single Category) or as differing examples of the same category, with one being superior to the other (Category Goodness). Essentially, this group of learners in Groups A and B for the present study may have perceived French categories as separate, but hadn't quite figured out how, nor in what way they should map the distinctions due to generalized perceptual difficulties of L1 American English learners of French. This then prohibited the possibility of the equivalence classification and subsequent category assimilations and dissimilations of the SLM to begin acting in inexperienced learners. Without the shift in

perception in this specific instance, production shifts were even less likely to occur. On the other hand, for experienced learners, it is unclear whether or not the perceptual shift occurred and paired with cumulative linguistic experience to motivate some specific category shifts, or if the cumulative linguistic experience alone brought out the category shifts as experienced learners in Flege (1987) and the present study behaved contrary to the poor perceptual performance of experienced learners in Levy and Strange (2008).

In Flege (1987), inexperienced learners were unable to produce French /y/ and French /u/ with significant difference and produced American English /u/ with slightly higher F2 frequencies, and thus between French /y/ and French /u/. Flege suggests that equivalence classification limited the distinction of the "similar" phonemes, American English /u/ and French /u/, and ultimately facilitated the acquisition of the "new" phoneme, French /y/ contingent upon the successful perceptual distinction of these categories. Since inexperienced learners often have difficulties with these categories, the assumptions on production in Flege (1987) are consistent with the perceptual results in Levy and Strange (2008).

In the present study, novice learners tended to produce French /y/ differently from their experienced and native speaker counterparts. In Figure 3, Groups A and B tended to produce French /y/ and French /u/ relatively close to one another, away from the norms with the experienced listeners of Group C, who were themselves closer to native French norms in Group D. Further, in Figure 4, it is shown that novice learners in Group A produced American English /u/ directly on top of the native French speaker's productions of French /y/.

Taken together with the similar high vowel productions in Flege (1987), equivalence classification of the SLM in inexperienced learners may have defaulted at category assimilation in terms of absorbing all categories into one. In attempting to reconcile those categorical

differences, marginal adjustments did in fact begin to occur, but larger category differences were evoked as a function of linguistic experience, manifest in the productions of Group C. Thus, after a certain amount of linguistic experience, an experienced learner is better able to categorize the sounds and reconcile the perceptual difficulties for production in the face of inexperienced learners that perceive these sounds as "similar." The mechanism of equivalence classification is comparing these sounds to a larger, more experienced category in experienced listeners, providing a higher probability of classifying a category as "new." In experienced learners, the distinction of French high vowels is successfully made due to a successful production of the "new" French phoneme /y/. Experienced learners also demonstrated categorical shifts for specific vowels in other parts of the L1 American English vowel space beyond the high vowels. Thus, equivalence classification paired with perceptual difficulties provides a stable explanation of the differences in native vowel category productions between inexperienced and experienced learners: perception-fed production difficulties exhibited by inexperienced learners who may be between the mechanisms of PAM-L2 and the SLM and the transcendence of these difficulties in experienced learners due to cumulative linguistic experience and successful instances of the SLM mechanisms. Therefore, arriving at equivalence classification is difficult and it evidently involves the interaction of unique language information and cumulative experience. In a follow-up study, Chang (2013) revisited the gap in cumulative linguistic experience in the interaction between American English and Korean by involving a new group of experienced learners. It was explained that production differences between the inexperienced learners and these new experienced learners could have varied as a function of linguistic novelty and recency effects that supersede linguistic experience.

