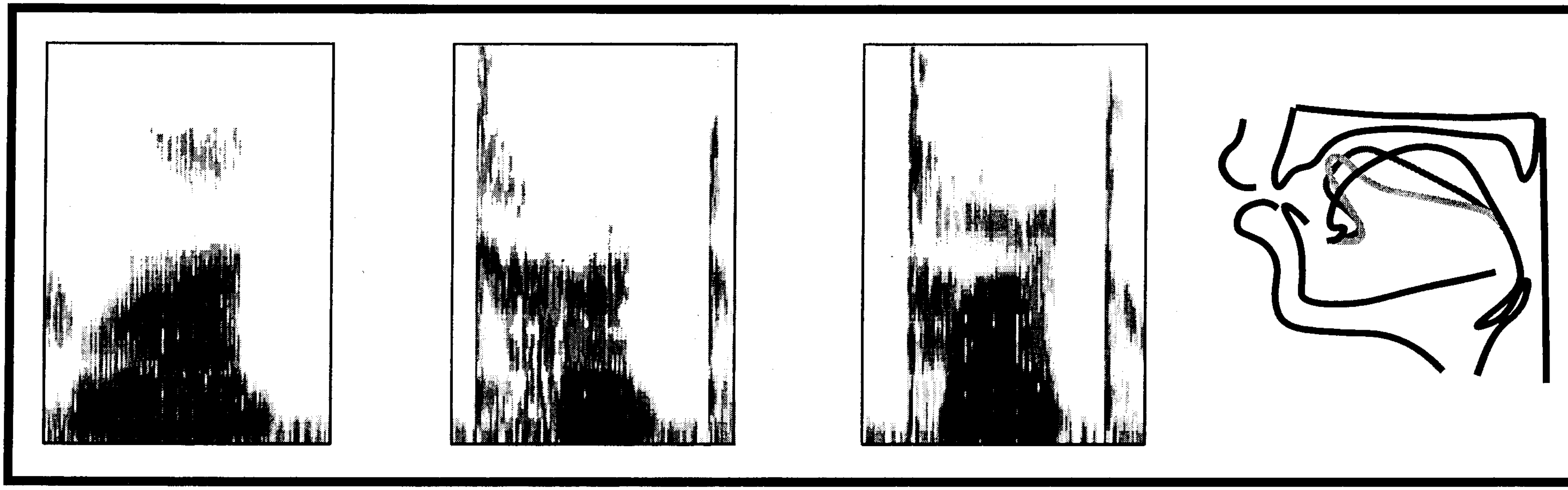
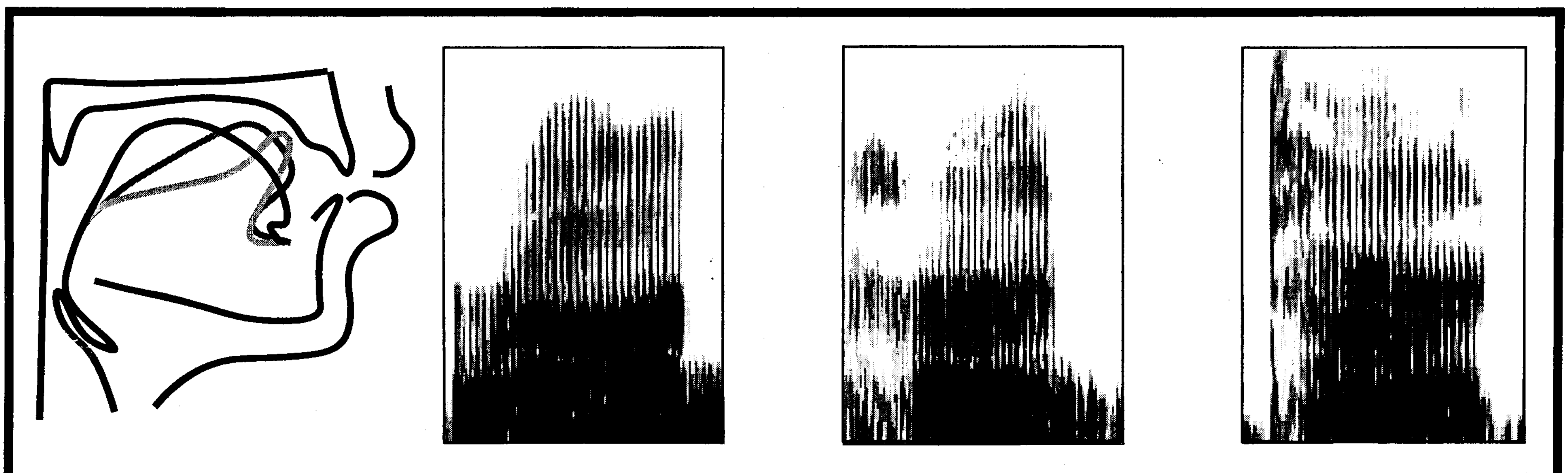


ACOUSTIC REALIZATIONS OF AMERICAN /R/ AS PRODUCED BY WOMEN AND MEN

UCLA WORKING PAPERS IN PHONETICS NO. 90

ROBERT HAGIWARA

AUGUST 1995



UCLA Working Papers in Phonetics 90

August 1995

Acoustic Realizations of American /r/ as Produced by Women and Men

Robert Hagiwara

robh@humnet.ucla.edu

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGMENTS

As in any undertaking of this sort, acknowledgments pages are at best an inadequate way to express one's gratitude to the countless individuals who assisted in many ways, large and small, to the completion of a dissertation. I single out but a few here, but I hope all will know of the intensity of my gratitude.

