PRODUCTIONS OF / R / IN NATIVE MANDARIN SPEAKERS AND NATIVE ENGLISH SPEAKERS

By

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TABLE OF CONTENTS

LIST OF TABLES

Table Page

LIST OF FIGURES

CHAPTER I

INTRODUCTION

The importance of English is felt throughout the world with more than half the publications in the world in English. Linguists believe that since the 1930s, the English language has become highly influential, touching the lives of many people, different cultures and continents (Kachru, 1990).

Accurate production of the English language is necessary for successful communication. Production always affects what we communicate and how well we communicate (Beebe, 1984; Van Weeren & Theunissen, 1987)). The need to communicate effectively is felt in every aspect of life, even in the halls of higher learning. A study by Anderson-Hsieh & Koehler in 1988 noted that some American students found their foreign instructors' command of English inadequate for teaching due to their poor productions. Jones (1979) and Molholt (1988) reported the need to improve the communication skills of international teaching assistants since their production of the English language made them difficult to understand.

Hinofotis & Bailey (1980) suggested that in order for an English as a second language (ESL) learner to communicate orally regardless of his or her command of grammar and vocabulary, a certain threshold level of production must first be attained, or their faulty productions can "severely impair the communication process". However, in

China, the focus in the English curriculum is on grammar-translation and pattern drills. The ability to do grammatical analysis well takes priority over correct production, leaving many Chinese with the difficulty of communicating effectively in spite of many years of studying the English language (Campbell & Zhao, 1993). The difficulty of adult Mandarin Chinese learners of English to produce the English language as authentically as the native speakers has long been attributed to the fact that Mandarin and English are two extremely different languages. Even after being in the United States for 25 years, some Chinese still have trouble in English productions (Scovel, 1969; Molholt, 1988).

The difficulty with English productions faced by Mandarin speakers may be attributed to the phonological system of Mandarin. There are some English phonemes that resemble Mandarin Chinese phonemes, but their productions are different, while some English phonemes do not have any Chinese counterparts. Evidence has shown that adult learners of a second language generally do not pronounce the phones of a second language (L2) in a perfectly native-like way. Lado (1957) stated that elements that are similar to one's native language will make it easier for second language learners to learn, while dissimilar elements only make it more difficult for the L2 learner. The English / r / phone family is one of the more dissimilar elements that presents a unique challenge to the Mandarin speaker trying to learn English. The Mandarin language does possess an / r /, but unlike the English / r /, the Mandarin / r / is produced as a palatal fricative (Tiee, 1969).

It is very difficult to teach a completely new (L2) phoneme to a person who has to adjust present (L1) phoneme capabilities to a completely new and very different phonologic system. The reasons for that apparent limitation on phonetic learning ability are not well understood (Munro, 1993). The instructor of English phonemes must teach the appropriate manner, place, and dynamics of the / r / production as an entirely new construct. The variability in its place of production and the flexibility of some of the articulatory adjustments add to the complexity. Chinese learners of the English language encounter numerous difficulties in the process of learning the accurate production of the English / r / (Mochizuki, 1980; Skaer, 1984; Henly & Sheldon, 1986).

The productions of the English / r / are made with a great degree of variability among English speakers (Boyce & Espy-Wilson, 1997). Two common ways of categorizing the production of the English / r / are retroflex and bunched. Retroflex describes the "turning back" of the tongue tip with the tongue body in mid-central position, and lips often rounded. Bunched articulation is produced with the elevation of the tongue blade toward the palate with the tongue tip turned down. Depending on the phonetic context, the position of the tongue can vary considerably. For example, the / r / in "*r*abbit" is often produced with the tip of the tongue curled up and back in the oral cavity, making the / r / a palatal retroflex.

These production varieties do not appear to be independent of vowel context. Prevocalic and postvocalic contexts seem to have little influence on the nature of the / r / produced. Regardless of whether the / r / appears in a prevocalic or postvocalic context, the / r / can be produced as retroflex or bunched. Delattre (1968) found that in American English, the bunched / r / is used more frequently than the retroflex / r /, independent of the vowel context. On the contrary, Olive, et al. (1993), indicated that the prevocalic / r / occurring before the vowel within a syllable is usually produced by retracting and raising the tongue toward the soft palate. Postvocalic / r / occurring after the vowel within the same syllable is produced by advancing and raising the tongue toward the palatal region. Generally, the postvocalic / r / also appears to be extremely variable because of an abundance of undershooting during its production, even among native English speakers. That variability along with the prominence of prevocalic errors which impact intelligibility have led this investigator to focus primary attention on the prevocalic / r /.

One common way of studying speech sounds is to examine their acoustic and temporal characteristics. The most salient feature of / r / is its low third formant [the lowest of any sound in American English (Shriberg & Kent, 1995, p. 326)], which can range between 1100 and 2000 Hz, though normally it is in the region of 1600 Hz for both men and women. Formants are regions of energy concentration governed by the configuration of the vocal tract.

Research on the acoustic characteristics of the English / r / primarily focus on: the steady-state formants, duration of the steady-state, and the transition duration of the second and third formant. The English / r / is produced by adjusting the articulators into a posture so that on initial steady-state contains the appropriate formants. That short duration steady-state is terminated by a fairly long transition in which the tongue drops down and shifts to ultimately produce the next vowel phoneme. The initial adjustments of the articulators, the length of the steady-state, and the speed and extent of the transition all contribute to the correct acoustic product.

It does not appear that the alveolar, velar, or labial segment that preceeds postvocalic / r / affect the essential shape or duration of the *F*3 trajectory (Boyce & Espy-Wilson, 1997). It is on the first and second formants of / r / that changes in frequencies may be more evident. Changes in the frequency of *F1* are influenced by factors such as place of articulation, amount of vocal tract constriction, the laryngeal height, laryngeal volume and lip rounding. Changes in place and degree of vocal tract constriction determine the frequency of *F2*, while *F3* appears to be influenced by the degree of lip rounding.

Steady-state formants. The steady-state portion of the English prevocalic / r / is useful in distinguishing the / r / from other phonemes. The influence of *F1* on / r / is small; it is *F2* and *F3* that have considerable effect on its perception. At lower *F2* values (600 – 840 cps), labio-velarization is heard, while at higher *F2* values (1200 – 1560 cps), the effect of palatalization is heard. *F3* values of / r / need to be lower in frequency and fairly close to the *F2* onset in order to prevent any confusion with other phonemes, particularly the / l / (O'Connor, 1957).

A study by Klein in 1971 on children's productions of the prevocalic / r / found that children who produced intelligible / r / had the *F2* originating between 1533 to 1625 cps, and *F3* at 2833 to 3317 cps. In comparison with children subjects, research data on adults reported considerably lower frequency values.

