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Preface

For many undergraduate students, especially those who are finishing their programs and continuing on to graduate studies, developing the necessary skills to publish their research is critical. Taking a research paper and transforming it into a publication-ready manuscript is often a long road. However, it can also be an engaging, educational experience beyond compare.

With this in mind, we put together Volume 25 of WPLC with the intention of giving undergrads the opportunity to participate in the publishing process. This special edition is intended to showcase exceptional papers from undergraduate students, edited by a team of undergraduate guest editors. The diverse selection of articles in this volume exemplifies the range of research interests of undergrads in our department—one of UVic Linguistics' greatest strengths.

Editorial Committee,
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Editorial Committee

A forensic study of whisper and recall

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Certain criminal acts, such as fraud and verbal assault, may be of a solely verbal nature. In these cases, it is imperative that prosecutors have an accurate portrayal of exactly what was overheard by ear-witnesses. With aims of maximizing recall by ear-witnesses in judicial situations, this study presents findings based on experimental, comparative recall measures of whispered vs. normal (modal) speech, when the content was originally encountered in a disguised manner (i.e. whispered). Non-word tokens were recorded and acoustically matched in Praat, including 30 target-whisper, 30 test-modal and 30 test-whisper (for a total of 90 tokens). In the first phase of testing, participants heard 10 randomized tokens from the target-whisper bank, to be identified in the second phase via either the whispered or modal prompts. Correct identifications were tallied, and results show a benefit to presenting stimuli in a whisper when originally encountered in a whisper. These findings and applications to ear-witness testimony are discussed, with recommendations toward introduction of whispered stimuli in ear-witness line-ups.
Keywords: whisper; recall; ear-witness

1 Introduction

Ear-witness testimony can often be unreliable. Surprisingly, ear-witnesses who are more certain of their accusations of guilt are more often incorrect (Orchard & Yarmey, 1995). One issue in identification lies with the ease of voice disguise, where simply whispering significantly lowers successful speaker identification: "The easiest and perhaps most common way to disguise a voice is to whisper" (Reich & Duke, 1979, p. 1023). A growing bank of research exists regarding the shortcomings of speaker recognition and identification across voicing styles. Yet, current forensic literature lacks a discussion of witnesses' ability to recall and identify specific content heard in this disguised manner.

A leading researcher in the forensic linguistics field suggests that "for ear-witnesses to be really useful we must find ways of improving their performance for voice identification, and content recall" (Öhman, 2013, p. 9). Despite ear-witnesses' poor performance at identifying disguised voices, common judicial practice still presents only normally-voiced samples to ear-witnesses as a memory aid (akin to eye-witness procedures where a suspect is presented alongside several foils). This study will therefore test the quality of content recall across voicing styles, as to support inclusion of whispered stimuli in suitable

police ear-witness line-ups. Research will focus on the recall of content encountered in whispered speech, presented later in normal vs. whispered voicing, across a short timeframe.

2 Background

2.1 Speaker recognition and ear-witness applications

Lisa Öhman perhaps puts it best, stating, "[M]any civil and criminal cases involve testimony regarding statements or content of specific conversations. Furthermore, there are 'language crimes' (e.g. verbal sexual harassment, fraud) where the witness's memory of a conversation is the only available evidence" (p. 9). In these and all cases, it is important that prosecutors have the very best quality of information to come to a correct verdict.

In 1995 Daniel Yarmey developed a comprehensive review of ear-witness speaker identification. He noted that for some crimes the only evidence that may be available and helpful to the courts is the human listener. In such cases where evidence is in short supply, the power of the witness is hard to deny. While this is no place to dissect the judicial system's practices, there have been many questions related to the reliability of ear-witness testimony, especially when it is well researched that voices are easily disguised by a whisper alone.

Related research in two notable studies involve speaker recognition testing across whisper-whisper tokens, and whisper-normal tokens, among other variables of voice disguise. These studies included presentations of disguised voices, to be identified later among disguised and natural usages, among other variables. Findings from these studies describe that, "the inclusion of a whisper-disguised speech sample in the stimulus pair significantly interfered with listener performance […]" (Reich & Duke, 1979, p. 1028). Secondly, "voice disguise through whispering […] significantly influenced identification performance" (Orchard & Yarmey, 1995, p. 254). This paper utilizes similar methods, focusing on participant's ability to identify disguised and undisguised tokens. The purpose being to test *recall of content*, rather than *recognition of voices*.

2.2 Acoustics and neurocognitive consequences of whispered speech

In his review of ear-witness identification, Yarmey notes that, "Whispering conceals the most salient characteristics of a voice such as: pitch, inflection, and intonation" (Yarmey, 1995, p. 794). Whispered speech is produced with a more open glottis than normal voicing and with longer syllable durations and stop-closure intervals (Yarmey, 1995, p. 793). In particular, missing from the signal are "pitch and harmonic relationships, with no differential in power between 200_{HZ} and 2000_{HZ}" (Tartter, 1989, p. 1678). These missing characteristics have been positively correlated to the negative impact whispering has on identification of speakers by Tartter, Yarmey, Öhman et al. Since listeners can actively identify

and extract useful phonetic information from a whisper, what cues remain for analysis in the utterance?

Seeking more information, in her 1989 article "What's in a Whisper?", Vivien Tartter investigated the acoustic characteristics of whispered speech. She revealed that certain cues to identification do remain intact in the signal, such as "nasal resonance and formant dampening, appropriate formant frequencies and transitions, transition durations, and appropriate burst and frication spectra" (p. 1683). In her article, she discusses auditory techniques used by listeners to dissect the deprived signal, such as cognitively determining pitch via the second formant frequency (p. 1683). She further identifies other whispered phoneme identification cues, including "high frequency cues to voicing, such as frication, or burst duration and intensity where low frequency information is lacking" (p. 1683). Despite these remaining characteristics in the whispered signal, Tartter's research points to a modified analysis of whispered voices compared to that for modal, using reconstructed, or otherwise different cues to phoneme cognition and identification, especially where low frequency cues are lacking.

In a more recent study entitled "Phonetic Feature Encoding in the Human Superior Temporal Gyrus," researchers were able to isolate the neurological correlates of the entire English phonetic inventory. Using "high-density direct cortical surface recordings," showed that the superior temporal gyrus relies on "distinct phonetic features for pre-lexical identification of phonemes" (Mesgarani et al., 2014, p. 1). If distinct phonetic features are indeed the neurological correlates of phonemes, it remains to be seen what consequences perception of the whispered speech signal, lacking in those aspects outlined by Tartter, carry forward to the recall of content.

2.3 Prosody, inter-speaker content recall, and non-word inclusion

In 2007, Lisa Archibald and Susan Gathercole tested short-term memory for non-words in school-aged children, finding suggestions that "distinct coarticulatory and prosodic cues may play important roles in recall of multi-syllabic phonological forms" (p. 604). Aligned with this finding, in 1988 John Mullennix, David Pisoni, and Christopher Martin showed that simply exchanging speakers in the test phase had negative effects on recall of items. Their study shows that the effects of talker variability are "more robust and less dependent on task than word frequency or lexical structure" (p. 375). They go on to propose that "information about the talker's voice is intimately related to early perceptual processes that extract acoustic-phonetic information from the speech signal" (p. 375). Considering the results of these studies, it seems content recall is affected by prosodic cues and voice characteristics, similar to those in recognition outlined above. Research presented below will consider these findings with necessary methodological adaptations to Orchard and Yarmey's 1995 research on recognition.

2.4 Research question and hypothesis

Q) Is recall of target items affected by the use of different voice qualities across stimulus pairs (whisper-whisper vs. whisper-normal)?

H_1) Given the acoustic differences between whispered and normal voicing discussed above, it is predicted that cross modal recall will be weaker (whisper-normal) than same mode recall (whisper-whisper).

4 Methodology

4.1 Participants

20 undergraduate students from the University of Victoria were tested. The participants were evenly split into test (whisper-normal), and control (whisper-whisper) groups. All were native English speakers with no reported hearing deficiencies and normal or corrected to normal vision.

4.2 Stimuli

A total of 90 bisyllabic, possible English non-word tokens (e.g. 'artson', 'juber') were recorded in Praat, using a Headrush USB headset. Tokens followed English phonotactic constraints and were developed at random for the purposes of this experiment. The 90 tokens were comprised of 30 "target-whisper", 30 "test-normal" and 30 "test-whisper" stimuli, which were recorded separately from the "target whisper" tokens. Each set was composed of the same 30 non-words. The non-words were all initial-syllable stressed for regularity. All tokens were provided by the same male speaker and acoustically matched in Praat for duration, relative amplitude, and volume to minimize external differences in the testing. Tokens were as clear as possible, containing no background noise or auditory glitches that may have aided in recall. As non-words present "a relatively pure measure of phonological short term memory," lexical and word frequency effects should be eliminated via this method (Archibald & Gathercole, 2007, p. 602). A text list of the 30 non-word stimuli is presented in Appendix A. Audio tokens were loaded onto a Samsung Galaxy S3 phone, and presented at normal listening volume with headphones via the default Samsung player. This maximized portability and greatly aided in recruiting participants. Modal-modal stimuli were not presented based on the small scale of this research.

4.3 Procedure

Participants were randomly assigned to groups (whisper-whisper, whisper-normal), and were individually presented 10 randomized "target-whisper" tokens,

a subset of the 30 test words, heard in whispered voicing (See Appendix A). Each participant heard a different, randomized subset of these target items. Randomization was accomplished via the shuffle function on the player. Recall testing presented all 30 tokens, in whispered or normal speech as per their group. Again, whisper-whisper trials made use of different whispered recordings for presentation and test phases (i.e. target-whisper, test-whisper) to equalize the test groups in terms of the number of times they encountered the stimuli.