I want to thank my complete advisory committee, Abeer Alwan, Susie Curtiss, Vicki Fromkin, Ralph Sonnenschein, and especially Peter Ladefoged, rightly considered the world's foremost phonetician (and phonetics teacher), for their comments, criticisms, and constant support (several even in retirement).

The UCLA Phonetics Laboratory, its supporting institutions, and its director, Pat Keating, provided a well-equipped and open academic environment that encouraged free pursuit of scholarship. The lab's many members, past and present, also deserve my thanks, for their friendship as well as their scholarship. In particular, I want to thank Richard Wright, who spent one whole afternoon helping write (or writing outright) several of the CSL macros used to collect and analyze much of my data; Cheng-Cheng Tan, who rewrote the code of Plot Formants which made much of the graphical work in Chapter 2 (nearly) painless; Keith Johnson, whose many insightful comments and questions about cross-speaker variation brought many of the issues to which this research speaks to the forefront of my imagination (and whose statistical handholding at key moments kept me from imploding); Caroline Henton, whose interest in women's speech inspired my own, whose commitment to empirical research on women's speech and whose enthusiasm in the early stages of this research inspired much of the rest of the dissertation; and Suzi Fosnot, whose friendship have smoothed over several rough spots.

Other friends, near and far, also deserve special remark: Pam Munro for her unflagging (and sometimes undeserved) support; Sharon Hargus, Vi Hilbert (Taq^{w}šəblu), and Ellen Kaisse for early inspiration as a linguist; Rebecca Inman, Gary Koshi, James Walker, Clay Colwell and Sean Burger for occasional pinochle, drinks, shelter, long phone conversations, e-mail, and small adventures; Tim Beasley, Katherine Crosswhite, Susan Banner Inouye, and Richard Wright for minor distractions (critical to my sanity) at extremely late stages.

I also want to thank my parents, Patrick and Misako Hagiwara, for their boundless love, encouragement and generosity — without their emotional support and financial assistance, particularly in the last year of this work, I could never have finished this work.

"A survey of phonetic studies that had 'representative' data on vowels shows that a paltry 4% contained data from females."

— Caroline Henton, *The Abnormality of Male Speech* (1992)

"... but my feeling is that if God did not want us to make gender-based generalizations, She would not have given us genders."

— Dave Barry, *Dave Barry's Complete Guide to Guys* (1995)

Chapter 1. An introduction to the studies presented here

1.1 The importance of studying the phonetics of women's speech

The goal of phonetic theory is to describe the sounds of the world's languages, explain how they pattern, and to model both the physical and psychological structures required to produce and understand them. To that end, it is important to have data from a representative cross-section of languages, dialects, and speakers. Since the introduction of the sound spectrograph, acoustic analysis of the speech signal has been greatly enhanced, resulting in a greater understanding of the acoustic properites of speech. However information has not been acquired over the necessary cross-section of speakers. Basic acoustic information about women's voices, for instance, which are widely regarded as difficult to study spectrographically due to their relatively higher-pitched voices and broader formant bandwidths, is gravely underrepresented in the literature.

Even before the spectrograph, the phonetics of women's speech had not traditionally been an object of rigorous scientific investigation, possibly due to the relative denigration of women's issues generally. Henton (1992) discusses the relationship between attitudes about women and phonetic research.

As a result of this trend, whatever its cause, reliable data on phonetic characteristics of female speakers is hard to come by. Especially in this time of rapid advances in speech technologies, both analytical and practical, this situation can and must be remedied.

Thus, a program of research on women's speech (of which the present work is only a part) must be defined, with the following goals. First, the void in empirical phonetic data regarding the speech of adult female speakers must be filled. Second, developing and extending research into variation in phonetics as a function (in part) of speaker sex must be a priority. In particular, an attempt must be made into distinguising those differential features of men's and women's speech which follow from the sexual dimorphism of vocal tract structures (i.e. physiological differences between the sexes in vocal tract size and shape).

The present work selects American /r/ as a useful place to institute the goals of this program. American /r/ is characterized by formants and transitions, similar to vowels. Speaker sex-related differences in vowel formant frequency have long been a subject of interest, and one of few areas where a reasonable amount of knowledge about women's speech has been acquired. Thus, extending the study of American /r/ can be embarked on immediately, using standard analytical (spectrographic) techniques. Thus the following chapters seek to make explicit and to test assumptions about the acoustic properties of American /r/ as produced by women, which traditionally have not been based on empirical observation of women's voices, but extrapolated from observation of men's voices.