A novelty bias predisposes an individual to attend to novel stimuli. In adults, the novelty bias manifests in inhibited performance on a task when responding to novel distractors as compared to familiar ones. It is hypothesized that the underlying cognitive process of the novelty bias in relation to auditory input involves "the violation of the cognitive system's expectation based on learning conditional probabilities and, to some extent, the occurrence of a perceptual change from one sound to another (Parmentier, Elsley, Andrés, and Barceló, 2011, p.374, as cited in Chang, 2013; see Chang, 2013 for a full review). On the other hand, a recency effect has to do with the "temporal order in which information is received" (Chang, 2013). Serial position effects occur when the items presented in a given order begin to interfere with each other due to the time that has passed as the items were presented and these effects have manifested in linguistic environments. Recency effects are also found to be distributed to other cognitive processes and involve memory in general, suggesting that they have a very large behavioral influence in an individual (see Chang, 2013 for a full review). Applying the novelty bias and recency effects to his study, Chang (2013) examined the vowel category productions of the same complete novice L1 American English learners of Korean as L2 from Chang (2012) in comparison to productions of the same stimuli in experienced individuals in the same immersion program. The results showed that in contrast to inexperienced learners of Korean, experienced learners did not show a global, generalized decrease in F1 for L1 American English vowel categories. For these findings, Chang provides a number of explanations in relation to novelty bias and recency effects.

First, the novelty of linguistic categories will decrease as a speaker is repeatedly exposed to L2 in learning and re-learning over time. Chang suggests that speakers maintain this bias as they stand to learn more about the environment if novel items are always given preference, much

like a child learning language, a claim parallel to one of the SLM's postulates, which state that children and adults use the same learning mechanism, equivalence classification, throughout life (Chang, 2013; Flege, 1995). Second, shifting to the experienced learners in the study that showed no effect of L1 phonetic drift, Chang draws the conclusion that recency effects override cumulative experience as represented in the shifting and accommodating of environmental VOT values of the bilingual speaker of Brazilian Portuguese and English in Sancier and Fowler (1997). Not only does recent experience in L2 have immediate effects on L1 phonetic category productions, shifting between L1 and L2 environments also allows the L1 to recover from recency effects and establishes a system of diminishing returns as evidenced in the divisions of productions in experienced learners of French in Flege (1987) and the experienced learners of Korean.

In the present study, the novelty bias proposed in Chang (2013) may be acting upon the inexperienced learners of French in Groups A and B but to a much lesser extent than the inexperienced learners of Korean. So much less, that no effect has manifested within the time frame tested. Relative to the novelty an inexperienced learner in Chang (2012, 2013) would perceive between American English and Korean, the learners in Groups A and B might not perceive that French is particularly novel compared to American English. Then, taking the other factors of baseline acoustic differences between French and American English, perceptual difficulties, quantity of usage, and quality of input, there are many factors unique to the relationship to French and American English that do not match up to the environment of phonetic drift in Chang (2012). Further, in the experienced learners of French in Group C, L2 French may no longer be novel and thus phonetic drift could not be motivated by the novel comparison of categories between French and American English. However, the pairing of

cumulative experience and the fact that the participants were all living in France without breaks at the time and had done so for at least 5 years supports the phonetic drift tendencies observed in their L1 American English vowel space. Were these participants in Group C to return to the United States, the logic in Chang (2013) suggests that the phonetic drift would then begin to neutralize and the L1 vowel space would be less and less affected by L2 experience. Additionally, this contradicts the claim in Chang (2013) that L2 effects on L1 are greater earlier in life as phonetic drift tendencies were only shown in experienced learners of French. Rather than a complete contradiction to the findings, it is plausible that the largest phonetic drift effects do, in fact, occur earlier in L2 experience, just not as early as 6 weeks for L1 American English learners of French. There are not enough stages of learners represented in the data that are able to represent an exact contradiction to this claim, especially if the phonetic drift for the language pair of French and American English occurs at 8 or 10 weeks after first exposure to French as L2.

In short, certain specific elements of PAM-L2 and the SLM are supported by the results in the present study. The mechanism of equivalence classification in the SLM aided experienced learners with the production of "new" phonemes in French as L2 while it inhibited production in inexperienced learners because of an overwhelming, perceived similarity between "new" and "similar" phonemes. The perceptual classifications of PAM-L2 also provide an explanation of how perceptual difficulties may have informed or inhibited the formation of phonetic category productions and demonstrate that the unique characteristics of the relationship between French and American English help to explain the absence of phonetic drift as compared to the observation of phonetic drift in Chang (2012). Metalinguistic information such as novelty biases, recency effects, and subjective perceptions of language difficulty may also be contributing to this unique relationship. Nonetheless, rather than a failure of fitting into the framework of these

models and studies, these findings instead provide evidence for the benefits of simultaneous usage of the two models and a consideration of other cognitive processes beyond language.