Lisker (1957) found that the *F2* and *F3* of the English intervocalic / r / were between 850 – 1300 cps (cycles per second) in adults. O'Connor et al. (1957) looked at the influence of vowels on the second and third formants of the prevocalic / r / in adults, and found that *F2* onset before the vowels / i, e, ɛ / is 840 – 1560 cps, and *F3* is 840 – 1920 cps. On / ɔ, o, u / *F2* is 600 – 1200 cps and *F3* is no higher than 1680 cps. Dalston (1974) in a study on the productions of prevocalic / r / found that in male adults, *F2* was between 969 – 1154 Hz and *F3* was between 1451 – 1641 Hz. For female adults, *F2* was between 1080 – 1250 Hz and *F3* was between 1732 – 2424 Hz. Sharf and Benson

(1982), and Sharf and Ohde (1983) reported that the *F2* and *F3* for adults were between 700 – 1100 Hz and 1600 – 2400 Hz respectively.

The duration of the steady-state also helps in defining the English / r /. For listeners to appropriately identify the / r /, the steady-state duration should approximately be 50 msec (Minifie et al., 1973). Dalston (1974) reported that the *F3* at the steady-state has a mean of 30.9 msec.

Transition duration. The transition duration of the English / r / from the steady-state to the vowel formant, helps to discriminate the / r / from other groups of phonemes. A very brief duration could lead to confusion with nasals and stops, while a long duration may increase the risk of "losing the consonant impression entirely in favor of a vowel of changing color" (O'Connor et al., 1957).

O'Connor et al. (1957), discovered that a transition duration of up to 300 msec for the second-and-third formant transitions of / r / does not destroy the / r / effect, though a duration of 50 msec or less alters the / r / to a retroflex flapped sound. Dalston (1974) found that the *F3* transition duration had a mean of 71.4 msec.

Purpose

The misproductions of / r / in Mandarin speakers may result from several factors. First, the articulators may be inappropriately postured for the steady-state portion. The steady-state portion may be too short in duration. The transition portion may be too short. These misproductions may also be attributed to the absence of the English / r / in the Mandarin language. In the Mandarin language, an / r / is produced as a palatal fricative and not a palatal glide. A portion of the comparison of the English and

Mandarin phonemic systems is listed in Appendix A. [From "Contrastive Analysis of the Monosyllable Structure of American English and Mandarin Chinese" by Tiee, H.H. (1969), Language Learning, XIX, pg. 9, Table 1.]

Unfortunately, there has been limited research on the / r / misproductions in Mandarin speakers to provide a conclusive explanation. Most studies on / r / misproductions in Asians, have focused on Japanese speakers, whose phoneme system is a branch of the Mandarin language. Several studies have reported differences among Japanese speakers (Mochizuki, 1981; Skaer, 1984; Henly & Sheldon, 1986).

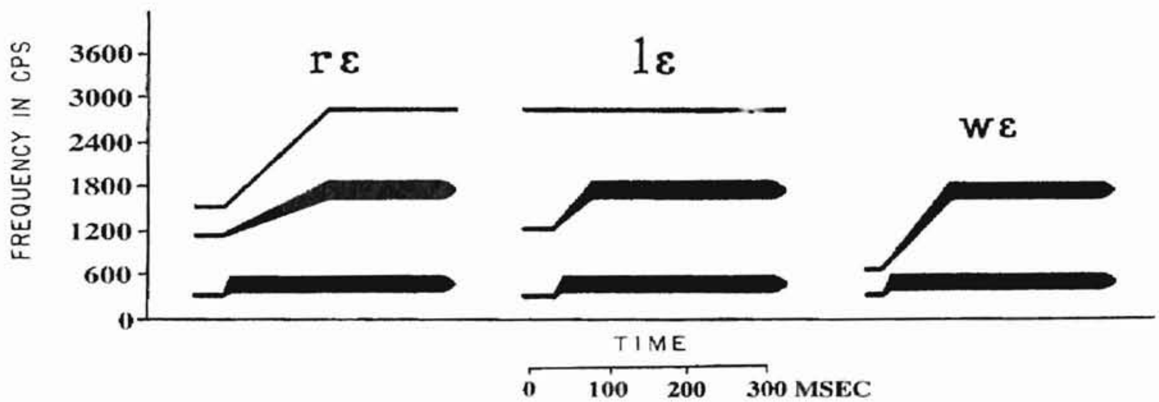
It is hypothesized that the Mandarin speakers may be producing their / r / with insufficient mouth opening, lip rounding, tongue height, and with their tongue primarily in the center of the oral cavity. The effects of a more constricted oral cavity will likely result in lower $F1$ values for the Mandarin group. Insufficient lip rounding and tongue backing will result in higher $F2$ values, while insufficient tongue tip raising will increase $F3$ values.

The central positioning of the tongue among the Mandarin speakers may indicate that the distance from which the tongue has to shift to ultimately produce the next vowel may be shortened, thereby shortening transition duration values. If the steady-state posturing is not appropriately accurate to start with, the transition cannot be executed appropriately.

The duration of the steady-state among the Mandarin speakers may either be shorter or longer. The Mandarin speakers may shorten duration in anticipation of the vowel following the / r /, or they could be lengthening the duration of the steady-state in an effort to position their tongue correctly for the / r / production.

Differences in place and manner of production can result in alteration in formant structures, resulting in the / r / being produced either more w-like or l-like, or may be even a substitution of a / w / or / l / for / r /, as shown in Figure 1.

Figure 1. Simulated spectra for / r, w, l /. [From O'Connor et al., "Acoustic cues for the Perception of Initial / w, j, r, l / in English." Word, 13 (1957), 24-43, Fig. 1.]



The purposes of the present investigation are to compare the *F1, F2, F3* configurations, lengths of the steady-state and the transition portions of the / r / in Mandarin speakers with those of native English speakers.

CHAPTER II

METHOD

Subjects

A total of 36 female subjects between the ages of 18 – 35 participated in this study. Subjects were divided into two groups – native Mandarin speakers from China and native English speakers. Each group consisted of 18 subjects, all students from Oklahoma State University. A native Mandarin speaker in this study is defined as a person whose first language is Mandarin and whose family speaks it in the home. All Mandarin subjects obtained at least a score of 550 on the Test of English as a Foreign Language (TOEFL). All subjects met the following criteria: presented no vocal pathology or currently taking any medication that impacted oral speech, and had no formal voice or speech training in the past one year. All native English subjects also demonstrated speech free of any observable disorder. Subjects passed a hearing screening meeting the criterion of a pure tone three-frequency average, non-aided, of 25 dB (ANSI, 1969) or better, in the better ear. An interview was conducted with each subject to gather information regarding selection criteria, current medication, and alcohol and tobacco use.