1.1.1. Issues in the study of the speech of women

Until relatively recently, women's voices were not included in basic phonetic research. With respect to the study of American /r/, some examples are worth noting. Lehiste (1962) collected acoustic data only from men, precluding the problem of reading women's spectrograms altogether. Delattre & Freeman (1968) collected articulatory (cineradiographic) and acoustic data from both women and men. However, they excluded the women's acoustic data from the final, published study because "... [A]s usual, details of formant patterns are more visible on men's spectrograms than women's." (p. 48) It may be worth noting that "more visible on men's spectrograms" does not seem to imply "*invisible* on women's spectrograms"; rather, only that the desired information was more trivially recoverable in one case than the other. More recently, some researchers have gathered acoustic data from both men and women, but have chosen to ignore possible sex-specific effects in the data (Espy-Wilson 1987).

More generally, female voices have often been regarded merely as deviations from a male standard, when considered at all. Obvious anatomical differences between men and women (vocal tract length, larynx size, vocal fold length), give rise to differences in acoustic detail (fundamental frequency, formant frequency, formant bandwidth, etc.) which have been widely regarded as easily scalable deviations from an established male standard (for instance, Titze 1989), in spite of evidence to the contrary (Fant 1973).

In addition to representing 'speech machines' of slightly different physiological make up, men and women also represent different speech communities. That is, it is important to bear in mind the potentially confounded factors of speaker sex and speaker gender. For the present purposes, "sex" is taken to be a biological classification, dividing speakers into two groups, male and female. Physiological differences, for instance in larynx size, are a function of sexual dimorphism. Thus some phonetic differences, such as absolute pitch range of a speaker's voice, follow from speaker sex. These kinds of differences must be distinguished from gender differences in speech, where "gender" can be seen as a social instantiation of speaker sex. For instance, it has been found that phonetic reduction occurs less often in women's speech (Byrd 1994). This fact presumably does not follow from physiological factors, and thus may be thought of as involving learned, socially-determined patterns of behavior peculiar to women and men (as social groups), rather than females and males (as a biological groups).

Many languages codify the social distinction between men and women at many different levels of the grammar, dividing syntactic structures, morphological markings, and/or vocabulary items into sets which only men or only women use. Languages may also code social differences between the genders at a measurable phonetic level — one or the other group might speak more slowly, or louder, or with some linguistically non-contrastive voice quality, or with different intonational patterns, or any number of other possible distinctions, than the other group. Speakers may thus be identified as belonging to a social class of men or to a different social class of women, in much the same way as a speaker may be identified as 'coming from New York' or 'being educated' or as being a member of any number of other social groups who can be identified by 'how they talk'.

Of course, certain features of speech, such as the absolute pitch range of a given voice, are clearly individual. Others, such as the average pitch range for a given class of voices, may be physiologically determined. Women, who as a population have shorter vocal cords than men, have on average higher pitched voices. However, while this contrast is physiologically motivated, the degree to which it is true is likely to be a matter of learned modes of behavior. The men of one group may speak using a 'higher register' of their potential range than the men of another group, or the women out of a lower range, lessening whatever physiologically motivated difference may exist. Alternatively, speakers might choose to make underlying differences more extreme for social reasons.

Thus any difference one encounters between the speech of men and that of women should be examined carefully to determine whether it involves a) a physiological constraint on the speech of one group or the other, b) a culturally-determined, learned pattern of speech behaviors, or more likely c) a combination of the two.

Such phonetic differences are of interest to a theory concerned with *universals*, which must not only establish what is the same about the speech of women and men, but also what is different. By determining which differences are inherent products of differential vocal tract physiology and which are not, it can further be determined which are products of underlying physical contraints on the form of human speech and which must be particular to the human language, and thus involve 'knowledge' at some level.

1.1.2 A brief survey of the available literature

The literature concerned with the speech of women comes from a variety of perspectives. Much is concerned with auditory 'scaling' or 'normalization', wondering how listeners, even infants, determine how to interpret a given acoustic signal based on known or presumed characteristics of the talker — that is, what features of the signal are or may be linguistically relevant. Some is concerned with producing 'acceptable' female voices through speech synthesis, or building a speech recognition system that can extract information from a variety of different voices. Relatively few studies seek to describe the empirical characteristics of a female voice *per se*, in the same way that much attention has been paid to the observable characteristics of male voices.

1.1.2.1 Vowels and physical characteristics of the vocal tract

Physiologically, women are known to have, on average, slightly shorter vocal tracts than men (men ≈16 cm, women ≈13 cm). This is illustrated in Figures 1.1 and 1.2, which are proportioned according to Fant's (1973) measurements.