After randomized target presentation, testing consisted of the participants receiving an ordered test page on which to indicate the tokens they recalled. At this point either whispered or normally voiced prompts were presented as per the participant's group. Audio tokens were presented in the same order as listed on the test page (see Appendix A), as to minimize participant's time spent searching for already randomized stimuli. A one-second delay between tokens was included for participant's processing.

4.4 Analysis

Participant scores were based on accurate identification of targets from the presentation phase, with scores out of 10 for each trial. Correct identifications were each worth one point, where incorrect identifications (akin to a wrongful accusal) deducted a point from the score. Simple descriptive statistics of the between groups, dependant variable scores (*/10) such as average, median, and standard deviation were calculated in Excel. Results are presented below.

5 Results

As predicted, testing showed an advantage to recall when stimuli were of the same modality, "whisper-whisper" (mean = 4.5, SD = 2.8), than when of different modality "whisper-normal" (mean = 3.1, SD = 2.12). As detailed below in Figure 1, average scores were higher, though more variable in the whisper-whisper condition. The overall trend shows the linear averages of participants' scores. Complete raw data are presented in Appendix B in table format.

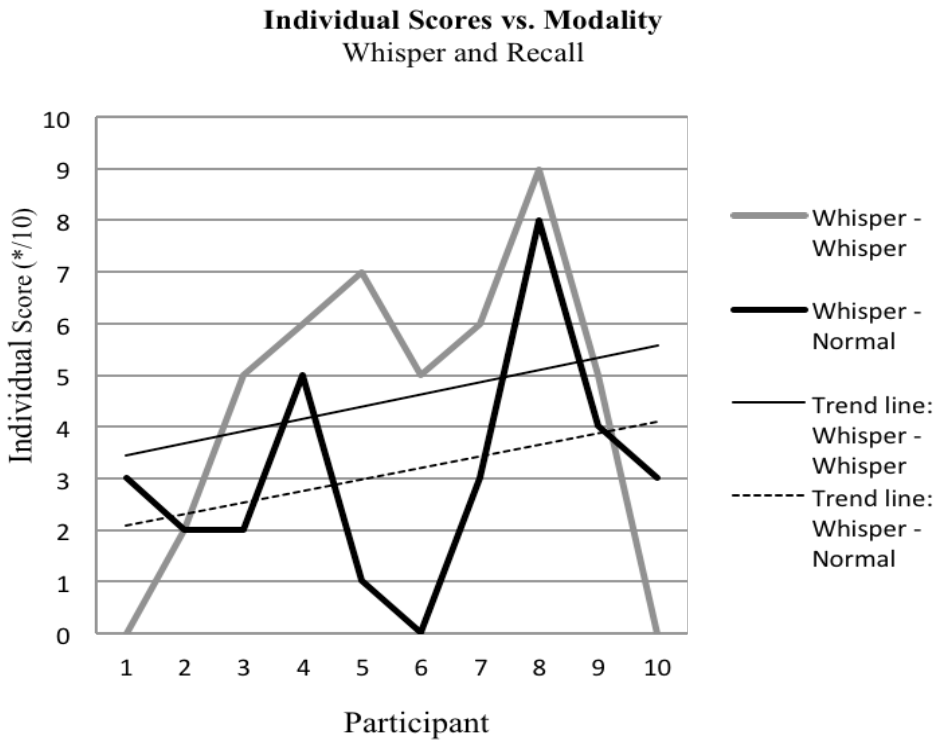

*Figure 1: Modality vs. Individual Score of each of 20 the participants (10 per group). Whisper-Whisper is presented in grey, with Whisper-Normal in **black**. Linear averages appear in solid and checked lines respectively.*

6 Discussion

These results are aligned with findings from voice recognition studies and relatable studies on item recall. As with Orchard and Yarmey, Ohman, and Tartter's findings discussed above voice disguises, such as whispering, have measurable impact on listener's ability to connect utterances made by the same speaker. It makes intuitive sense that the more alike a prompt is, the better the recall will be. As such, this study supports the inclusion of whispered stimuli in applicable forensic scenarios where the accused had whispered in the original encounter. By extension, a reasonable assumption can be made that other common voice disguises (eg. harsh, creaky, etc.) should be mimicked in any recall aids. Future testing is recommended to verify this assumption regarding item recall, though similar studies on recognition have already reached similar conclusions.

The direct cause of the observed disparity in average scores is only speculative at this point, though inherent acoustic differences between whispered and normal speech certainly play a role.

7 Conclusion

Same and cross-modal recall test scores were compared. Findings showed that a benefit exists to providing ear-witnesses with as similar a reconstruction as possible when aiding recall in judicial applications. The observed data from this study, as well as those of the experiments discussed above, support this conclusion. As no financial, ethical or other considerations are affected by this method, investigators would do well to adapt their methodologies to reflect the careful findings of the scientific community.

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Appendix A

30 token non-words (in test order). Non-word test stimuli were presented in this order and according to modality. Participants checked off the stimuli that they recalled from the presentation phase on the test page. Scores were out of 10, with incorrect responses deducting a point from the score.

1. Flondo
2. Artson
3. Classit
4. Govish
5. Daxon
6. Badan
7. Rontol
8. Wabled
9. Brofson
10. Pendle
11. Aidom
12. Dooted
13. Tiskler
14. Banton
15. Gassive
16. Ostush
17. Waltet
18. Scraffle
19. Tromson
20. Scouble
21. Dufsit
22. Guitan
23. Ipsit
24. Popten
25. Maendle
26. Rissle
27. Embrit
28. Nersten
29. Haltred
30. Juber

Appendix B

Table 2: Dependant variable scores for each participant (1-10), arranged by test group. Average, median, and standard deviation of the data points are presented at the bottom

	Recorded Data	
Participant	Whisp-Whisp	Whisp-Norm
1	0	3
2	2	2
3	5	2
4	6	5
5	7	1
6	5	0
7	6	3
8	9	8
9	5	4
10	0	3
Average	4.50	3.10
Median	5	3
Standard Deviation	2.80	2.12

An Analysis of the Split-Phonology Hypothesis in Michif: Sociolinguistic and Phonological Perspectives

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Michif, a mixed language spoken by the Métis people, is highly unique. Unlike other mixed languages that take their lexicon from one base language and their grammar from another, Michif is divided etymologically within the lexicon: nouns and noun phrases come from French, and verbs and verb phrases come from Cree. This 'split' in the lexicon has led many researchers to question whether or not the phonology of Michif is similarly divided. This paper seeks to contribute to this Michif split-phonology debate. In so doing, we discuss the context that fostered the unique characteristics of Michif as a mixed language, summarize previous claims made in the split-phonology debate, and present a case study grounded in a phonological process from one of Michif's base languages—the French-origin *liaison*. While results show that liaison occurs only between etymologically French words, we argue that this does not necessarily mean that the entire phonology is split. There are unique challenges and considerations involved in analyzing liaison in Michif which make any conclusion tentative at best. As such, it may be that the two base phonologies are intertwined in complex ways that our current linguistic understanding of phonological systems does not yet know how to account for.
Keywords: Michif; mixed languages; split-phonology hypothesis; liaison

1 Introduction

Spoken in Western Canada, North Dakota, and Montana by the descendants of French fur traders and Indigenous Cree speakers, Michif[1] is one of the world's few mixed languages, a language resulting from contact between multiple varieties (Bakker, 2003). Unlike pidgins and creoles, mixed languages do not have a superstrate and a substrate; typically, they instead take their lexicon from one language and their grammar from another (Bakker & Muysken, 1995).

[1] Michif is also sometimes spelled *Mitchif, Métchif* or *Méchif*.

However, even within mixed languages Michif is unique: instead of taking its lexicon from one base language and its grammar from the other, Michif is divided within the lexicon. It takes its nouns from French and its verbs from Cree, with Cree phrases[2] following Cree syntax and French phrases following French syntax. Therefore, its lexicon is widely accepted as being 'split'. This has raised questions among linguists as to whether or not the Michif phonological inventory is similarly divided along etymological lines: can Michif be said to have one unified phonological system, or are there two separate, coexistent ones? While some researchers (e.g., Evans, 1982; Bakker, 1997) claim that there are in fact two, described by Bakker (1997) as "one for the Cree part and one for the French part, each with its own rules" (p. 7), others argue that there is only one system (e.g., Papen, 2011; Prichard & Shwayder, 2014). As such, the nature of phonological patterning in Michif is not yet clear.

This project seeks to build on this previous scholarship and provide evidence for a split phonology in Michif. In so doing, we discuss the context which fostered the unique characteristics of Michif as a mixed language, summarize previous claims made in the split-phonology debate, and conclude with a case study grounded in a phonological process from one of Michif's base languages: the French-origin *liaison*. Liaison is a French phonological process where underlyingly silent, word-final consonants are pronounced when followed by a vowel-initial word (e.g., [pətikɔpɛ̃] 'petit copain' vs. [pətit̲ami] 'petit ami'). Given that French makes up a large portion of Michif's lexicon, whether or not liaison is a productive process with both etymologically Cree and French words will be significant for the Split Phonology Hypothesis.

Our research questions are therefore twofold: (1) Is the French liaison rule productive in Michif and, if so, (2) is it restricted to only the etymologically French portion of the language? If liaison does apply to only the French portion of the lexicon, this could be taken as evidence that a split phonology does exist, with French phonological processes applying only to French words. If liaison is fully productive (that is, applies to both etymologically French and Cree words), this could be taken as evidence that a split phonology does not exist, and phonological processes—at least those inherited from French—apply to words whose origins are in either language. Our results show that liaison occurs only between etymologically French words, and even following the fossilized [t] in *tout*. However, this does not necessarily mean that the entire phonology is split. There are unique challenges and considerations involved in analyzing liaison in Michif which make any conclusion tentative at best. It may be that the two base phonologies are intertwined in complex ways that our current linguistic understanding of phonological systems does not yet know how to account for. We will return to these issues below.