Materials

The reading task was a list of six monosyllabic words with / r / in the initial position in each of the following context: / i /, / ʌ /, / u /. These vowels were selected so that the / r / phoneme would occur in context with three different basic vowel classes, high front, high back, and central. The word list is included in Appendix B. The written task was a questionnaire pertaining to tongue placement during the production of / r /. The questionnaire is included in Appendix C. The oral readings were recorded using a Nagra reel-to-reel tape recorder, a unidirectional microphone, and studio quality tapes. The microphone was positioned approximately 15 inches away from the subject. All recordings were analyzed using the Kay Elemetrics CSL 4300 Computerized Speech Lab.

Procedure

Each subject was assessed at the OSU Speech-Language-Hearing Clinic in a quiet environment, free from as much extraneous noise as possible. Prior to testing, each subject was orally briefed about the purpose of the study and signed an informed consent form approved by the Oklahoma State University Institutional Review Board. Each subject was then assigned an alphanumeric reference number. After the examiner completed each interview, each subject was administered a hearing screening using GSI model 17 portable audiometer in a sound treated room. General speech behavior was screened during spontaneous conversion with the subjects.

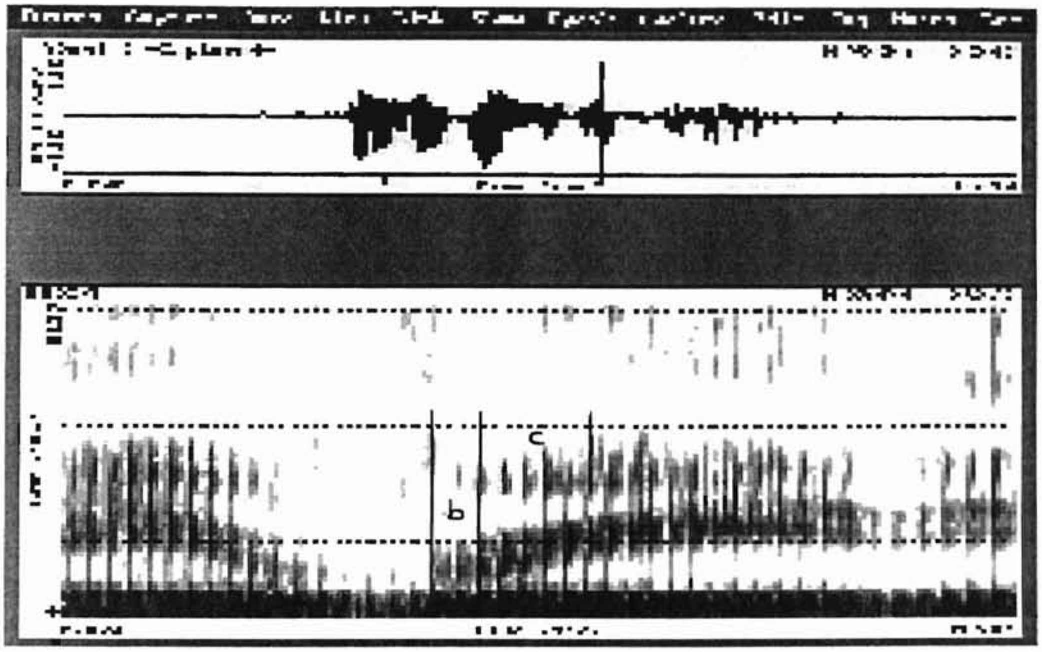
On passing the hearing screening and the speech requirements, each subject was asked to produce a randomized list of / r / words. Each word was presented to each subject one at a time over a period of five trials. Each subject was given the following taped instructions: " You will be presented with a series of cards. Each card will contain a word, you are to say each word." Following this task, each subject completed a questionnaire pertaining to tongue placement during the production of / r /.

Analysis

A wide band frequency-by-time record and amplitude display was made for each test word with / r / in the prevocalic position. The Linear Predictive Code (LPC) was used to generate the frequency-by-intensity of each spectrogram to obtain the following acoustical information:

1. frequency of each of the first three / r / formants in the steady-state;
2. duration of the steady state of each formant, defined by the distance (in milliseconds) between the visible onset of each formant and the point at which that formant demonstrates a noticeable change in slope, shown as **b** on the spectrogram below;
3. duration of each formant of the transition, defined by the distance (in milliseconds) between the end of the steady state and the onset of the vowel of each formant, as shown as **c** on the spectrogram below (Figure 2).

Figure 2. Spectrogram of the word *reed*..



Reliability

Interjudge reliability in determining *F1, F2, F3* in the steady-state, duration of the steady-state, and the transition duration of / r / were determined. An independent observer, a graduate student in speech-language pathology, repeated the analysis procedures for 11 percent of the subjects. The Pearson product moment correlation coefficient was calculated using independent observer and investigator measures. The Pearson product moment correlation coefficient was .969 for *F1, F2, F3* in the steady-state, .932 for the duration of the steady-state, and .909 for the transition duration.

Intrajudge reliability was determined by the investigator re-evaluting 11 percent of the subjects. The Pearson product moment correlation coefficients were calculated with the investigator's initial measurements. The Pearson product moment correlation coefficient was .975 for *F1, F2, F3* in the steady-state, .916 for the duration of the steady-state, and .912 for the transition duration.

CHAPTER III

RESULTS

Frequency of the First Three Formants in the Steady-state

A two-factor (2 X 3) mixed analysis of variance (ANOVA) was conducted among the / r / words in the presence of lip-retracted (/ i /), neutral (/ ʌ /), and lip-rounded (/ u /) vowels across the Mandarin and English groups to assess the frequencies of the first three / r / formants in the steady-state. The Mandarin and English groups served as the two levels of the independent variable, and vowel types formed three levels of one repeated measure. That comparison was run on three separate trials, once for *F1*, a second time for *F2*, and a third time for *F3*.

F1 in the steady-state. The frequencies of the steady-state of the first formants, *F1*s were compared across groups and vowel types. ANOVA contrast comparing groups across vowel types revealed no significant differences, $F(1, 34) = 4.848$, $p > .01$. There was a significant vowel main effect, $F(2, 68) = 23.679$, $p < .01$, but no significant group by vowel context interaction, $F(2, 68) = 1.503$, $p > .01$ (see Table 1).

Table 1. ANOVA source table - *F1* in the steady-state for / i /, / ʌ /, and / u /.

Source	SS	df	MS	F	P
Between Subjects					
Group	25869.558	1	25869.558	4.848	0.035
Error	181413.634	34	5335.695		
Within subjects					
a (vowel type)	41077.199	2	20538.600	23.679	0.000
a* Group (/ i, ʌ, u /)	2608.088	2	1304.044	1.503	0.230
Error	58981.713	68	867.378		

Tukey post-hoc contrasts were made by combining *F1* values across the two groups and comparing across means for each vowel subgroup. The results of that contrast are contained in Table 2.

Table 2. Combined group means for *F1* in the steady-state (all values in Hz).