However, the sex difference in vocal tract size is not proportional in all structures. Much of the difference in vocal tract length between men and women is attributable to the length of the pharynx relative to the length of the oral cavity; men have longer pharynxes in proportion to their oral cavity lengths than women. According to Fant, the adult male oral cavity length, measured from the incisors to the back wall of the pharynx, was 8.25 cm. The adult male pharyngeal length, measured from the soft palate to the level of the glottis, was 9.1 cm. The overall length of such a vocal tract, adding the lips and taking into account the curvature of the vocal tract, comes to 16 cm.

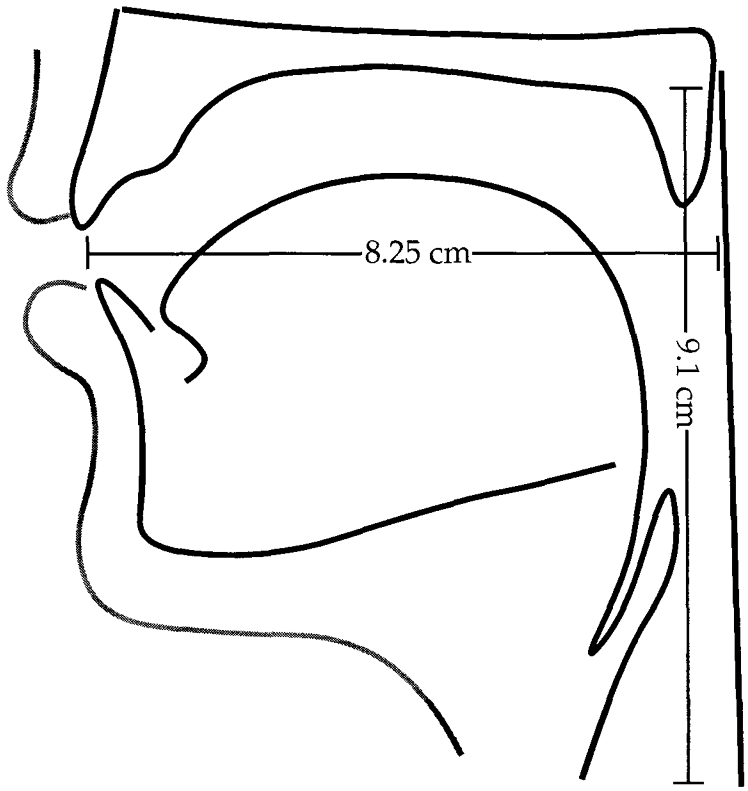


Figure 1.1. Schematic sagittal diagram of an adult male vocal tract.

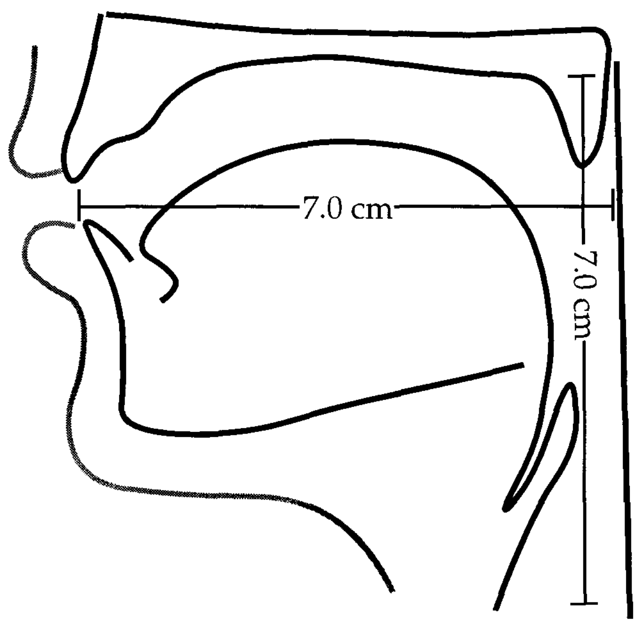


Figure 1.2. Schematic sagittal diagram of an adult female vocal tract.

The adult female vocal tract is approximately 80% of the length of the adult male's: approximately 13 cm. However, as Fant's measurements indicate, the adult female vocal tract is proportioned differently. The oral cavity length and pharynx length are both 7 cm. Thus, much more of the vocal tract length is apportioned to the oral cavity for the female than for the male.

Because women have shorter overall vocal tracts, they have different (higher) neutral formant frequencies than men. However, it is not true that women's formants are merely scaled versions of men's formants. Fant (1973) shows that, while different than men's formants, observed formant frequency differences between men and women differ not only from formant to formant, but vowel to vowel as well, and therefore a simple mathematical transform from one to the other is not possible.