[2] Here, the term *phrase* is used in the theoretically syntactic sense (e.g., noun phrase, verb phrase, etc.). Generally, other lexical categories such as adjective, determiner, adverb, etc. within a phrase are all from the same source language, although items from another source language can be added (Bakker, 1997, p. 102).

2 Sociolinguistic perspectives

Michif is the language of the Métis people in Canada and the United States. There are many languages spoken by the Métis, including English, Métis French, Métis Cree, and Métis Saulteaux, but "only Michif is truly theirs" (Martin & Bonneville, 2001, n.p.). Michif is unique; it is one of the few mixed languages of the world—that is, a language formed when "two halves are combined into one organic whole" (Bakker, 1997, p. 210). Mixed languages (such as Michif, Mednyj Aleut, Ma'a, Media Lengua, etc.) are often likened to pidgins and creoles, though there are important differences. A pidgin is formed when two groups come into contact and form a grammatically reduced language for the purpose of communication; it is not spoken as a native language (Bakker, 1997). Creoles are contact languages with complete grammatical systems, and a creole is thought to be derived from a pidgin once a new generation of speakers uses it as a first language (Bakker, 1997). Creoles typically have a single dominant (i.e., *superstrate*) language as the main influence, providing the majority of the grammatical rules (Bakker & Muysken, 1995). This is contrasted with a mixed language, which is a language that "shows positive genetic similarities, in significant numbers, with two different languages" (Bakker, 1997, p. 195). Thomason (2001) thus characterizes mixed languages as ones "whose grammatical and lexical subsystems cannot all be traced back primarily to a single source language," contrary to all other forms of language, as the grammars of mixed languages can be directly traced to two languages (p. 21).

A mixed language is formed in a dual language situation. However, this is not simply a language contact occurrence, but actually involves an intertwining. For this to occur, bilingual speakers with an understanding of both parent languages are necessary. The result of this intertwining is generally that one language supplies the grammar for the new mixed language, while the other provides that lexicon. Bakker (1997) has proposed that, if this highly bilingual environment is present, there are three factors that play a role the formation of a mixed language: (1) a high number of speakers of both languages, (2) no outside linguistic pressure, and (3) a distinct group of people. For the first factor, Bakker argues that the most important aspect is that the parent languages be uniformly divided within the community. The second factor is that there must be no outside linguistic pressure, such as a dominant language group asserting pressure on the speakers of the two parent languages. Finally, the speakers of the two parent languages must make up a distinct group of people that are separate from the cultures of the origin languages. All three of these factors appear in the history of the Métis people.

The Métis were the descendants of French fur traders and Cree women, and began to self-identify as such in the early 1800s. The first records of the Michif language are from approximately 1820. Margaret Desjarlais, a native speaker of Michif, describes the origins of the language in an interview with Peter Bakker (1996):

> *When the French Canadians came from across the ocean, they started to marry Indian women and then they had children. The Indian woman couldn't speak French to her children. The Frenchman couldn't speak Cree to his children, so he spoke to them in French. Therefore some of them learned to speak French and Cree. Therefore he speaks only French and Cree mixed.* (p. 8)

This description of the birth of Michif is analogous to the birth of the Métis culture, as a group of people who had ties to both the French and Cree peoples but did not necessarily belong to either group. This was fuelled by a desire to be both—and neither—Cree and French. The Métis thought of themselves as their own people, and the Michif language helped to define Métis culture. The development of the language was further helped along by Bakker's (1997) three factors discussed above: almost all speakers were found in an identical environment, as the men were French speakers, and the women were Cree speakers. There was also no outside linguistic influence. Due to struggles in the Red River area and other conflicts with the government, the Métis withdrew from many aspects of mainstream Canadian society (Rosen, 2015). By doing so, they avoided linguistic and social pressures to conform to English or French, which helped preserve Michif for some time. This leads to the third factor, that the speakers of the parent languages must be removed from their original cultures. Since the Métis were not accepted by either the colonial settlers or First Nations people, the mixed language was able to continue to form in this regard.

However, Michif is distinct among mixed languages. Bakker (1997) argues that the native language of the males (i.e., the fathers) usually provides the lexicon, while the language of the females (i.e., the mothers) provides the grammar (p. 207). Michif appears to defy this, as the language is not 'split' between the lexicon and the grammar, but within the grammar itself: the nouns and noun phrase syntax come from French, while the verbs and verb phrase syntax come from Cree[3]. This irregular split in the lexicon has led to much debate about the phonology of this mixed language—specifically, whether or not the phonology of the language is similarly divided along etymological lines.

[3] While this at first seems to go against the usual trends of mixed languages, Bakker (1997) suggests that this difference is due to the polysynthetic nature of Cree. Cree verbs exhibit high degrees of affixation, and because of this complexity, a Cree verb can also be said to be a representation of the grammar.

3 Split-phonology debate

Michif being composed of fully realized portions of French and Cree raises a question regarding its phonology: are there separate phonologies that deal with each historically distinct portion of the language, or is the phonology unified? This question has seen a great deal of debate among researchers of the language.

The first area of debate is the phonemic inventory of Michif. Some researchers have posited two wholly distinct phonemic inventories for the French and Cree portions (Rhodes, 1986; Bakker, 1997). This is due partly because they observe words from each origin using a different set of phonemes than the other, some being completely restricted to one etymological origin. Recently, Rosen (2007) has argued that it is not necessary to stipulate two distinct phonologies because there is an uneven distribution of phonemes between the French and Cree components, and she provides acoustic evidence that similar phonemes considered to be distinct by other researchers have in fact mapped onto each other. Additionally, Rosen (2007) believes there to be no evidence that both the long-short contrast of Cree phonology and the tense-lax contrast of French are both independently operational; she argues that in Michif, there is a single collapsed two-way contrast system based on vowel quality rather than vowel length.

In addition to distributional differences in the phonemic inventories, there are also cases where single phonemes are said to function differently between the two source components. For example, Rhodes (1986) found /a/ to be realized as [ɑ], [ʌ], or [ɛ] in the Cree component of the grammar, while in the French component it surfaces as only [a] or [æ]. Conversely, Rosen (2007) found that for the speakers in her study, /a/ surfaced as [a] or [ʌ] in both French and Cree contexts.

One area that does seem to support a unified phonology is stress assignment. The difference in stress assignment between Cree and French is only apparent in words over two syllables long, and in Michif it appears that French words have been converted to the Cree system of stress assignment (Bakker, 1997). The length of stressed syllables in three-and four-syllable words reflects Cree patterning, with the antepenultimate syllable receiving main stress, rather than stress being lexically determined as in French.

A significant area of contention is that of phonological processes, which in some cases seem to be limited to French or Cree contexts. Papen (2003) argues that certain vowel deletion processes are limited to French contexts: for example, he claims that the French phonological rule that some grammatical words with a CV shape elide their vowels before vowel initial words is still functional in Michif. This can be seen with the word *di* (historically French *de*).

(1)	zhoor	di	nwel
	day	*of*	*Christmas*
	'Christmas'		

(2)	pou'	d-oor
	skin	*of-bear*
	'bearskin'	

For example, the [d] is fully realized in (1), but before a vowel-initial word such as in (2), it is elided. Papen (ibid) additionally argues that a similar French-origin process, wherein /ɪ/ is deleted following a single pronounced consonant, is also operational in Michif. He claims that these rules are only applied to French origin words, and therefore provide evidence for a split phonology.

Finally, the question of whether the French phonological process of liaison remains operational in Michif has received a great deal of attention. Liaison describes a process wherein a final, unpronounced consonant becomes pronounced as the onset of a following vowel-initial word. There are a number of contexts where liaison takes place, but the most common context is within a noun phrase, where the final consonant of determiner or adjective is pronounced as the onset of a following noun. This can be seen in example (3).

(3)	les	amis
	DET	*friends*
	'the	friends'

The /s/ in 'les' would not be pronounced in isolation or before a consonant-initial noun, but here it is syllabified as the onset of the vowel-initial 'amis' and pronounced.

Liaison within entirely French-origin noun phrases has drawn the most attention. Papen (2003) argues that liaison in Michif functions in much the same way is it does in French: in a study of dictionary material, he found that vowel-initial nouns in Michif either remain vowel-initial or have the expected liaison consonant (e.g., from an an in/definite article) as their onset the majority of the time. There are, however, cases where historically vowel-initial words have unexpected initial consonants—these appear to correspond to liaison consonants that have become fossilized as onsets of the noun. Rosen (2007), however, takes a much different view, arguing that all vowel-initial French-origin nouns have been re-analyzed as consonant-initial, with liaison consonants fossilizing as onsets. She believes that cases where the initial consonant is variable can be analyzed as morphological rather than as instances of liaison.

Other contexts of liaison have been largely ignored until a recent paper by Prichard & Shwayder (2014), which examines the extent to which liaison is limited to etymologically French words. They analyze two instances of liaison. The first instance consists of a French-origin pronoun followed by a Cree-origin

verb. The second instance of liaison consists of a French-origin adjective being triggered by a vowel initial Cree noun (a few do exist as exceptions to the general tendency). Liaison occurs in both instances, and they take this as evidence of a unified phonology; though liaison consonants may be limited to French-origin words, the fact that non-French-origin words can trigger them suggests that liaison itself is operational in all components of the grammar.

4 Case study

It appears as if there is as much evidence for a split phonology as there is against it. With this in mind, we turn to our case study.