6. Summary

Overall, this study attempted to observe phonetic drift in L1 American English learners of French as L2. While phonetic drift in the entire vowel space was not observed after immediate contact with French as L2 in inexperienced learners, some individual vowels of American English were shown to have shifted in experienced learners. These findings were consistent with the cognitive mechanisms proposed by the SLM (Flege, 1987, 1995), but ultimately contradicted the findings on immediate phonetic drift in Chang (2012). Taken together, these results provide evidence of trends in the malleability of phonetic categories in L1 and the importance of linguistic experience in the acquisition process. Further research in the realm of L1 malleability should focus on a range of experienced learners and other language pairs in order to understand the nature of language development in L2 learners. Should this research also hope to observe phonetic drift in novice learners, it should focus on programs with heavy immersion standards and low L1 influence and be acutely cognizant of the language pairs it hopes to examine.

Appendix A: Specific Speaker Data

Group A/B

	Gender	Age	Location	Language other than FR or EN	Parent/Guardian Location	Parent/Guardian Language other than FR or EN
1	Female	19	Tampa, FL	n/a	Ocala, FL; Tampa, FL	Spanish L2 fluency
2	Female	20	Bluebell, PA	Korean L2 fluency (classroom)	Seoul, Korea	Korean L1
3	Female	20	Los Angeles, CA	Spanish L2 intermediate (classroom)	Los Angeles, CA	Spanish L2 fluency
4	Female	18	Nashville, TN	Mandarin Chinese L2 fluent (classroom)	Southern Florida	Minimal Spanish L2
5	Male	18	Pittsburgh, PA	German L2 proficiency (classroom)	Shore Hills, NJ; Trenton, NJ	n/a
6	Male	21	Boston, MA	Hebrew L2 proficiency (classroom)	Greensboro, NC / Louisville, KY; Brooklyn, NY	Hebrew
7	Female	18	Tampa, FL	n/a	Edison, NJ	n/a
8	Male	20	Los Altos, CA	n/a	Saigon, Vietnam	Vietnamese L1
9	Female	20	Alameda, CA	Spanish L2 intermediate (classroom)	Portland, OR	n/a
10	Female	18	New York, New York /	Spanish fluency (classroom) + 1	Greenwich, CT; Philadelphia, PA	Latin; Arabic L1 / L2 significant experience in

			Farmington, CT / Greenwich, CT	year of immersion in Spain		English, Chinese, French, German, Italian, Russian
11	Female	20	Long Island, NY / Chicago, IL	n/a	Nekoosa, WI; Chicago, IL	n/a

Group C

	Gender	Age	Location	Language other than FR or EN	Parent/Guardian Location	Parent/Guardian Language other than FR or EN
12	Female	33	Milledgeville, GA	n/a	Milledgeville, GA; Newberry, SC	n/a
13	Female	52	Boston, MA	Small amount of Spanish L2 and German L2 (classroom)	New York State	French L2 / German L2
14	Male	28	Bucks County, PA	n/a	Philadelphia, PA; South Jersey, NJ	n/a
22	Male	35	Long Island and Manhattan, NY / Bucks County, PA	Basic-Intermediate Modern Greek L2, Spanish L2, German L2, Italian L2 (classroom)	Brooklyn, NY; Jackson, NJ	Modern Greek L2
23	Female	56	Los Angeles, CA	Spanish L2 proficiency (classroom)	Chicago, IL; Pittsburgh, PA	Yiddish L1

Group D

	Gender	Age	Location	Language other than FR or EN	Parent/Guardian Location	Parent/Guardian Language other than FR or EN