Bladon, Henton & Pickering (1984) suggest that male-female vowel formant differences are to some degree attributable to learned behaviors. They argue that rather than normalizing formant frequencies (i.e. multiplying female formant frequencies by some factor and getting the corresponding male frequencies), hearers normalize spectral shapes after passing them through a mask or filter resulting in a 'smeared' spectrum. Performing these 'auditory' transformations to male and female vowel spectra yields spectral profiles which are nearly identical. Thus auditorily, what one hears as the 'same' vowel as spoken by a male and a female, can be identified as such in spite of differences in formant frequency, bandwidth, harmonic density, etc. For the speakers they studied, a one Bark negative shift was required for complete identity, but their survey of the literature shows that the degree of this shift ranges considerably (RP 1.2 Bark, Utrecht Dutch .56 Bark). Since it is unlikely that the vocal tracts of British men and women differ greatly in a way which those of Dutch men and women do not, it is probable that the differential Bark-shift magnitude is the product of learned behaviors rather than anatomical patterns.

1.1.2.2 Voice quality

Henton & Bladon (1985, 1988) discuss the incidence of creak and breathiness in the voices of British English speakers, concluding that British men (in the two dialects studied) used creak significantly more than women, to the point of some men who used creaky voice almost to the exclusion of modal voice; in contrast, women were found to use breathiness more than men. The effect is stronger in Modified Northern (MN) British English than in the dialect called Received Pronunciation (RP) (that is, MN men and women are respectively more creaky and breathy that their RP counterparts), and thus the effect clearly involves learned behaviors, although it is not clear exactly which populations are adjusting their phonatory behaviors in which directions. Whatever physiological reasons exist for creak to be the preferred alternative to modal voice in men, and breathiness in women, the degree to which this non-distinctive use of voice quality is employed must to some extent be culturally determined.

The breathiness regarded as characteristic of female voices (as indicated, for instance, by Klatt & Klatt 1990) allows resonances associated with the trachea to 'leak' into the spectrum. Klatt & Klatt (1990) regard this resonance as important in their synthesis of an acceptable female voice. Karlsson's (1991) female speaker model does not have this resonance, and accordingly Karlsson does not include it in her synthesis. Thus the presence and degree of breathiness and the accompanying acoustic consequences of such phonation in 'normal' female speech is a matter of continuing debate and requires further explicit empirical examination.

1.2.2.3. Consonants

As little as is known about the relation of women's vowels to men's, less is known about consonants. Some claims about differences that show up in men's vs. women's speech concern stops. Flege & Massey's (1980) of American English suggests that the number of women who do not prevoice is "significantly larger than the proportion of male speakers (5/20) who do not prevoice." (p.17). Prevoicing is a situation in which the vocal folds begin to vibrate prior to the release of a stop closure, particularly in English where the phonemic voiced stops are generally merely voiceless and unaspirated in initial position. Only five of the 14 women in Flege & Massey's study prevoiced their voiced stops, where 15 out of 20 men did. Thus, they conclude:

> This is consistent with the finding ... that women prevoiced somewhat less frequently than men. This sex-linked phonetic difference can perhaps be attributed to the relatively smaller vocal tract of women as compared to men. (p. 17)

However, Pat Keating (p.c.) has looked at prevoicing in the TIMIT database, and found that only 21 of 858 eligible /b,d,g/ consonants were prevoiced. Still, prevoicing of /b/ is most common, lending some credence to the notion of greater vocal tract volume contributing to the ability to prevoice. A primary component of vocal tract volume is vocal tract length, and thus men would be expected to prevoice more. (This general line of reasoning would suggest that short men and women, or more precisely men and women with comparatively short vocal tracts, should prevoice less than tall men and women respectively; this requires setting aside potentially strong socio-phonetic pressures to prevoice (or not) as a mark of gender identity.)

Moreover, contrary to Flege & Massey's finding, Keating found that approximately half (11) of the prevoiced tokens were produced by women. Thus there is much less prevoicing in the TIMIT database than might be expected, and much more of it is attributable to female speakers that Flege & Massey predict. (Because of the small numbers, Keating did not run statistical tests on the TIMIT prevoicing data, but she did not find any obvious trends in Flege & Massey's direction when controlling for dialect region.)

Because , women might be expected to release final stops more than men. Byrd (1994) investigated this claim, again using the TIMIT database. In her study, she looked at sentence final oral stops. She found that women did, in fact, release sentence final oral stops significantly more often than the men in the database. It is not clear to what degree this finding generalizes to, for instance, word- and phrase-final stops in the database as a whole.

Byrd also found that the women represented in the TIMIT database, who constitute only 31% of the speakers recorded, speak significantly more slowly than the men; one wonders if the stop-release facts might not in fact be attributable to a more careful speech style, rather than to a physiological motivation. Other differences Byrd has identified include more glottal stops and fewer flaps in appropriate environments, which may also be attributable to more careful speech by women.

Fricatives are another understudied variable in female speech. Schwartz (1968) and Ingenmann (1968) both report that speaker sex can be reliably identified from signals which consist only of (unvoiced) fricative noise. As Ingenmann found, this was not true of labial and interdental fricatives, where the frication spectrum is not filtered by cavity resonances. However, the sibilant fricatives [s] and [ʃ], in both Ingenmann's and Schwartz's studies, differed sufficiently to allow determination of speaker sex. Smith (1995) has data which suggest that the mechanism of linguistic stress has different effects on the incidence of voicing during /z/ depending on the sex of the speaker.