4.1 Data and methodology

The data for our analysis have been drawn from online Michif educational materials, specifically the narrated children's book section of the Gabriel Dumont Institute's Michif Museum website. All books were translated from English and narrated in Michif by Flamont and Pelletier (2006a, 2006b, 2006c, 2006d). The children's books were the only Michif-language materials available on the Michif Museum's website that were both narrated and written in Michif, as well as having an accompanying English translation. As such, the data set is limited to tokens found within these materials only, and only six were found.

Context	Alfred's First Day at School	Lisa and Sam	The Big Storm	The Pow Wow
French-French (F-F)	1	1	2	4
French-Cree (F-C)	0	1	0	2
Total N	1	2	2	6

Table 1: Number of potential liaison contexts by children's book.

Audio files from each book and their accompanying text were downloaded and searched for potential liaison contexts—that is, French-origin words ending in consonants and preceding a vowel-initial word. The etymology of words in potential liaison context was highly important. Since whether or not liaison can apply to non-French origin words is one of the main research questions of this project, it was necessary to determine, with as much accuracy as possible, whether the words in the potential liaison contexts came from French or Cree. However, there are no Michif-English, Michif-French, or Michif-Cree dictionaries available, and there is no conventional writing system for the language; consequently, while some items are more transparent than others (e.g., Michif *l'ikol* from French *l'école, l'itee* from French *l'été*), the origin of all words was not entirely clear. As such, based on the fact that Michif takes its nouns from

French and its verbs from Cree, we have assumed that all nominal items (as evidenced in the translations) in liaison contexts came from French and verbal items in liaison contexts came from Cree[4].

A summary of the potential liaison contexts identified in the texts can be found in Table 1. 'French-French' contexts refer to those where a consonant-final word of French origin precedes a vowel-initial word of French origin. 'French-Cree' contexts refer to those where a consonant-final word of French origin precedes a vowel-initial word of Cree origin. Since there is no evidence for liaison occurring in Cree, Cree words ending in a consonant preceding a vowel-initial word of any origin were not considered to be potential liaison contexts. Following data collection, tokens with the requisite phonological environment for liaison were analyzed in Praat to determine whether or not the word-final consonant was pronounced and elided.

4.2 Results

All of the French-French contexts analyzed contained liaison, while liaison in French-Cree contexts was not found. Fossilization and orthography added additional complications, to be discussed below.

The analysis was made challenging due to the lack of a standardized orthography for Michif, because orthographic representations of speech may obscure processes of liaison. For example, in the phrase *tout dah la ville*, (cf. Figure 1), [d] could represent either a fossilized consonant or an instance of liaison. In this case, we analyzed the [d] as a liaised consonant due to the lack of evidence for *dah* (but ample evidence for *ah*) as a lexical item in Michif. Throughout the texts, there are many instances of *ah* used as a preposition in a parallel distribution to the *dah* in the above phrase (such as in the phrase *sa premier jour ah l'ikol*), suggesting that this word comes from the French *à*, meaning *to*.[5]

[4] Based on the English translations available in the books, we were able to look up words in the Gabriel Dumont Institute's online English-Michif dictionary (http://www.Métismuseum.ca/michif_dictionary.php), which features over 11,500 translations and audio pronunciations by Michif-language expert Norman Fleury.

[5] Additionally, as a grammatical function word, *ah* occurs in too many variable contexts for any consonant to proceed regularly enough to fossilize as an onset. Also, *de* would never precede *à* in French, making the grammaticality of the source construction questionable. It is possible that such a construction is not ungrammatical in Michif, but without access to native speakers, this cannot be certain.

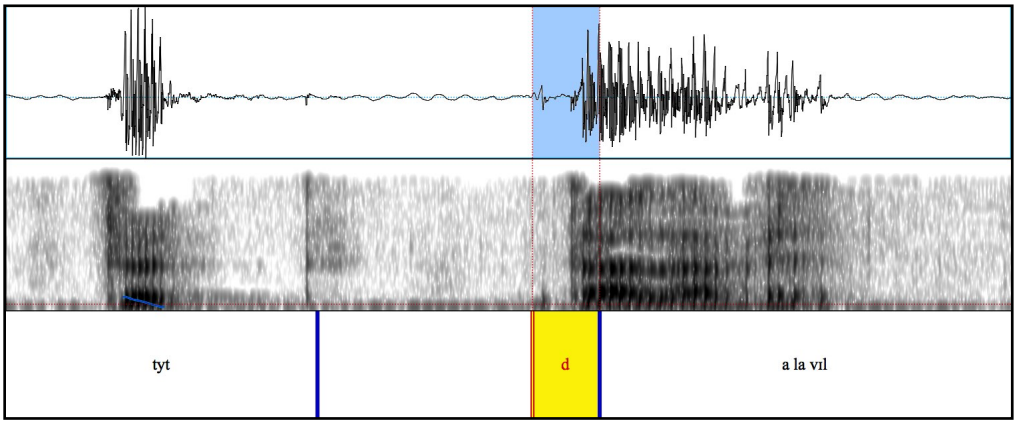

Figure 1: Spectrogram for (F-F) phrase tout dah la ville *with liased* [d].

The word *tout* in Michif itself appears to contain an instance of fossilization: while the final [t] is only pronounced in French in liaised or grammatically feminine contexts, it is always pronounced in Michif as [tut] irrespective of the phonological environment or grammatical gender[6]. This is shown in Figure 2, where *tout* precedes the consonant-initial grammatically masculine (evidenced by the masculine singular definite article *li*) *swayr.*[7]

[6] It is also possible that this is not in fact fossilization, but the retention of a Québecois French dialect feature. According to Laurence Godard (personal communication), in colloquial Québecois French, the final [t] in *tout* is sometimes pronounced irrespective of grammatical environment. However, more speakers are needed to determine the validity of this possibility.

[7] The [t] is audible, but is not obvious on the spectrogram. This is hardly surprising assuming that this /t/ is unaspirated, which /t/ often is in Michif. Optional aspiration of /t/ is a result of influence from English (Bakker, 1997).

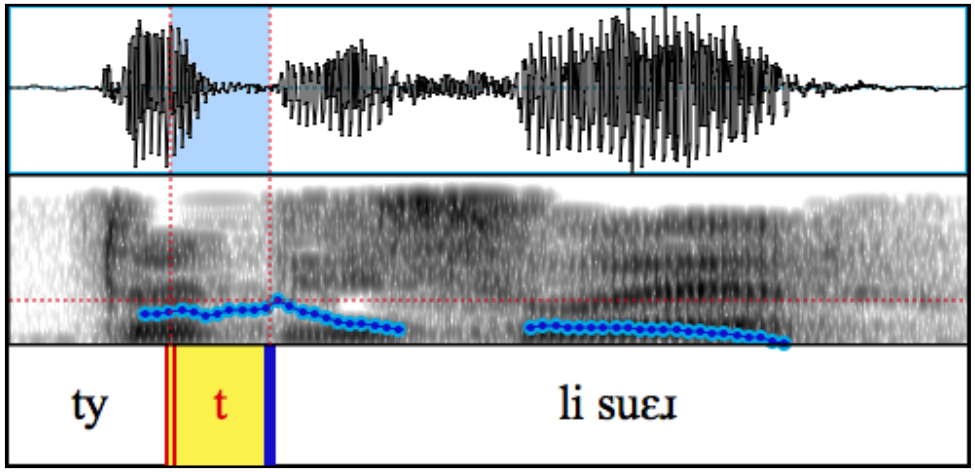

Figure 2: Spectrogram for phrase tout li swayr *with final* [t] *of* tout *pronounced*.

Taking this fossilization into account, this would appear to conform to French native speaker intuitions. Even if there is a pause, if there is a word that ends in a consonant followed by a word beginning in a vowel, speakers cannot drop the liaison (Goddard, personal communication). In Figure 1, the speaker applies this rule productively. He pronounces the fossilized [tut], pauses, and then applies the liaison rule to add [d] to *ah*.

While liaison appears to be triggered despite the fossilized [t] consonant in a French-French context, it does not do so with French-Cree contexts. This is shown in the spectrogram of the French-Cree phrase *tout-oh-wuk* in Figure 3, where the fossilized [t] in *tout* is pronounced, but there is no [d] as in Figure 1.

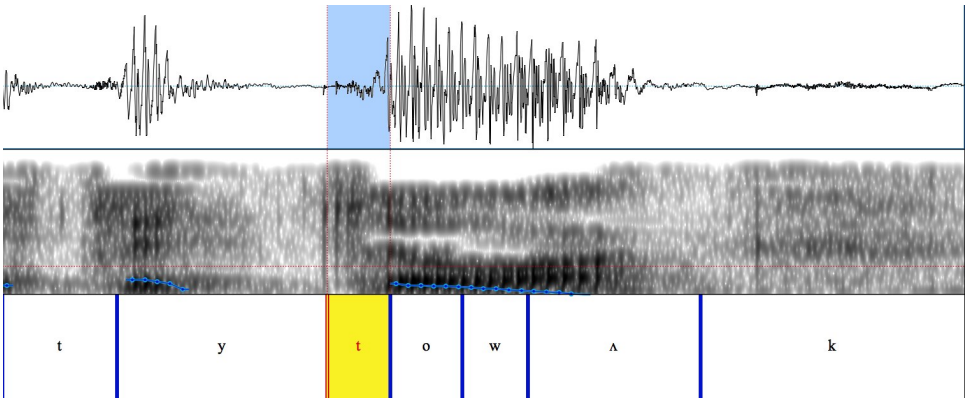

Figure 3: Spectrogram for (F-C) phrase tout-oh-wuk *with pronounced fossilized* [t], *but no liaison*

The other remaining French-Cree token, *apres aqua*, does not appear to exhibit liaison either, as shown in Figure 4. However, there is some variation in whether or not the final consonant in *apres* can undergo liaison in French; it is described as an "optional liaison context" (Lawless, n.d.). Consequently, it is not entirely unsurprising that liaison is not present in this instance.