Speakers	/ i /	/ ʌ /	/ u /
Combined means for English & Mandarin	348	393	357

Critical Value (CV) within groups (3, 68) = 30

The *F1* values for the / r / in the / ʌ / vowel contexts were significantly higher than the other two means. The *F1* values for / r / in the / i / and / u / contexts were not significantly different from each other.

F2 in the steady-state. The ANOVA comparing groups across vowel types for *F2* revealed significant differences across groups, F (1, 34) = 22.554, p < .01; and across vowel types, F(2, 68) = 14.176, p < .01. There was a significant group by vowel context interaction. F(2, 68) = 5.663, p < .01 (see Table 3). The main effect for group indicated that the Mandarin speakers had higher *F2* values than the English speakers.

Table 3. ANOVA source table - *F2* at the steady-state for / i /, / ʌ /, and / u /.

Source	SS	df	MS	F	P
Between Subjects					
Group	1477944.037	1	1477944.037	22.554	0.000
Error	2227994.398	34	65529.247		
Within subjects					
a (vowel type)	453414.699	2	226707.350	14.176	0.000
a* Group (/ i, ʌ, u /)	181121.255	2	90560.627	5.663	0.005
Error	1087447.046	68	15991.868		

Tukey post-hoc comparisons were made across *F2* group means for each vowel type. The results of those contrasts are contained in Table 4.

Table 4. Group means for *F2* in the steady-state (all values in Hz).

Speakers	/ i /	/ ʌ /	/ u /
English	1366	1287	1348
Mandarin	1713	1486	1504

Critical Value (CV) between groups (2, 34) = 235
Critical Value (CV) within groups (3,68) = 128

The Mandarin speakers produced / r / *F2* frequencies which were significantly higher for the / i / vowel contexts than they were for either the / u / or / ʌ / contexts (CV 3, 68 = 128). The *F2* values for the / u / and / ʌ / were not significantly different from each other. The English group had *F2* / r / steady-state frequencies that did not differ significantly from each other. The comparisons of the *F2* frequencies across group for each vowel context revealed that the Mandarin group also had higher values for / ʌ / and / u / than the English group (CV 2, 34 = 235), although these were not significant.

F3 in the steady-state. The ANOVA contrasts comparing groups across vowel types for *F3* revealed significant differences across groups, $F(1, 25) = 47.676$, $p < .01$; and across vowel types, $F(2, 50) = 12.170$, $p < .01$. There was no significant group by vowel context interaction, $F(2, 50) = 4.286$, $p > .01$ (see Table 5). It should be noted that for this measure, only nine out of the 18 Mandarin subjects showed evidence of an *F3*. The main effect for group indicated that the Mandarin speakers had higher *F3* values than the English speakers.

Table 5. ANOVA source table – *F3* in the steady-state for / i /, / ʌ /, and / u /.

Source	SS	df	MS	F	P
Between Subjects					
Group	2280298.765	1	2280298.765	47.676	0.000
Error	1195730.278	25	47829.211		
Within subjects					
a (vowel type)	218559.528	2	109279.764	12.170	0.000
a* Group (/ i, ʌ, u /)	76977.985	2	38488.992	4.286	0.019
Error	448959.583	50	8979.192		

Tukey post-hoc contrasts were made across *F3* group means for each vowel type. The results of that contrast are contained in Table 6. The mean Mandarin values were based on nine subjects who evidenced *F3* values. All 18 English speakers' / r / productions contained an *F3* value.

Table 6. Group means for *F3* at the steady-state (all values in Hz).

Speakers	/ i /	/ ʌ /	/ u /
Combined means for English & Mandarin	2127	1979	2007

Critical Value (CV) within groups (3, 68) = 117

Post-hoc comparisons across vowel contexts revealed that the *F3* values were significantly higher for the Mandarin group for the / i / vowel (CV 3, 50 = 117) than for either the / ʌ / or / u / vowel. The English group had *F3* values that did not differ significantly across any vowel group.

Overall results indicate that the Mandarin group had lower *F1* values and higher *F2* and *F3* values for all vowel contexts than the English group. A table of means for each group for each frequency is shown in Table 7.

Table 7. Individual group means for *F1, F2, F3* in the steady-state for all vowel types.

	F1 in Hz			*F2* in Hz			*F3* in Hz		
	/ i /	/ ʌ /	/ u /	/ i /	/ ʌ /	/ u /	/ i /	/ ʌ /	/ u /
English	361 (50)	404 (54)	379 (51)	1366 (140)	1287 (140)	1348 (116)	1895 (133)	1836 (152)	1806 (164)
Mandarin	335 (50)	382 (56)	335 (48)	1713 (288)	1486 (179)	1504 (237)	2358 (218)	2122 (195)	2207 (169)

Standard Deviation (SD) values are in parenthesis.

Duration of *F1, F2* and *F3* in the Steady-state

A two-factor (2 X 3) mixed ANOVA was used to analyze the duration of the steady-states of the first, second and third formants. The Mandarin and English groups formed two levels of the independent variable, and the three vowel types (/ i, ʌ, u /)

formed three levels of a second repeated measure. That comparison was run on three separate trials, once for *F1*, a second time for *F2*, and a third time for *F3*.

Duration of F1 in the steady-state. The ANOVA contrast comparing groups across vowel types for *F1* revealed significant differences across groups, $F(1, 34) = 44.218$, $p < .01$; and across vowel types, $F(2, 68) = 5.453$, $p < .01$. There was a significant group by vowel interaction, $F(2, 68) = 5.933$, $p < .01$ (see Table 8). The main effect for group indicated that the Mandarin speakers had longer steady-state duration values than the English speakers.

Table 8. ANOVA source table - Duration of *F1* in the steady-state for / i /, / ʌ /, and / u /.

Source	SS	df	MS	F	P
Between Subjects					
Group	35389.120	1	35389.120	44.218	0.000
Error	27211.148	34	800.328		
Within subjects					
a (vowel type)	920.241	2	460.120	5.453	0.006
a* Group (/ i, ʌ, u /)	1001.241	2	500.620	5.933	0.004
Error	5738.019	68	84.383		

Tukey post-hoc contrasts were made across *F1* group means for each vowel type. The results are contained in Table 9.

Table 9. Group means for the duration of *F1* in the steady-state (all values in msec).

Speakers	/ i /	/ ʌ /	/ u /
English	30	33	33
Mandarin	70	60	74

Critical Value (CV) within groups (3, 68) = 9

A comparison across vowel contexts revealed that the Mandarin group did have significantly longer steady-state duration for all three vowels (CV 3, 68 = 9). The English group produced steady-state duration for each vowel context that did not vary significantly across any of the vowel contexts.

Duration of F2 in the steady-state. The ANOVA contrast comparing groups across vowel types for *F2* revealed significant differences across groups, $F(1, 34) = 32.775$, $p < .01$; and across vowel types, $F(2, 68) = 8.384$, $p < .01$. There was a significant group by vowel interaction, $F(2, 68) = 7.032$, $p < .01$ (see Table 10). The main effect for group indicated that the Mandarin speakers had longer steady-state duration values than the English speakers.