15	Female	19	Versailles, France	n/a	Bretagne, France; Alsace, France	n/a
16	Female	19	Seine-et-Marne, France	Spanish L2 intermediate	Seine-et-Marne, France; Gant, Belgium	Russian L2 proficient
17	Female	19	Orleans, France	Spanish L2 proficiency, minimal Chinese L2 (classroom)	Orleans, France; Paris, France	Portuguese L1 / Spanish L2; German L2
18	Male	19	Paris area, France	Portuguese L1 native bilingual / Spanish L2 proficiency; minimal Chinese L2 (classroom)	Guimaraes, Portugal	Portuguese L1
19	Female	19	Paris, France	Minimal German L2, minimal Spanish L2 (classroom)	Paris, France	Spanish L2, Italian L2 and Portuguese L2 proficiency
20	Female	19	Houilles, France	Spanish L2 basic-intermediate (classroom)	Normandy, France; Pays de la Loire, France	Intermediate German L2
21	Female	20	Picardy, France	German L2 proficiency	Picardy, France	Some German L2

Appendix B: Stimuli

French vowels used in production for Experiment 1

/i/		/y/		/u/		/e/		/ø/	
il fit deux bâtiments	/fid/ - fit deux	je n'ai pas bu de jus	/byd/ - bu de	il faut que tous ces hommes mangent	/tus/ - tous ces	il a des enfants	/dez/ - des enfants	il a deux voitures	/døv/ - deux voitures
les tortues vivent longtemps	/viv/ - vivent	j'ai mangé du fromage	/dyf/ - du fromage	au bout du couloir	/bud/ - bout du	tu as tes affaires	/tez/ - tes affaires	c'est peu de fromage	/pød/ - peu de
le régime de Vichy pendant la guerre	/viʃi/ - Vichy	il n'y a pas de puce sur ma carte	/pys/ - puce	j'aime les petites pousses de laitue	/pus/ - pousses	je connais la fée verte	/fev/ - fée verte	voilà ceux qui m'aiment	/søk/ - ceux qui
il fume la pipe à tabac	/pip/ - pipe	il faut que tu comprennes	/tyk/ - tu comprennes	c'est vous qui l'aimez	/vuk/ - vous qui	il veut ses vêtements	/sev/ - ses vêtements	j'ai eu trois feu verts sur la route	/føv/ - feu verts
vous dîtes qu'elle voulait nous voir	/dit/ - dîtes	elle fut paresseuse	/fyp/ - fut paresseuse	la soie est très douce et fine	/dus/ - douce	tout ce que j'ai préparé	/ʒep/ - j'ai préparé	je fais le vœu de ne plus fumer	/vød/ - vœu de
c'est la vie des enfants	/vid/ - vie des	on peut le faire vu qu'il nous comprend	/vyk/ - vu qu'il	c'est le fou qui s'est trompé	/fuk/ - fou qui	laisse-le chez toi	/ʃet/ - chez toi	les jeux d'enfants	/ʒød/ - jeux d'enfants

/ɛ/		/œ/		/ɔ/		/o/		/a/	
je veux qu'il sèche ses vêtements	/sɛʃ/ - sèche	son chef d'œuvre est formidable	/dœv/ - d'œuvre	un petit os du corps humain	/tɔs/ - petit os	passons par la côte d'Azur	/kot/ - côte	tu connais sa sœur	/sas/ - sa sœur
les enfants jettent des pierres	/ʒɛt/ - jettent	je voudrais un petit œuf bio	/tœf/ - petit œuf	le chien mange un petit os de dinde	/tɔs/ - petit os	un sot qui fait rire	/sok/ - sot qui	je veux ta pomme	/tap/ - ta pomme
je voudrais cette pomme	/sɛt/ - cette	la coquille d'œuf fait partie de la recette	/dœf/ - d'œuf	je vais aller voir mon pote ce weekend	/pɔt/ - pote	j'aime Peau d'Âne	/pod/ - Peau d'Âne	mon chat joue avec mes amis	/ʃaʒ/ - chat joue
le chef de cuisine	/ʃɛf/ - chef	une petite œuvre artistique	/tœv/ - petite œuvre	allez à la poste pour envoyer votre lettre	/pɔst/ - poste	mon beau-frère	/bof/ - beau-frère	mot de passe oublié	/pas/ - passe
elle ne cesse de fumer	/sɛs/ - cesse	elles peuvent danser ce soir	/pœv/ - peuvent	son chapeau a une poche secrète	/pɔʃ/ - poche	le chat saute sur moi	/sot/ - saute	je veux qu'il sache la vérité	/saʃ/ - sache
j'ai la tête ailleurs	/tɛt/ - tête	ils peuvent acheter quelque chose	/pœv/ - peuvent	c'était mon rêve de gosse de le voir	/gɔs/ - gosse	le taux de chômage	/tod/ - taux de	je n'ai pas d'espèces	/pad/ - pas d'espèces