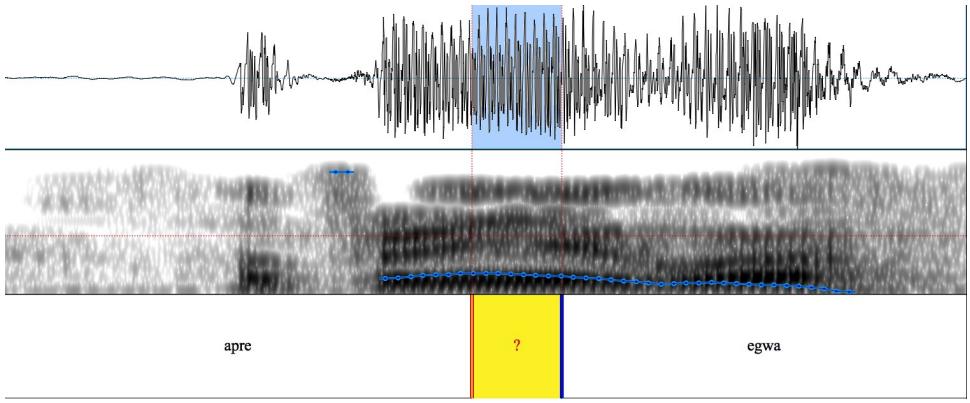

Figure 4: Spectrogram for (F-C) phrase apres aqua, *with no liaison*

Fossilization notwithstanding, there are French-French instances where liaison appears to be more straightforward; for example, Figures 5 and 6.

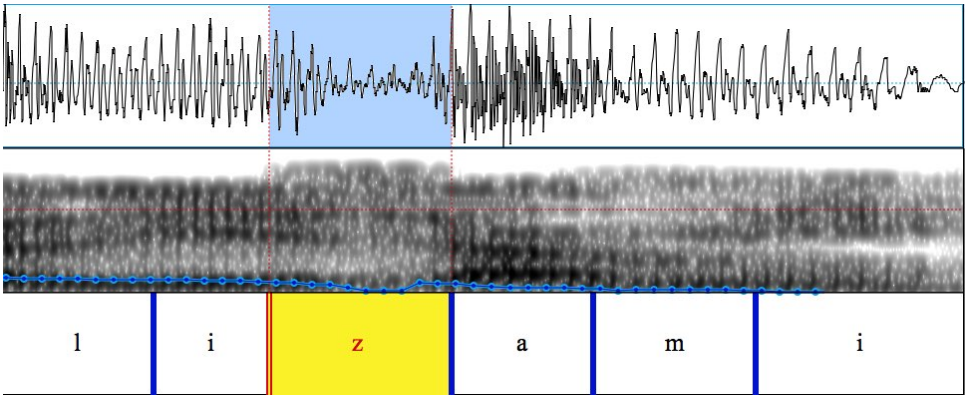

Figure 5: Spectrogram for (F-F) phrase les amis *with liaised* [z]

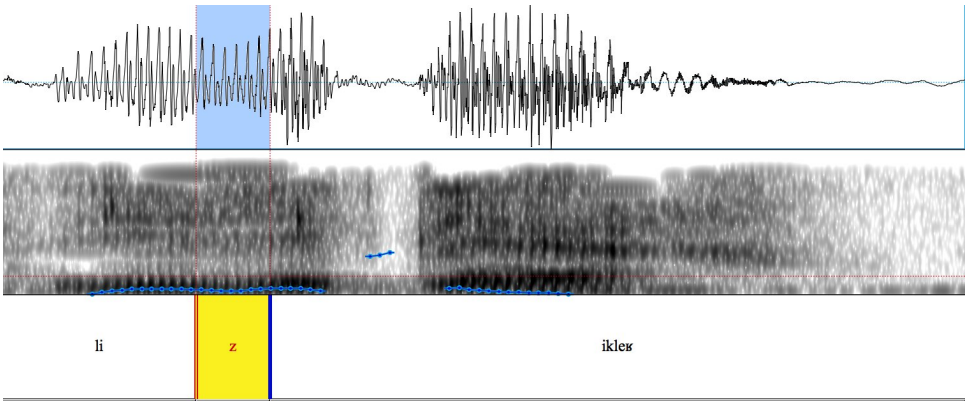

Figure 6: Spectrogram for (F-F) phrase les zeclarr *with liaised* [z]

However, orthography is again problematic, particularly for *zeclarr* in Figure 6. As with *dah*, based on dictionary consultation, there is no evidence for *zeclarr* as a lexical item in Michif—yet there is plenty of evidence for *eclarr,* not just as an independent item but also in compounds such as *fayr d'iklayr* ('*lightning rod*'). It does seem telling that the orthography in the text shows a <z> as being part of the onset of a vowel-initial word following a plural determiner where liaison would be present in French, but the same noun in non-liaison contexts (e.g., in a compound following an always realized consonant, such as *d'*) does not have a *z*, either in the orthography or in the pronunciation. This strongly suggests that this is an instance of liaison, but that it is not orthographically realized as such. This is unsurprising, considering the lack of a standardized orthography. This may indicate that speakers are unaware of the process of liaison in Michif. Since most Michif speakers aren't bilingual in French (Martin & Bonneville, 2001), it is unsurprising that French orthography would not influence Michif orthography.

5 Discussion and Implications

Rosen's (2007) analysis of vowel-initial French-origin nouns in Michif as categorically possessing fossilized onset consonant is not supported by our data. We have found a number of instances where historically vowel-initial nouns had different onset consonants in various contexts that one would expect to see liaison consonants, such as with the word *ikol*. This word was realized as *d'ikol* when preceded by the preposition *di*, and as *l'ikol* when preceded by the definite article. It seems clear from this example and the many others like it that liaison is functioning at some level within Michif.

Our results also counter those of Prichard and Shwayder (2014), who concluded that vowel-initial Cree-origin words can trigger liaison in French-origin words. That does not appear to be true for our data; we found liaison only within French-origin noun phrases. However, Prichard and Shwayder's (2014) results were based upon just one instance of liaison with a Cree-origin word, and it happens that the French word supposedly undergoing liaison is *tout*. In this study, we identified *tout* as having a fossilized final /t/, and the pronunciation of this /t/ therefore does not represent liaison. It may be that the *tout* token that they analyzed also had a fossilized /t/, in which case liaison was not, in fact, triggered by the following Cree-origin word. This would be consistent with our findings. Alternatively, if we take their conclusion at face value, there would seem to be some degree of variability in the application of liaison for speakers of Michif. The existence of variability would be evidence against a split phonology; it hardly seems likely that Michif speakers who do use liaison have a split phonology, while those who do not have a unified one. If the application of liaison rules is variable for individual speakers (which it likely is, assuming variability between speakers), then the presence or absence of liaison cannot be accounted for with wholly different models of the phonology. This would require that the phonology be unified at some times and split at others.

This variability, as well as the fossilization that has occurred on some nouns, presents a problem for the development of a standard form of the language. Should some forms, perhaps more common ones, be accepted as correct, or should variability be permitted? If the latter route is chosen, how will this be represented in a standard orthography? Existing orthographies seem to favour writing liaison consonants as the onset of the following word, but this makes the difference between liaison consonants and fossilized consonants opaque, which presents a challenge to learners of Michif. Additionally, variable spellings may present a complication in the creation of dictionaries. It can also make looking up words more difficult for learners and create problems for language software that could be used to support the language. However, these are issues that we respectfully leave to the Métis community to decide.

In addition to the possibility of variability, it may also be that these results simply point to Michif as participating in a wider, cross-linguistic process of phonological intertwining that depends largely on the contact a given language has with another (Hyekyeong Ceong, personal communication). In other words,

French-origin processes may be productive in Michif in a similar way that Latin-origin processes are productive in Latin loan words in English, or Chinese-origin words in Korean and Japanese. This is an issue that we leave open to further research, as a larger body of data—and perhaps access to native speakers—would be necessary.

6 Conclusion

Determining the productivity of liaison in Michif is complicated because the language does not have a standardized orthography, and as such, it is difficult to determine whether certain consonants are instances of liaison or are fossilized onto lexemes.

Although our data suggest that liaison occurs only in the French-French contexts, particularly following the fossilized [t] in *tout*, it does not necessarily mean that the entire phonology is split. The literature surrounding the Michif split-phonology debate shows conflicting evidence for and against the hypothesis, but all studies on the topic suffer from low token counts for analysis, and this study is no exception. This, combined with the difficulties posed by the lack of Michif spelling conventions, makes any conclusion tentative at best. It may be that the two base phonologies are intertwined in complex ways that our current linguistic understanding of phonological systems does not yet know how to account for. Future studies would benefit from access to either a larger body of data from which to draw tokens, access to native speakers for elicitations, or both. While we are reluctant to form generalizations based on the small amount of data, it is our hope that we have made some small contribution into growing scholarship on the unique language that is Michif.