Table 10. ANOVA source table -Duration of *F2* in the steady-state for / i /, / ʌ /, and / u /.

Source	SS	df	MS	F	P
Between Subjects					
Group	22852.231	1	22852.231	32.775	0.000
Error	23706.093	34	697.238		
Within subjects					
a (vowel type)	1054.296	2	527.148	8.384	0.001
a* Group (/ i, ʌ, u /)	884.241	2	442.120	7.032	0.002
Error	4275.296	68	62.872		

Tukey post-hoc comparisons were made across *F2* group means for each vowel type. The results of those contrasts are contained in Table 11.

Table 11. Group means for the duration of *F2* in the steady-state (all values in msec).

Speakers	/ i /	/ ʌ /	/ u /
English	26	27	29
Mandarin	59	48	61

Critical Value (CV) between groups (2, 34) = 24
Critical Value (CV) within groups (3, 68) = 8

Post-hoc comparisons revealed that the Mandarin group had significantly longer steady-state duration than the English group for the vowels / i / and / u / (CV 2, 34 = 24).

The *F2* duration did not differ significantly in the / ʌ / vowel contexts. The comparison for each group for each vowel revealed no significant difference for the English group across vowel contexts. The *F2* duration of the Mandarin productions of / r / in the / ʌ / contexts were significantly shorter than for the / i / and / u / vowels (CV 3, 68 = 8). The / i / and / u / duration did not differ significantly from each other.

Duration of F3 in the steady-state. The ANOVA contrast comparing groups across vowel types for *F3* revealed significant differences across groups, $F\ (1, 25) = 38.854$, $p < .01$. There was no significant differences in vowel main effect and group vowel interaction (see Table 12). It should be noted that for this measure, only nine out of the 18 Mandarin subjects showed evidence of an *F3*. The main effect for group indicated that the Mandarin speakers had longer steady-state duration values than the English speakers.

Table 12. ANOVA source table-Duration of *F3* in the steady-state for / i /, / ʌ /, and / u /.

Source	SS	df	MS	F	P
Between Subjects					
Group	20853.358	1	20853.358	38.854	0.000
Error	13417.870	25	536.715		
Within subjects					
a (vowel type)	265.568	2	132.784	1.468	0.240
a* Group (/ i, ʌ, u /)	263.568	2	131.784	1.457	0.243
Error	4521.185	50	90.424		

Overall results indicate that the Mandarin group had longer duration values for all vowel contexts than the English group. a table of means for each group for each frequency is shown in Table 13.

Table 13. Individual group means for the duration of *F1, F2, F3* in the steady-state for all vowel types.

	Duration of *F1* in msec			Duration of *F2* in msec			Duration of *F2* in msec		
	/ i /	/ ʌ /	/ u /	/ i /	/ ʌ /	/ u /	/ i /	/ ʌ /	/ u /
English	30 (10)	33 (13)	33 (11)	26 (8)	27 (11)	29 (9)	26 (7)	27 (10)	27 (8)
Mandarin	70 (23)	60 (23)	74 (27)	59 (21)	48 (21)	61 (26)	54 (23)	49 (27)	63 (27)

Standard Deviation (SD) values are in parenthesis.

Transition Duration of *F1, F2* and *F3*

A two-factor (2 X 3) mixed ANOVA was used to analyze the transition duration of the first, second and third / r / formants. The Mandarin and English groups formed two levels of the independent variable, and the three vowel contexts (/ i, ʌ, u /) formed three levels of one repeated measure. That comparison was repeated on three separate trials, once for *F1*, a second time for *F2*, and a third time for *F3*.

Transition Duration of F1. The ANOVA contrast comparing groups across vowel types for *F1* revealed significant differences across groups, $F(1, 34) = 130.724$, $p < .01$, and across vowel types, $F(2, 68) = 6.393$, $p < .01$. There was no significant group by vowel interaction (see Table 14). The main effect for group indicated that the Mandarin speakers had shorter transition duration values that the English speakers.

Table 14. ANOVA source table – Transition Duration of *F1* for / i /, / ʌ /, and / u /.

Source	SS	df	MS	F	P
Between Subjects					
Group	31246.009	1	31246.009	130.724	0.000
Error	8126.759	34	239.022		
Within subjects					
a (vowel type)	1700.838	2	850.419	6.393	0.003
a* Group (/ i, ʌ, u /)	876.199	2	438.100	3.293	0.043
Error	9045.796	68	133.026		

Tukey post-hoc contrasts were made by combining *F1* values across the two groups and comparing across means for each vowel subgroup. The results of that contrast are contained in Table 15.

Table 15. Group means for the transition duration of *F1*(all values in msec).

Speakers	/ i /	/ ʌ /	/ u /
Combined means for English & Mandarin	63	53	59

Critical Value (CV) within groups (3, 68) = 12

Post-hoc comparisons of combined means of the groups across vowel contexts revealed that the transition duration were significantly longer for the transition from the / r / to the / i / vowel than they were for the / ʌ / context (CV 3, 68 = 12). There was no significant difference between the transition durations in the / u / and / ʌ / contexts. The main effect for group indicated that the *F1* durations were longer for the English group.

Transition Duration of F2. The ANOVA contrast comparing groups across vowel types for *F2* revealed significant differences across groups, $F(1, 34) = 94.084$, $p < .01$, and across vowel types, $F(2, 68) = 15.871$, $p < .01$. There was no significant group by vowel interaction, $F(2, 68) = 2.548$, $p > .01$ (see Table 16). The main effect for group indicated that the Mandarin speakers had shorter transition duration values than the English speakers.

Table 16. ANOVA source table – Transition Duration of *F2* for / i /, / ʌ /, and / u /.

Source	SS	df	MS	F	P
Between Subjects					
Group	22837.688	1	22837.688	94.084	0.000
Error	8253.042	34	242.737		
Within subjects					
a (vowel type)	2625.389	2	1312.694	15.871	0.000
a* Group (/ i, ʌ, u /)	421.556	2	210.778	2.548	0.086
Error	5624.389	68	82.712		

Tukey post-hoc contrasts were made across *F2* group means for each vowel type. The results of that contrast are contained in Table 17.

Table 17. Group means for the transition duration of *F2* (all values in msec).

Speakers	/ i /	/ ʌ /	/ u /
Combined means for English & Mandarin	63	52	62

Critical Value (CV) within groups (3, 68) = 6

The comparisons of the *F2* duration values for the groups for each vowel context revealed that both groups had *F2* values that differed significantly for the / ʌ / contexts but not for the / i / or / u / contexts (CV 2, 34 = 16).