Resonant consonants may also show male-female differences. Keith Johnson (p.c.), as part of his work on normalization, wonders whether there is a male-female difference in nasal resonances that is statistically reliable when individual resonances vary so much. However, non-nasal sonorant consonants have never before been an object of study in female speech.

1.2. Embarking on a new research program

1.2.1 Why study non-vocalic sounds in women's speech?

Henton (1987) has suggested that research on male/female differences in consonants is likely to reveal very little of interest, at least for purposes of producing good female synthetic voices. Consonants, in particular stops, carry little linguistic information that is not represented elsewhere in the speech signal (for instance, as transitions on vowels). The proposed dissertation takes a different view, that the study of non-vowel articulations and acoustic realizations are essential if a reliable theory of linguistic phonetics is to be achieved.

While the study of acoustic *silences* in speech, such as characterize stops, would be unlikely to produce any meaningful results, the study of non-vowels should not be ignored. Properties of stops, such as burst noise, aspiration amplitude and length, etc. and fricatives are to some extent dependent on excitation of vocal tract resonances, and thus might well show sex-related differences. It seems unwise (and unscientific) to merely assume that they do not, especially given the growing body of evidence suggesting that men and women pattern differently in various articulatory and acoustic dimensions.

Even less wise would be ignoring resonant consonants. Resonants, particularly glides, are extremely vowel-like; they are characterized by formants and transitions rather than by abrupt spectral changes and discontinuities in the speech signal. Sex-related differences *have* been found for vowels, and therefore are only to be expected in (at least) the more vowel-like resonant consonants.

1.2.2 The focus of this dissertation

While there is certainly more to be discovered and discussed in the realm of voice quality and vowel spaces, this dissertation seeks to expand the existing research into women's speech by focusing on the so-called retroflex approximant [ɹ] found in American English and a handful of other languages. This sound, in American English, is unique in that it has both syllabic (i.e. vocalic) and consonantal allophones. It is extremely vowel like, being characterized by formants and transitions rather than sharp discontinuities in the speech signal, which are more characteristic of consonants (Stevens, 1980). It is therefore of an acoustic type which is likely to show physiologically motivated differences between male and female speakers. American /r/ is also, traditionally, not well understood acoustically or articulatorily, being extremely rare in the world's languages.

1.2.3 *Articulation and acoustics of American /r/*

Articulatorily, the picture is slightly more complicated. As mentioned earlier, men and women not only have different vocal tract lengths, the pharyngeal-to-oral length ratio is different for men and women. This means that the articulators are distributed differently along a resonating tube. Under Perturbation Theory, these differences could result in sex-specific differences in articulatory configuration of various sounds.

"Perturbation Theory", that is, modeling of articulation-to-acoustics as perturbations to a uniform tube and the resulting effects on the 'neutral' resonances of the tube (Chiba & Kajiyama 1941), is used by Ohala (1985), Lindau (1985), and Veatch (1991), among others, to relate the low F3 of American /r/ to the complex, triply-constricted vocal tract characteristic of this sound. A brief exposition of Perturbation Theory and its relationship to the problem of sex-specific variation follows.

Figure 1.3 illustrates a tube open at one end. If a series of pulses, i.e. phonation, is introduced at the closed (left) end of the tube, a complex standing wave will be created in the tube. The gray sinusoidal line in the figure indicates the amount of 'flow' in the tube associated with one of the components of the standing wave. The regions of peak flow (where the gray line is near the upper and lower sides of the tube pictured) correspond to the positions of 'antinodes' in the tube. Introducing a constriction near an antinode results in a lowering of the resulting formant frequency.

Above the tube illustrated in Figure 1.3 is the approximate position of various linguistically important structures in the vocal tract for male speakers. Below the tube are the approximate positions of the same articulatory structures, but for a hypothetical female speaker.

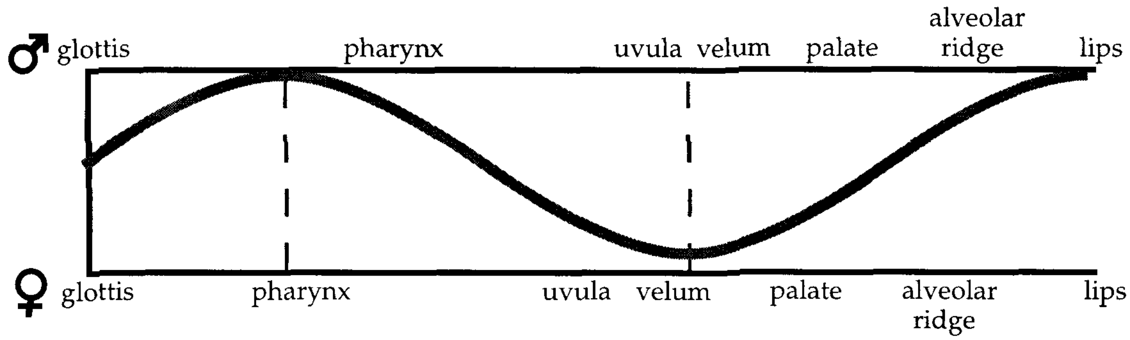


Figure 1.3. The third resonance of a hypothetical tube.