Acknowledgements

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Don't judge a voice by its cover: Visual interference in vocal age judgments

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Previous studies show that individuals perceive the same face as older when preceded by young relative to old adaptor faces, and the same voice as older when preceded by young relative to old adaptor voices. However, research had not yet addressed whether these adaptation effects can occur cross-modally. Therefore, this study sought to determine whether adaptation to young or old *faces* influences the perceived age of *voices*. To do this, 20 participants ages 20-23 years were tested individually over 40 experimental trials. In each trial, participants saw either a young or old face; they then heard a voice and were asked to judge the age of the speaker. It was predicted that voices would be perceived as *older* when preceded by young adaptor faces. Results in fact showed the opposite trend: voices were consistently judged to be *younger* when preceded by young relative adaptor faces. Thus, it appears that adaptation evokes the opposite effect on age judgments when the adaptor and test stimulus differ in modality (i.e. one stimulus is visual while the other is auditory). To explain these results, it is proposed that individuals rely more heavily on visual cues than auditory ones when assessing age in their conversational partners, and that sensory cues from different modalities are unconsciously integrated even when a known incongruence exists.
Keywords: Perception; adaptation; age; face; voice

1 Introduction

Faces are arguably the most conspicuous indicator of a person's chronological age (Burt & Perrett, 1995). Although other factors are certainly prevalent, faces alone generally elicit robust and accurate age judgments (George & Hole, 2000). However, Schweinberger et al. (2010) were able to demonstrate a facial age aftereffect (FAAE) in which exposure to old adaptor faces (approximately 70 years) caused subsequently presented test faces to be perceived as younger than when the same test faces were presented after young adaptor faces (approximately 20 years). These results suggested that age judgments, though usually reliable, could be significantly influenced by adaptation, the habituation to a given stimulus after prolonged or repetitive exposure (Zaske & Schweinberger, 2011, p. 283).

Furthermore, the voice is often described as the auditory equivalent of the face (Belin et al., 2004). Even when a voice is used to produce non-speech sounds, such the cough or cry of a baby, we are able to glean valuable paralinguistic information about the vocalizer's physical and emotional state (Belin et al., 2004). Studies have also demonstrated that listeners can classify speaker age using exclusively vocal cues (Ptacek & Sander, 1966). That is, age judgments are largely accurate even in the absence of visual information. Therefore, to complement Schweinberger et al.'s 2010 study that revealed the FAAE, Zaske and Schweinberger (2011) investigated whether adaptation to young or old voices could influence listeners' perception of age in test voices. Similarly, they found that the same test voice was judged to be older when preceded by a young adaptor voice (20 years) than when preceded by an old adaptor voice (70 years). This phenomenon, deemed the vocal age aftereffect (VAAE), strongly supported their previous findings about the influence of adaptation on age estimates.

Given the assertion that faces and voices are perceptual counterparts, the adaptation effects observed in these studies should also occur cross-modally. That is, exposure to young or old faces should influence the perceived age of test voices, and exposure to young or old voices should influence the perceived age of test faces. Since research had not yet investigated the cross-modal effects of adaptation on age judgments, pairing visual and auditory stimuli was the focus of the present study. Specifically, this study sought to determine whether adaptation to young or old faces could cause listeners to over- or under-estimate age judgments of subsequently presented test voices.

Can adaptation to young or old faces influence the perceived age of test voices? It was expected that test voices would be perceived as *older* when preceded by young relative to old adaptor faces, and *younger* when preceded by old relative to young adaptor faces. These findings were predicted by analogy to Schweinberger et al.'s FAAE (2010) and Zaske and Schweinberger's VAAE (2011).

2 Methodology

The methodology for this study largely followed that of Zaske and Schweinberger (2011), but included a number of adaptations intended to simplify the research design.

2.1 Participants

Participants were 20 native English speakers: 4 male and 16 female, between the ages of 20-23. Since Zaske and Schweinberger only found a significant interaction between speaker and listener gender in their post-adaptation condition, and this study did not include a post-adaptation phase, an equal number of male and female participants was not required. All participants had

normal hearing ability and normal (or corrected to normal) vision, and were recruited mainly by word of mouth.

2.2 Stimuli

Adaptor stimuli were images of 10 young (approximately 20 years) and 10 old (approximately 50 years) faces, half male and half female. 50-year-old faces were chosen over 70-year-old faces for the 'old' condition because this study used a smaller subset of voices and vocal ages than did Zaske and Schweinberger. Since the adaptor faces used by Schweinberger et al. (2010) were not publicly available, adaptor faces for this study were strategically selected from the Internet in hopes that they would be novel to all participants.

Test stimuli were voice recordings of 20 native English speakers. These speakers were approximately 30 or 40 years old, with 10 people (5 male and 5 female) falling into each age category. Speakers were recorded uttering the vowel-consonant-vowel (VCV) syllables /aba/ and /igi/. All utterances were standardized for length to eliminate speaking rate, a common cue for vocal age, as a confounding variable (Harnsberger, 2010). Other properties of speech (such as pitch and vocal quality) were preserved; this ensured that listeners still heard sufficient acoustic information to make accurate vocal age judgments.

2.3 Procedure

Participants were each tested individually on a computer in the University of Victoria phonetics lab. Instructions appeared on a computer screen, not verbally, to ensure that adaptation to the experimenter's voice would not influence the results. Each trial began with a red fixation cross for 500 ms, followed by presentation of an adaptor face for 3500 ms, and then a green fixation cross for 500 ms. The green cross signalled that a voice was about to be played. Participants then heard a voice and indicated by pressing 2, 3, 4, 5, or 6 on the computer keyboard whether they thought the speaker was 20, 30, 40, 50, or 60 years old.

For all trials, the adaptor faces and test voices were gender congruent so as to eliminate gender differences in vocal quality as a confounding variable. With the exception of gender congruency, though, face and voice pairings were randomized. Participants were explicitly told that a voice would never belong to the person in the preceding photograph, but that they should pay close attention to the faces presented nonetheless. They were also told that a question would be asked after the activity to ensure that they had carefully attended to the faces. As a final precaution, participants were instructed to raise their hand if they recognized a face or voice (from an encounter prior to this study) on any given trial.

Each face was presented twice, once with an /aba/ utterance and once with an /igi/ utterance, such that the experiment was comprised of 40 trials in total (20 speakers x two utterances). Since Zaske and Schweinberger (2011) allowed breaks after every 48 trials and this study contained only 40, there was no need for a rest period.

Unlike Zaske and Schweinberger's research (2011), this study did not include a post-adaptation phase (trials in which there was a delay between presentation of the adaptor stimulus and presentation of the test stimulus). This is because the *occurrence* of cross-modal adaptation effects, not the duration for which they persisted, was the focus here. As stated above, the effect of speaker and listener gender congruence on perception was not analyzed in this study, as Zaske and Schweinberger (2011) only found significance for this in post-adaptation trials.

2.4 Data analysis

Since all participants demonstrated strong facial recall when answering the final question and none reported familiarity with experimental stimuli, no data were excluded from analysis.

Data were sorted by the factors *adaptor stimulus* (young vs. old) and *test stimulus* (30 vs. 40). Each combination of factors (young, 30; young, 40; old, 30; old, 40) was then examined to determine the average perceived age (and standard deviation) of test voices under each experimental condition.

3 Results

It was predicted that voices would be perceived as older when preceded by young adaptor faces than when preceded by old adaptor faces. However, results of this study were as follows.

30-year-old voices heard after exposure to a young adaptor face were, on average, judged to be younger (mean = 31.77 years, s.d. = 11.37 years) than 30-year-old voices heard after exposure to an old adaptor face (mean = 34.32 years, s.d. = 13.13 years). Furthermore, 40-year-old voices presented after a young adaptor face were judged to be younger (mean = 37.03 years, s.d. = 12.20 years) than 40-year-old voices played after an old adaptor face (mean = 38.74 years, s.d. = 12.35 years). These values are summarized in Table 1.

Experimental Condition	Mean	Std. Deviation
30-year-old voice, young adaptor face	31.77 years	11.37 years
30-year-old voice, old adaptor face	34.32 years	13.13 years
40-year-old voice, young adaptor face	37.03 years	12.20 years
40-year-old-voice, old adaptor face	38.74 years	12.35 years

Table 1: Means and standard deviations for perceived age of 30- and 40-year-old test voices after adaptation to young or old faces

It was therefore found that voices were consistently judged to be *younger* when preceded by young relative to old adaptor faces and *older* when preceded by old relative to young adaptor faces. Thus, it appears that adaptation has the opposite effect on age judgments when the adaptor and test stimulus differ in modality

(i.e. one stimulus is visual while the other is auditory). Figure 1 depicts the trend in perceived ages of 30- and 40-year-old voices after adaptation to young (dashed line) or old (solid line) faces. It is important to note that perceived vocal age increased with actual age for both adaptation conditions, but that age judgments were consistently higher in the old adaptor face condition. It is also interesting to note that average age estimates all fell between 30 and 40 years, even for 30-year-old voices played after young adaptor faces and 40-year-old voices played after old adaptor faces.

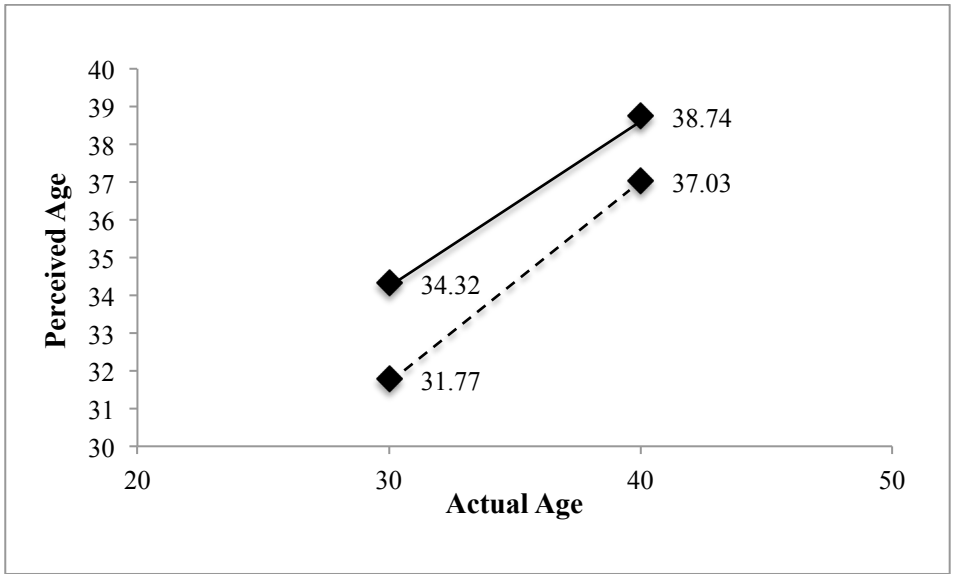

Figure 1: Average perceived ages of 30- and 40-year-old voices after adaptation to old (solid line) or young (dashed line) adaptor voices.