Transition Duration of F3. The ANOVA contrast comparing groups across vowel types for *F3* revealed significant differences between the Mandarin and English groups, $F(1, 25) = 19.185$, $p < .01$, and across vowel types, $F(2, 50) = 10.074$, $p < .01$. There was no significant group by vowel interaction, $F(2, 50) = 2.983$, $p > .01$ (see Table 18). The main effect for group indicated that the Mandarin speakers had shorter transition duration values than the English speakers.

Table 18. ANOVA source table – Transition Duration of *F3* for / i /, / ʌ /, and / u /.

Source	SS	df	MS	F	P
Between Subjects					
Group	8177.784	1	8177.784	19.185	0.000
Error	10656.741	25	426.270		
Within subjects					
a (vowel type)	1861.633	2	930.816	10.074	0.000
a* Group (/ i, ʌ, u /)	551.262	2	275.631	2.983	0.060
Error	4619.731	50	92.395		

Tukey post-hoc contrasts were made across *F3* group means for each vowel type. The results of that contrast are contained in Table 19.

Table 19. Group means for the transition duration of *F3* (all values in msec).

Speakers	/ i /	/ ʌ /	/ u /
Combined means for English & Mandarin	59	50	59

Critical Value (CV) within groups (3, 68) = 12

Post-hoc comparisons revealed that the transition duration differed significantly for the / ʌ / vowel contexts for the combined group (CV 3, 68 = 12). There were no significant differences for the / i / or / u / vowel contexts.

Overall results indicate that the Mandarin group had shorter transition duration values for all vowel contexts than the English group. A table of means for each group for each frequency is shown in Table 20.

Table 20. Individual group means for the transition duration of *F1, F2, F3* for all vowel types.

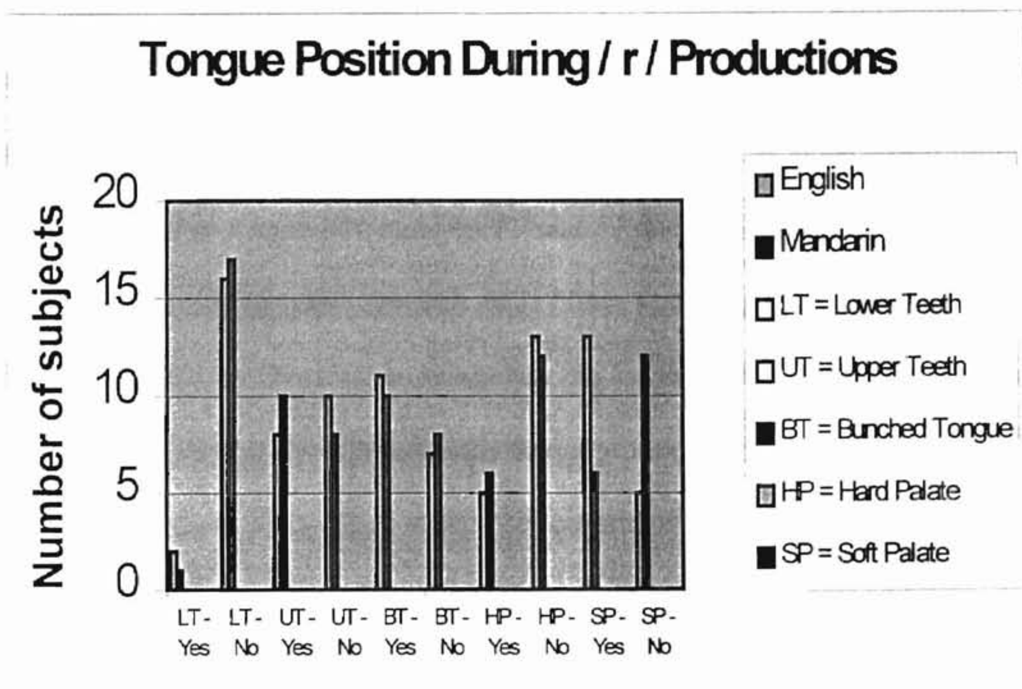
	Duration of *F1* in msec			Duration of *F2* in msec			Duration of *F2* in msec		
	/ i /	/ ʌ /	/ u /	/ i /	/ ʌ /	/ u /	/ i /	/ ʌ /	/ u /
English	83 (19)	70 (17)	73 (20)	78 (16)	69 (14)	74 (14)	70 (17)	63 (15)	66 (17)
Mandarin	42 (12)	36 (9)	45 (15)	48 (13)	35 (10)	50 (16)	48 (13)	36 (17)	51 (17)

Standard Deviation (SD) values are in parenthesis.

Tongue Position During Production of / r /

Subjects were asked to indicate their tongue position during the production of / r /. Each subject was to marked on the questionnaire if their tongue touched their bottom teeth or upper teeth, bunched the back of their tongue, touched the hard or soft palate. Among the 18 Mandarin speakers, 12 indicated no hard or soft palate involvement, 10 bunched the back of their tongue, 10 reported their tongue touching their top teeth, and one said that her tongue touched her bottom teeth. The English group generally reported bunching their tongue (11 subjects) and some involvement with the soft palate (13 subjects) during / r / productions. Results are shown in Figure 3.

Figure 3. Tongue Position during / r / Productions



CHAPTER IV

DISCUSSION

Research on the acoustic and temporal aspects of the English / r / has revealed important characteristics that make up an / r /. Dalston (1974) indicated that appropriate formant structures in the steady-state contributes to the correctness of the / r /. First, Dalston (1974) studied correct productions of / r / by adult females and found *F1* to fall between 120 and 600 Hz, *F2* between 600 and 1560 Hz, and *F3* between 1732 and 2424 Hz. Second, Minifie et al. (1973), and Dalston (1974), identified the duration of the steady-state as an important feature of a correct / r /. A duration of approximately 30 to 50 msec is necessary for a listener to appropriately identify the / r /. A third characteristic of the correct / r / is its transition duration from the steady-state to the vowel formant. A transition duration of up to 300 msec for *F2* and *F3* does not destroy the / r / effect.

Acoustic and temporal research on / r / have been largely confined to the Caucasian population. Studies on Asians like the Japanese, Cantonese and Mandarin generally conclude that these populations do not produce the / r / similar to that of their western counterparts, but provide very little acoustic or temporal data (Mochizuki, 1981; Molholt, 1988; Munro, 1993; Scovel, 1969).

The purpose of this investigation was then to compare the *F1, F2, F3* configurations, the lengths of the steady-state, and the transition portion of the / r / in

Mandarin speakers with those of English speakers. Despite years of learning the English language, many Mandarin speakers exhibit difficulty and variations in their production of the English / r /.

Steady-state formants. The first analysis compared *F1* in the steady-state among the Mandarin and English speakers. Generally, the Mandarin group revealed significantly lower *F1* values than the English group. This suggest that the Mandarin speakers may be producing their / r / with insufficient opening of the oral tract. *F1* is most often associated with the overall opening of the oral cavity, so lower values indicate less opening while higher values indicate greater opening. However, it should be noted that the *F1* values for both groups are within the normal range of 120 Hz – 600 Hz (O'Connor et al., 1957).