This figure illustrates the third natural resonance, that is, the component of the standing wave responsible for the third formant of the vocal tract being modeled. The figure suggests there are three ways to lower this formant: by causing a constriction at the lips (the far right of the figure, in the pharynx (in the region of the dotted line towards the left of the figure), or somewhere in the oral cavity proper. Note however the the region of peak flow in the oral cavity, designated by the dotted line to the right of center in Figure 1.3, and therefore the most efficient place to introduce such a constriction, falls in different positions in the male vs female mouth. The male must constrict in the velar-uvular region, where the female must do so more anteriorly. If, as Lindau (1985) and Veatch (1991) have asserted, Americans take every available opportunity to lower the third formant (that is, by constricting the pharynx, rounding the lips, *and* creating a constriction in the oral cavity), then it is possible, even likely, that men and women articulate this oral constriction differently.

However, Delattre & Freeman (1968) classified the articulation of American /r/ into six types, which tend to vary by speaker and prosodic position, based on cineradiographic films of some 46 speakers of various dialects of American English, both males and females. These types ranged from a very retroflex articulation to one in which the tongue tip is pointed down and the body of the tongue is retracted back and up toward the posterior palate. They discuss no sex-bias in the selection of articulatory type.

Their acoustic analysis of American /r/ concluded that formant frequency, transition length, etc. are more predictable by prosodic position (syllable initial, syllable final, position relative to stress, etc.) than by articulatory formation. This is in agreement with Uldall's (1958) study, which showed that varying articulatory formations of American /r/ produced nearly identical acoustic signals.

Sex-specific differences in the acoustics of American /r/ are expected simply because women's formants are always expected to be higher than men's. All else being equal, smaller cavities resonate at higher frequencies. Women's vocal tracts, being smaller than men's, should produce higher formant frequencies, even in American /r/. In light of the expectations of perturbation theory, and in particular the differences in optimum constriction locations (relative to articulators) between male and female vocal tracts, the details of the formant frequency differences between men's and women's productions of American /r/ may be more complicated.

On the purely acoustic side, it is frequently noted (for instance, Ladefoged 1993, Lehiste 1962, etc.) that /r/-glides in American English are characterized by lowering of the third (and other) formants, with F3 generally dropping to below 2000 Hz. It is assumed, since women's formants are generally higher in frequency than those of men, that a the third formant of an /r/ produced by a woman may not drop below 2000 Hz, but nonetheless F3 will lowered proportionally. But what is meant by 'proportional lowering'?

Put another way, if women's formant frequencies are usually higher than men's, what does that mean when the formants are lowered for linguistic contrast? Do men and women exhibit the same or different patterns of lowering for F3 of American /r/? Do men and women lower F3 to the same degree? What are the average values of the formants of /r/, and how do these differ between men and women? It is these questions that the studies presented in this work address.

1.3 Introducing the studies which follow

From the above discussion it is clear that the studies presented here represent only a small portion of the research needed to address the relevant phonetic issues. While some of the conclusions drawn from these studies will necessarily be specific to the dialect of English studied, the empirical and theoretical issues which these data inform have far-reaching consequences for the study of linguistic phonetics. Models of speech processing and of linguistic phonetic (grammatical) knowledge *must* have access to a wide range of phonetic data, including phonetic variation, if these models are to have any explanatory power. Predictions of these models must be tested against real, empirical data. Most importantly, the studies presented here seek to begin to fill the void in the knowledge concerning the phonetics of women's speech. Any theory of phonetics must be based upon and account for the phonetic facts which hold true for all (normal) speakers, rather than excluding more than half of the population (women and children) for no apparent reason.

Chapter 2 addresses the question of women's speech with study of vowel formants in a specific dialect of American English. The dialect in question is a relatively unmarked variety of southern Californian English as spoken by fifteen young adults who are similar in age, geographic and socioeconomic background, and education. The study presented in Chapter 2 is probably the first to focus on speaker-sex related differences in formant frequency in this dialect. Among the differences noted, token-to-token and speaker-to-speaker variation is in fact found to be greater among the women than the men in this study. Also, it is found that the distribution of vowel categories within the vowel space, as indicated by mean formant frequencies, differs between the men and the women. That is, the men and women of this dialect of American English do not have vowel formants which are trivially scalable variants of one another. Even sex-specific vocal-tract size factors such as described by Fant (1973) cannot completely account for these differences. It is therefore suggested that the nature of phonetic knowledge required to perform on-line vowel formant normalization in speech perception must not only contain generalizable knowledge of speech characteristics that differ as a function of speaker sex, but also specific knowlege of the nature of the linguistic forms (i.e. the acoustic range of vowel categories) being recovered from the signal.