4 Discussion

As illustrated in Figure 1, voices were consistently judged to be *younger* when preceded by young adaptor faces and *older* when preceded by old adaptor faces. While these findings appear to contradict those of Schweinberger et al. (2010) regarding the FAAE, as well as those of Zaske and Schweinberger (2011) concerning the VAAE, there are a number of possible explanations for these results.

First, individuals generally speak to only a fraction of the people that they encounter in a day. That is, they *see* many more people than they *hear*. It is therefore likely that individuals are more practiced at assessing age based on visual cues than auditory ones, so exposure to faces should (and does) readily interfere with vocal age judgments. This is supported by the work of Schweinberger et al. (2011) who found that participants were able to recognize faces more easily than they could recognize voices. Although recognition is a distinct cognitive process from age perception, participants' preference for faces

over voices suggests that faces would also be more heavily relied upon when assessing age in a conversational partner.

Second, it is likely that different strategies and mental processes are at work when judging stimuli from the same modality than when judging stimuli from different modalities. That is, while stimuli from the same modality are presumably evaluated in *contrast* to each other, stimuli from different modalities are likely evaluated in c*onjunction* with each other. In fact, research has shown that the brain quickly and efficiently integrates cues from faces and voices to increase the reliability of our sensory estimates (Campanella & Belin, 2007).

While this is certainly advantageous in most situations, it appears that this integration of visual and auditory information continues even when individuals are instructed to disregard cues from one modality. As a result, information gained from the adaptor faces in this study may have been unintentionally integrated with information from the test voices, thereby causing individuals to over- or under-estimate age in the voices that they heard. Further evidence for this theory comes from a study by Kamachi et al. (2003) which concluded that individuals link whatever visual and auditory information is available to them when constructing a unified perception of "what is being said [and] who is saying it" (p. 1709).

Finally, there were a number of limitations in the execution of this research. Not only were there fewer participants than Zaske and Schweinberger's (2011) study, but there were also far fewer stimuli. In particular, there was a much smaller range of auditory (test) stimuli. While Zaske and Schweinberger used voices that were morphed to sound 30-, 40-, 50-, and 60-years-old, this study used only 30- and 40-year-old voices. This also meant that 50-year-old faces had to be used as the "old" adaptor stimuli. It is possible that these notably younger "old" adaptor faces did not elicit as strong an adaptation effect as did the 70-year-old adaptor faces in Zaske and Schweinberger's study. What most likely accounts for the narrow range of average perceived vocal ages, though, is that the voices used as test stimuli in this study were actual recordings of approximately 30- and 40-year-old speakers rather than electronically morphed voices. Since it was not feasible to produce morphed voices for the purposes of this study, and therefore recordings of real speakers had to be used, a number of the speakers recorded were several years older than 30 or several years younger than 40. In short, some or all of the above confounds may have influenced the experimental results.

5 Conclusion

This study sought to determine whether adaptation to young or old faces influences the perceived age of subsequently presented test voices. Results in fact showed that voices were judged to be younger when preceded by young adaptor faces and older when preceded by old adaptor faces. Although contradictory to previous studies that used stimuli from a single modality, these findings were attributed to routine cognitive operations by which sensory cues from different modalities are rapidly and unconsciously integrated. It was also proposed that

individuals rely more heavily on faces than voices when assessing age in the people they interact with. Furthermore, the relatively small sample size, limited vocal stimuli, and other deviations from Zaske and Schweinberger's (2011) study may have affected these results.

Future studies should seek to further our understanding of cross-modal adaptation effects by adopting a similar procedure in which voices are used as the adaptor stimuli and faces as the test stimuli. Research could also investigate the extent to which accuracy improves when participants are provided with a face, a voice, or both in making age judgments.

Although it is clear that there is much work to be done before a more complete understanding of human perception can be reached, this study was a successful contribution to the existing literature on perception of age in conversational partners.

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The use of ultrasound biofeedback for improving English /r/

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Research suggests that the use of a two-dimensional dynamic ultrasound machine is a viable option for improving speech sound production accuracy. This non-invasive biofeedback technology allows for a person to see the movement of their tongue-shape features, so they can then modify their own articulation to match a correct model. The purpose of this research is to evaluate the efficacy of ultrasound as a tool in speech therapy, more specifically for the remediation of the North American English /r/. A case study was conducted with a single 22-year-old male participant, consisting of nine recording sessions focusing on /r/ pronunciation. A comparison between the recordings from the first and last sessions showed a lowering of the third formant (F3) by 347.4 Hz, while the difference between F3 and F2 was 166.2 Hz lower post sessions. In addition, results from a Likert scale questionnaire given to three native speakers of English either agreed or strongly agreed to clearly hearing the /r/ sound 33.4% of the time in recordings from the first session, compared to 68.8% in recordings from the last session. Although the results of this study did not compare the use of ultrasound in therapy to traditional therapy, its findings add to the evidence that the use of ultrasound biofeedback can facilitate production accuracy, across a broader population than has previously been tested.
Keywords: ultrasound; biofeedback technology; English /r/; lower third formant

1 Introduction

Communication is, and always has been, vital in our day-to-day life. Not only that, but it is a basic right of all persons to communicate the conditions of their own existence (National Joint Committee, 1992). We use it to convey information to one another through both linguistic and non-linguistic forms, as well verbal and non-verbal. Although all forms can be effective, speech is the most common form of communication humans use. We are born with a capacity for language, as even babies who are born deaf babble as newborns (Berk, 2012). This necessity for communication, and more importantly speech in our very social society, affects the way children living with hearing and language impairments assimilate into classrooms. This also applies to adults who have suffered from health problems affecting their speech. The growing role of Speech Language Pathologists (SLPs)

and the use of technology allow them to reach their full potential as members of society.

An example of this technology involves incorporating biofeedback treatment into speech therapy, as it is "a means of supplying an individual with information that is not normally available at a conscious level regarding the consequences of a behavior" (Shuster & Ruscello, 1995, p. 37). Research has proven technology that involves electromagnetic articulography, electropalatography, spectrograms, and ultrasound imaging to be effective, especially with persistent speech errors. These are errors that remain present from eight to nine years of age (Byun & Hitchcock, 2012). With that said, this technology is still recently being incorporated into clinical Speech-Language Pathology in British Columbia, as previous studies in this field are limited in number and scope. However, as Preston et al. (2013) state, "[T]hese alternative approaches might be viewed as clinically and economically viable if they can result in rapid and sustained gains in speech production" (p. 628).

The focus of the current paper and review of past studies will be on the use of the ultrasound imaging technology, which consists of a transducer and a monitor that displays a dynamic image of the tongue. The transducer is held beneath the speaker's chin, where ultrasonic waves meet with air in the oral cavity above the tongue and reflected back to the probe (Bernhardt et al., 2008, p. 150). According to Gick (2002), the ultrasound came into clinical use in the 1960s-70s, and since then it has been used in studies of speech production. Since then, ultrasound technology has advanced much like everything else and they have gone from being expensive and unwieldy to more affordable and even portable. This has opened many doors for the application of this useful tool, as it is more financially feasible over other forms of biofeedback and can ultimately be "implement[ed] on a larger scale clinical basis" (Preston, et at. 2013, p. 628).

In a study done by Adler-Bock et al. (2007), an ultrasound machine was used in the remediation of North American English /r/ in two hearing adolescents (12 and 14 years of age) with persistent /r/ difficulties. Prior to this study, no research was available on the use of ultrasound remediation of /r/ in this type of clients. Both children received 13 treatment sessions from an SLP that began with awareness and moved through a series of increasingly difficult activities for production of /r/. The participants had previously received traditional /r/ therapy with little success, and the results were measured through formant analysis and listener judgments rated by SLPs who were unfamiliar with the participants. They found an expected lowering of the third formant, and the post treatment ultrasound images of /r/ tokens "showed tongue shapes to be more similar to those of typical adults than had been observed before treatment" (Adler-Bock et al., 2007, p. 128). They concluded that alternative treatment methods like ultrasound imaging technology has "potential utility for remediation of /r/ in speakers with residual /r/ impairment" (Adler-Bock et al., 2007, p. 128).

In another recent study, Preston et al. (2013) included the ultrasound machine in treatment for children with "persistent speech errors associated with childhood apraxia of speech (CAS)" (p. 627). The researchers viewed the

feedback of motor performance as a crucial part of the speech production system, which includes auditory and somatosensory information. When the speaker experiences this feedback, they can then make adjustments when errors arise. Individuals with CAS can experience a disruption in this process, which is why the use of biofeedback "may be useful for teaching children to recognize errors and adjust their productions" (Preston et al., 2013, p. 628). Six children participated in this study. The treatment focused on tongue movement sequences where researchers used both verbal and visual cues to elicit correct productions. All participants reached the pre-established criterion, which was 80% accuracy of production for two consecutive sessions of two treated sound sequences, in an average time span of five sessions. In a two-month follow-up, the researchers discovered that the participants maintained the progress they had made during treatment.

Although this study focused particularly on children with CAS, anyone with a speech sound disorder can benefit from biofeedback as a tool for providing visual information about nature of movement and target movement. As Preston et al. (2013) state quite eloquently, "[B]y teaching children about articulatory targets using visual feedback of tongue movements, and by sequencing these movements in various words/phrases/prosodic contexts, the relationship between the speech motor plan and the actual movements may be strengthened" (p. 628).