Post-hoc test revealed that both groups differed significantly on their productions of / ʌ / and not for the / i / or / u / vowel contexts. This is not unexpected since the / ʌ / is produced with the tongue in the center of the oral cavity, the lips are neither spread nor round, and with very little constriction; resulting in a high *F1*. Both the Mandarin and English speakers appear to anticipate the / ʌ / during / r / production, causing both groups to have higher values for the / ʌ / vowel than for the / i / or / u / vowel.

Comparison of the *F2* values among the Mandarin and English speakers revealed both groups differed significantly for the / i / vowel contexts and not on the / ʌ / or / u / vowel. Produced with the tongue toward the front of the oral cavity, tongue tip raised and lips spread, the high front / i / vowel traditionally exhibits higher *F2* values than the neutral or high back vowel. As a result, during the production of the / r /, speakers from both groups appear to position their tongues toward the front of the oral cavity in anticipation of the high front vowel.

The significant group by vowel interaction would indicate that the vowels' impact on the / r / was significantly different in both groups. The significantly higher *F2* values of the Mandarin group for the / i / vowel context may indicate that the Mandarin speakers appear to increase tongue constriction while maintaining their tongue in the center of the oral cavity when making / r / with the / i / vowel. The *F2* is elevated (Fant, 1959) when tongue constriction is localized in the central portion of the mouth,.

Comparison of the *F3* values found the Mandarin group to have significantly higher values for the / i / vowel contexts than for the / ʌ / or / u / vowel contexts. Again, it is the anticipation of the high front / i / that result in the Mandarin speakers raising their *F3* / r / values to commensurate with the high *F3* values of the / i / vowel, by increasing tongue constriction while positioning the tongue in the center of the mouth.

In the data analysis for *F3* values, it was noted that only half of the Mandarin speakers showed evidence of an *F3*. The nine Mandarin speakers who had *F3* values, had mean values of 2122 Hz, 2207 Hz, and 2358 Hz for the / ʌ /, / u / and / i / vowels respectively. Though these values fall within the normal range of 1600 Hz and 2400 Hz (O'Connor, et al., 1957), it is possible that for the nine Mandarin speakers, their *F3* values may be even higher, making it difficult to capture their limited energy on the spectrogram.

Overall configuration of a lower *F1* and higher *F2* and *F3* values exhibited by the Mandarin group may suggest that the Mandarin speakers are making their / r / productions more like an / l /. To test this assumption, this investigator produced a correct / r / and an l-like / r / similar to those produced by the Mandarin speakers on the spectrogram for the three vowels / i, u, ʌ /. Results indicated that when / r / becomes l-like, *F1* decreases while *F2* and *F3* increases. In addition, / l / traditionally has a high *F3* value, making it difficult to capture its limited energy on the spectrogram. This may be why half of the Mandarin speakers do not exhibit an *F3* in their / r / productions.

Duration of the steady-state. The present study noted that the Mandarin group had significantly longer steady-state duration values across all vowel types than the English group. The longer steady-state duration may suggest that the Mandarin speakers prolong duration in an attempt to maneuver their tongue to the appropriate position for an / r / production.

Transition duration. Comparison of the transition duration of *F1, F2, F3* revealed that the Mandarin group had significantly shorter transition durations than the English group. That is expected since the Mandarin group generally reported that their / r / productions were made with their tongue in the center of the oral cavity. With this central position, it could be that the distance from which the tongue has to shift to ultimately produce the next vowel is shortened, resulting in shorter transition durations. Both English and Mandarin groups had shorter transition duration values for / ʌ / than for / i / and / u / vowels. That did not seem uncommon since the tongue has a shorter distance to travel from the / r / to the more neutral vowel than to the front or back vowels.

Questionnaire. The questionnaire on tongue position during / r / productions revealed that there are variations in place and manner of production among the Mandarin group. Twelve Mandarin speakers indicated no hard or soft palate involvement; while out of the 10 who indicated their tongue touching their top teeth, at least half revealed no palatal involvement. Even among the 10 that said they bunched the back of their tongue, at least half indicated no palatal involvement. Generally, it appears that the Mandarin speakers had tongue positions which were not elevated high enough, but primarily confined to the center of the oral cavity, and with minimal tongue tip involvement.

In summary, the Mandarin speakers appeared to produce their / r / with lower *F1* values and higher *F2* and *F3* values in the steady-state segment. According to Delattre (1951), *F1* values are lowered when there is insufficient opening of the oral cavity, and *F2* rises when there is inadequate lip rounding and tongue retraction. Delattre also noted that when tongue tip is not elevated sufficiently, toward a retroflex position, *F3* rises.

Therefore, it seems that the Mandarin speakers were producing their / r / with little mouth opening, lip rounding, tongue retraction and tongue tip elevation. That incorrect place and manner of production prolonged the duration of the steady-state, and shortened the transition duration. All these factors greatly alter the perception of the / r / produced by Mandarin speakers.

The knowledge that a lower *F1*, higher *F2* and *F3*, longer steady-state duration, and shorter transition, are characteristic of the / r / produced by the Mandarin speakers, provide clinicians a basis from which to develop their treatment plan.

First, the lower *F1* values indicate a more constricted oral cavity. Therefore, the Mandarin speakers when producing the / r / are doing so with insufficient opening of the oral cavity. To increase the *F1* values to be comparable with the *F1* values of a correctly produced / r /, clinicians may suggest to their Mandarin clients to lower their mandible so as to increase the opening of their oral cavity.

Secondly, the higher *F2* values produced by the Mandarin speakers indicate insufficient tongue backing and lip rounding. The Mandarin speakers may be producing the / r / with very little or no lip rounding at all, and their tongue may be positioned more anteriorly in the oral cavity. To lower the *F2* values to commensurate with the *F2* values of a correct / r /, Mandarin speakers may be encouraged to purse their lips and retract their tongue tip during / r / productions.

Thirdly, the higher *F3* values of the Mandarin speakers are indicative of insufficient tongue tip raising. The Mandarin speakers may be positioning their tongue tip just below their lower teeth. To increase *F3* values, clinicians may encourage their Mandarin clients to elevate their tongue tip towards the alveolar region.

When Mandarin speakers are able to make their / r / productions with the correct placement, this could inevitably alter the steady-state duration and transition duration. The ability to place their tongue in the correct position would shorten the steady-state duration, as Mandarin speakers would not find the need to prolong duration to compensate for their inability to locate the position for a correct / r /. The ability to elevate their tongue towards the alveolar region will lengthen transition duration, as the tongue would have to be maneuvered over a greater distant in preparation for the following vowel.