American English vowels used in production for Experiment 2

/i/		/u/		/ɪ/		/ʊ/		/ʌ/	
I'll have tea cups	/tik/ - tea cups	I'll have two cups	/tuk/ - two cups	he fits the bill	/fɪts/ - fits	the book from the store	/bʊks/ - books	place the cup on the counter	/kʌp/ - cup
they see four criminals	/sif/ - see four	the dew point comes in at dusk	/dup/ - dew point	remove the pits from the peaches	/pɪts/ - pits	she foots the bill every time	/fʊts/ - foots	she putts down the green	/pʌts/ - putts
four keys on a ring	/kiz/ - keys	we are building a chicken coop tomorrow	/kup/ - coop	she hits two homeruns at every game	/hɪts/ - hits	two cooks in the kitchen	/kʊks/ - cooks	he butts heads with his brother	/bʌts/ - butts
the feed is outside	/fid/ - feed	the food is outside	/fud/ - food	there are first aid kits in all rooms of the building	/kɪts/ - kits	he took four apples from the store	/tʊk/ - took	she shuts both doors at night	/ʃʌts/ - shuts
let the tea bag steep for five minutes	/tib/ - tea bag	they sue four criminals	/suf/ - sue four	she sits on the sofa	/sɪts/ - sits	watch out for the fish hooks on the dock	/hʊks/ - hooks	the rock juts out from the mountain	/dʒʌts/ - juts
two bees on the flower	/biz/ - bees	I bought five shoes yesterday	/ʃuz/ - shoes	he had a few zits on his chin	/zɪts/ - zits	she shook the tree	/ʃʊk/ - shook	he guts two fish per day	/gʌts/ - guts

/oʊ/		/ɛ/		/æ/		/ɑ/	
*one doe at the lake	*/doʊ.æ/ - doe at	he bets two hundred	/bɛts/ - bets	he bats two hundred	/bæts/ - bats	the pots are in the kitchen	/pɑts/ - pots

say Joe's name	/dʒoʊz/ - Joe’s	she said we could eat	/sɛd/ - said	the tack in the wall fell out	/tæk/ - tack	there are dots on the floor	/dɑts/ - dots
she will sew patches onto the vest	/soʊp/ - sew patches	a small peck on the cheek	/pɛk/ - peck	put the cap by the recycle bin	/kæp/ - cap	there are cots for the children	/kɑts/ - cots
the archer's bow tightens	/boʊt/ - bow tightens	they built a shed in the backyard	/ʃɛd/ - shed	a small pack on the ground	/pæk/ - pack	a small dock in the harbor	/dɑk/ - dock
hand the hoe to the gardener	/hoʊt/ - hoe to	the dog jets down the hallway	/dʒɛts/ - jets	the back of the store	/bæk/ - back	she spots four criminals	/spɑts/ - spots
they are calling the tow truck	/toʊt/ - tow truck	two debts to resolve	/dɛts/ - debts	she is sad about the breakup	/sæd/ - sad	the court reporter jots down the case	/dʒɑts/ - jots

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