The goal of the current paper is to support and add to the limited literature available that suggests the use of biofeedback, in this case a two-dimensional dynamic ultrasound machine, as an effect tool for speech therapy. The current study was conducted by an undergraduate linguistics student interested in learning more about the use of ultrasound equipment in the field of Speech-Language Pathology. The purpose was to investigate how a person with a persistent /r/ difficulty can make changes to their articulation over a short time span when that person can see the shape and location of their tongue in real time. This was achieved through comparison of the student's and participant's articulation, and discussions about the environment where we see /r/ in the English language.

2 Methodology

2.1 Participants

An individual case study design was followed for the current study. The participant was a 22-year old Canadian English-speaking adult male, Jason. He grew up in a middle- to upper-class family in Smithers, British Columbia, where he was the youngest of three children. He never received speech therapy of any kind, and /r/ was the only speech sound that he had not acquired naturally. He self-reported having a hearing test at age eight, where he was told he had normal hearing. There were no other developmental concerns.

2.2 Procedure & Stimuli

The study comprised nine sessions, each one hour long. The first session consisted of an introduction to the ultrasound machine (GE Logiq-e with a 7X 8C-RS probe), as well as a recording of 16 target word tokens, found in (1), taken from Adler-Bock et al. (2007), as well as a discussion about the ultrasound machine. These words included /r/ in all the different environments found in English. These environments are word-initial, word-medial, word-final and consonant-cluster, where vowel and consonant contexts play a large role in the articulation of the following /r/ phoneme.

(1)

Word-initial	*Word-medial*	*Word-final*	*Consonant -cluster*
read	heary	ear	pray
rid	hairy	air	bray
ray	hurry	her	tray
red	story	pour	dray

The subsequent seven training sessions revolved around the discussion of /r/, as it is "one of the most complex phones in the English language in its articulatory and acoustic characteristics" (Adler Bock et al., 2007, p. 128). After watching the ultrasound video of the initial recording, the closest tongue configuration between tip-up retroflexed or tip-down bunched (Adler-Bock et al., 2007) for Jason's /r/ was judged to be tip-down bunched, therefore sessions revolved around this tongue movement. The visual screen of the ultrasound machine was positioned between the researcher and the participant, and sticky notes were placed on the screen to mark the tongue back, tongue body and tongue tip. This served as a reference point for Jason to ensure he was moving his tongue back and upwards towards the palate. The researcher's /r/ tip-down bunched /r/ articulation served as a model as comparisons were made.

An outline of the sessions is described in (2), as well as comments on his progress. Stimuli from the first seven sessions can be found in Appendix A, and sentences from session eight in Appendix B. The choice of stimuli across sessions was created with a difficulty hierarchy in mind, an idea taken from Preston et al. (2013). The 16 token words were not included in sessions, but instead words with similar environments. This way the token words were not practiced during sessions, and improvement was not bias to specific words.

(2)

Session	*Focus*	*Comments*
1	Recording session of stimuli	Overall observation is there is not enough constriction taking place, replacement sound hard to classify.
2	Awareness of /r/	Jaw is shut and needs reminders to keep slightly open. Raising tongue to palate is unnatural movement for him. /r/ sound achieved at the end.
3	Transitions involving /r/	Jaw remains issue, pencil used as bite block, tongue needs to pull back and raise more.
4	Constrictions at the palate and pharynx	Not enough constriction being made with tongue, too much air passing through. Jason self-reports that constriction in pharynx is difficult and unnatural.
5	Transition of /r/ into vowels	Rounding is already taking place naturally, this transition is not difficult. Overall /r/ articulation becoming more natural. Markers on screen helping.
6	Transition of /r/ out of vowels	Difficult because of jaw movement, as well as overall tongue movement. Some vowels more difficult than others. Will review again next session.
7	Different vocalizations of /r / involving vowels	Reminder to articulate slower, as this is when best /r/ is achieved. Sound quality is largely improved.
8	Sentences with /r/	Only three words in twenty sentences are found to be difficult. Articulation is still conscious effort.
9	Recording session of stimuli	Jason has made rapid gains in /r/ production accuracy.

3 Results

The ultrasound image and audio recordings were synced using BlackMagic Design. The synchronization was needed to have Jason's ultrasound images match

auditory information for later analysis. Results consisted of *qualitative* analysis of tongue contour (articulation) and *quantitative* analysis of formant values (acoustics) of /r/, pre- and post-training. In addition, auditory analysis was conducted in the form of a perceptual task administered to three native-English speakers, to determine to what extent observed improvements in /r/ were audible.

3.1 Articulatory Analysis

Ultrasound images of a frozen /r/ articulation are shown in Figure 1 and Figure 2; taken in Sessions 1 and 9 respectively. This first session image in Figure 1 shows Jason's tongue to be fairly relaxed, with no retraction of the tongue and constriction against the palate. A frozen ultrasound image taken from the last session image in Figure 2 shows more constriction between tongue and palate taking place, a more accurate tip-down bunched tongue configuration. Both stimuli are taken from the token "air", where the /r/ is in word-final position, and follows a vowel. This token was chosen as it allowed for a clear view of the /r/ articulation on its own after the vowel.

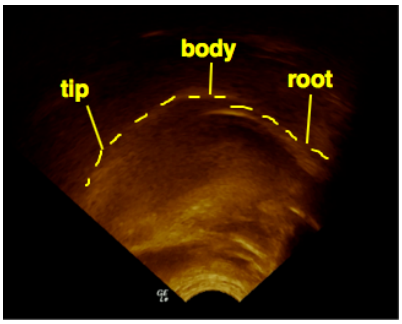

Figure 1: First session /r/ articulation

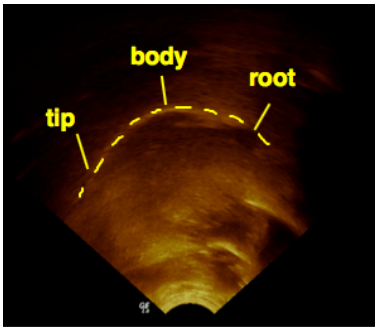

Figure 2: Last session /r/ articulation

3.2 Acoustic Analysis

To quantify the difference in articulation between the first and last sessions, the second, and third formants of /r/ were extracted from target words using a Praat

script, and the averages were calculated across the 16 tokens. F1 and F2 are plotted using Excel. Values for F3 are provided in (3), as well as the difference between F3 and F2.

(3)

	F3	*F3-F2*
Pre	2666.7 Hz	1028 Hz
Post	2318.3 Hz	861.8 Hz

As seen above, the frequency of F3 dropped between session one and session nine, consistent with improvement of /r/ production, as well as a smaller gap between F2 and F3 (Modha et al., 2008).

3.3 Auditory analysis

The auditory analysis consisted of a listening task that reflected the accuracy of the /r/ sound in 16 tokens between the first and last session. The tokens were presented in a randomized order, and participants were given a Likert scale questionnaire. Three native-English speakers completed this test, and their answers were consistent with each other. The results are presented below in (4), with Recording 1 taken from the first session, and Recording 2 from the last session.

(4)

I can clearly hear the /r/ sound in the word	*Recording 1*	*Recording 2*
Strongly Disagree	10.4 %	0%
Disagree	25%	8.3%
Neutral	31.3%	23%
Agree	29.2%	50%
Strongly Agree	4.2%	18.8%

The word tokens from Recording 2 were consistently ranked as more accurate to the listeners, which also supported the idea that Jason's /r/ articulation previous to the study was perceived with low accuracy ratings. Although there are many different variants of /r/, Gick et al. (2003) state that "what differentiates the variants of /r/ is which part of the front of the tongue is used to execute the palatal constriction"(p. 76). With that said, they all must have some constriction taking place in that area, along with in the labial and pharyngeal regions. This means that although there can be acoustic differences in articulation, Jason's /r/ was not perceived as well articulated by other listeners.

4 Discussion

This study builds on previous work as it brings forth additional evidence on the benefit of visual feedback in clinical settings: qualitative and quantitative evidence indicated improvement of /r/ across the study. There was no period of traditional therapy with an SLP without the use of ultrasound involved in this investigation; therefore, it is not known whether improvements could have been made without the use of biofeedback. However, the participant made very rapid gains in /r/ production accuracy in a short time frame, after 22 years of misarticulation. The ultrasound proved to be especially useful when the target sound was being uttered. This study supports the idea that ultrasound is effective as a visual feedback tool in the remediation of /r/, and potentially other phones as well.

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Appendix A

Table 1: Stimuli Used in Sessions 1-6 with Ultrasound

Session 1+2	Session 3	Session 4	Session 5	Session 6	Session 7
arrrrrrr grrrrrrr	crazy pray frizzy drizzy breezy frayed tried stay	zipper feather alligator November grasshopper computer butter October	reek rip rake rep rat rut room rookie wrote raw rot	ear erk farther dork tear horse fort fur park river bird	Car dark flair tear clear tire diary sore mortal sir germs girl barrel

Appendix B

Table 2: Stimuli Sentences used in Session 8

Theresa rakes red leaves in October
Randy wrote a letter to a girl
The hairy gorilla ate the fruit salad
The rain poured on the umbrella
Thirteen grasshoppers hurried into the yard

She played her guitar at the bar downstairs
Rex was furious that the raccoons ate his popcorn
The tray of buttercup marshmallows
On Thursday, Lorna threw three red rocks
The thermometer read one hundred and four
She opened her presents and poured champagne
The horse heard a noise in the barn
He was reading the Lord of the Rings
The sky was clear yesterday after the fire
The barrel of beer fell on the ground
The air was warm form the rays of sun
Randy has dreads in his hair
He got rid of the stale hamburger
Chris read his story to her pet spider
She could hear the storm and prayed it wouldn't rain

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