Future investigation may choose to do a comparative study on Mandarin speakers' productions of / r / and / l / to obtain data on the formant structures, duration of steady-state, and transition duration of each phoneme. A perceptual task involving English speakers rating the level of / r / distortions of Mandarin speakers would provide further evidence if Mandarin speakers are producing an l-like / r / or substituting / l / for / r /

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APPENDIXES

APPENDIX A

COMPARISON OF THE ENGLISH AND MANDARIN

PHONEMIC SYSTEMS

Comparison of the English and Mandarin phonemic systems

	Alveolar (sibilant)*	Palatal		Velar
		(Retroflexes)		
Stops	/ t / / d / / / t / / / / d / /			/ k / / g / / / k / / / / g / /
Fricatives	/ s / / z / / / s / / *	/ s / / z / / / sh / / / / r / /	/ / x / /	/ / h / /
Affricates	/ / z / / * / / c / / *	/ c / / j / / / zh / / / / ch / /	/ / j / / / / q / /	
Nasal	/ n / / / n / /			/ ŋ / / / ŋ / /
Lateral	/ l / / / l / /			
Glide	/ r /	/ y /		/ w /

Nonsyllabics are enclosed in single slant lines for English, double slant lines for Mandarin.

* sibilant sounds

Note. From " Contrastive Analysis of the Monosyllable Structure of American English and Mandarin Chinese" by Tiee, H.H., 1969. Language Learning, XIX, p. 9, Table 1.

APPENDIX B

WORD LIST

Prevocalic / r / word list:

Reed

Reef

Rut

Rug

Room

Root

APPENDIX C

/ R / QUESTIONNNAIRE

Oklahoma State University
Department of Communication Sciences and Disorders
/ r / Questionnaire Karen Wee

The following are questions concerning your tongue placement when you make an / r /. Circle the appropriate answer.

1. Does your tongue touch your bottom teeth? (yes / no)

2. Does your tongue touch your upper teeth? (yes / no)

3. Do you bunch the back of your tongue? (yes / no)

4. Does your tongue touch the roof of your mouth, toward the front? (yes / no)

5. Does your tongue touch the roof of your mouth, toward the back? (yes / no)

APPENDIX D

INTERVIEW QUESTIONNAIRE

Oklahoma State University
Department of Communication Sciences and Disorders
Subject Information Sheet Karen Wee

Subject #: _______ Age in years: _______ Gender: _______

TOEFL:_ met university standard / did not meet university standard

Current Medications: ____

Check any of the following that apply:

Hearing Loss ________ Hearing Aids __________

Speech Problems ________ Cardiovascular Accident (Stroke) ________

Chronic Laryngitis _______ Brain Injury ________

Neurological Diseases _______ Cleft Palate and/or lip ________

Cerebral Palsy ________ Smoker _______

Paralysis ________

Any formal speech training?

Any previous speech therapy?

How many alcoholic drinks do you have in a typical week?

_____ (< 2) _____ (3 – 7) _____ (7 +)

On a weekly basis, how often do you have five or more drinks in a row?

_____ 0 _____ 1 – 2 _____ 3 – 5 _____ 6 – 10 _____ 11 +

Hearing Screening: Pass / Fail

APPENDIX E

CONSENT FORM

CONSENT FORM

A. **Authorization**

I, __________________________, hereby authorize or direct Karen M.L. Wee , or associates or assistants of her choosing, to perform the following treatment or procedure.

B. **Description**

This is to inform you of an activity which may involve you. I, (Karen M.L. Wee), a graduate student in the Department of Communication Sciences and Disorders at the Oklahoma State University am conducting a study. I am interested in ascertaining the acoustic patterns of / r / produced by native English speakers and Mandarin speakers. I am seeking volunteers between the ages of 18 and 35 years of age. The information from this study will help speech-language pathologists in identifying speech differences of Mandarin speakers.

The study will begin with an interview and a hearing screening to determine if you meet the criteria necessary to participate in the study. If you do, you will be asked to read a list of words. Your speech will be tape-recorded. The recording procedure creates no risk and requires approximately 20 minutes.

The results of this research will be kept confidential. Each individual involved will be assigned a number. Your name will not be used. The questionnaire and subject data will be separated from the informed consent forms and there will be no way to associate the subject information data to the subjects' names. The tape-recorded samples will be kept locked in Dr. Arthur L. Pentz's office when not in use. They will not be destroyed, however, for the information collected on these tapes could prove useful in future studies of a similar nature. They will not be used for additional research without your consent. Keep in mind that no names will be used, and anonymity will be preserved.

C. **Voluntary Participation**

I understand that participation is voluntary and I will not be penalized if I choose not to participate. I also understand that I am free to withdraw my consent and end my participation in this project at any time without penalty after I notify the project director. I can contact Sharon Bacher, IRB Executive Secretary, Oklahoma State University, 203 Whitehurst, Stillwater, OK 74078. Phone: 405-744-5700.

D. Consent

I have read and fully understand the consent form. I sign it freely and voluntarily. A copy has been given to me.

Date: ______________________ Time: ______

__________________(a.m./p.m.)

Signed: ________________________

____

Signature of Subject

I certify that I have personally explained all elements of this form to the subject or his/her representative before requesting the subject or his/her representative to sign it."

Signed: ________________________

____

Project Director of his/her authorized representative

APPENDIX F

IRB APPROVAL

OKLAHOMA STATE UNIVERSITY
INSTITUTIONAL REVIEW BOARD

Date: March 6, 2000 IRB #: AS-00-117

Proposal Title: "PRODUCTION OF /R/ IN NATIVE MANDARIN SPEAKERS AND NATIVE ENGLISH SPEAKERS"

Principal Investigator(s): Arthur Pentz
Karen Wee

Reviewed and Processed as: Expedited

Approval Status Recommended by Reviewer(s): Approved

Signature:

Carol Olson, Director of University Research Compliance

March 6, 2000
Date

Approvals are valid for one calendar year, after which time a request for continuation must be submitted. Any modification to the research project approved by the IRB must be submitted for approval with the advisor's signature. The IRB office MUST be notified in writing when a project is complete. Approved projects are subject to monitoring by the IRB. Expedited and exempt projects may be reviewed by the full Institutional Review Board.

VITA

Karen M.L. Wee

Candidate for the Degree of

Master of Arts

Thesis: PRODUCTIONS OF / R / IN NATIVE MANDARIN SPEAKERS AND NATIVE ENGLISH SPEAKERS

Major Field: Speech

Biographical:

Education: Received Bachelor of Arts (4 yr. Specialist) degree in Psychology from Brandon University, Brandon, Manitoba, Canada in May, 1991. Completed the requirements for the Master of Arts degree with a major in Speech-Language Pathology in July, 2000.

Experience: Completed externships at Will Rogers Elementary and Skyline Elementary in Stillwater, Oklahoma, and Cushing Regional Hospital in Cushing, Oklahoma.

Professional Memberships: National Student Speech-Language-Hearing Association.