Syllabic /r/ is the focus of the study presented in the next chapter. As a vowel of American English, the formant frequencies of syllabic /r/ forms part of the data used in Chapter 2. However, Chapter 2 focuses on the first two formants, the most important indicators of vowel category. In Chapter 3, the frequency of the third formant (F3) will be studied in detail. Using the F3 frequencies of the non-rhotic vowels as a baseline, this study will address the issue of F3 lowering for /r/. American /r/ is usually described as having an extremely low third formant. Lehiste's (1962) landmark study of /r/ only analyzed data from male speakers. The present study provides a comparison of the F3 of /r/ with that of the vowels, as well as of the F3 of men with the F3 of women.

Chapter 4 examines post-vocalic (syllable- and word-final) /r/ as produced by the same speakers as Chapters 2 and 3. It is found that in general the pattern of F3 lowering established in Chapter 3 is repeated in post-vocalic /ɹ̯/. This is not surprising, since syllabic /ɹ̩/ is derived historically from post-vocalic /ɹ̯/.

In Chapter 5, initial /ɹ/ is the focus. It is demonstrated that initial /ɹ/ is unlike syllabic and final /r/ in that the F3 frequencies associated with it are usually much lower. This establishes that the formants of /r/ are dependent to some degree on syllabic position, and that the nature of these allophones differ as a function of speaker sex.

Moving from the acoustic domain to the articulatory, the study in Chapter 6 addresses articulatory variation among the speakers studied in previous chapters. If a major articulatory correlate of /r/ in American English is a multiply constricted vocal tract, where are these constrictions are located and is there is a sex bias in the manner in which they are made? The answer to this question is of more than merely empirical interest, since the choice between the two depends on whether the speaker controls the parameters of speech in terms of articulatory or acoustic parameters, or both. If the intent is to produce a given acoustic pattern, the most efficient way for a given speaker to produce such a pattern is to some degree independent of how other speakers choose to do so. If, on the other hand, the intent is to produce recognizable *articulatory* patterns, a model in which the auditory system is flexible enough to recover such patterns from diverse acoustic signals is called for.

By inserting a probe into the mouth during articulation, a degree of articulatory variation can be observed. The probe-contact data is related to known possible articulatory configurations (Delattre & Freeman 1968; Narayanan 1995). In spite of expectations drawn from Perturbation Theory (discussed below), no sex-specific variation in choice of articulatory configuration was observed. In short, it is found that the retroflex tongue shape, supposed by Delattre & Freeman (1962), Lindau (1985), and related sources, to be rather rare, is quite common in southern California. However, speakers who emply the retroflex tongue shape appear to do so to the exclusion of other tongue shapes, where 'tongue bunchers' tend to use different tongue shapes for initial /ɹ/ than for either syllabic or final /r/.

Chapter 7 summarizes the findings of previous chapters, drawing more global conclusions than could be drawn from each study individually. Results from parallel analyses (specifically, Bark transformed formant frequencies) are addressed. Implications of the findings for phonetic theory are discussed. In particular, it is be suggested that the variation observed in the formant frequency data pose serious problems for theories of formant normalization. Further implications for language development and clinical applications are discussed briefly. Finally, it is argued in this last chapter that the nature and extent of phonetic variation, in both acoustic and articulatory domains, must be explored further before an adequate model of phonetics can be formulated and tested.

1.4 A note on phonetic symbols

Throughout this work, the use of phonetic symbols adheres as closely as possible to conventions set down by the International Phonetic Association (1993). Departures from strict IPA conventions, such as labels for the preceding-vowel category in Chapter 4, are discussed when necessary. However, some preliminary discussion of the precise symbols used for American /r/ is called for.

American /r/, considered as a category, a phonological unit, or a set of allophones will be represented with the upright lower-case /r/ symbol enclosed by slashes. Slashes are used throughout when discussing abstract phonological categories, such as American /r/, the vowel /i/, etc. Phonetic brackets are used only when discussing a particular token or the realization of a particular phonological category in real speech, such as a voiceless [ɹ̥] produced by a particular speaker, or the unrounded [ɯ] allophone of /u/ in southern California English.

When a particular allophone of /r/ is referred to, a particular symbol will be used. /r/ in initial position will be represented by the familiar turned-r symbol, as in /ɹ/. This symbol is described by the IPA as representing a coronal approximant. This symbol was deemed appropriate for several reasons. First, it is a symbol traditionally associated with American /r/ in phonetic literature. Second in Chapter 6, initial /ɹ/ is coronal for most of the speakers in the study. (Because /r/ is not always retroflex, the IPA retroflex appoximant symbol was rejected.)

To denote /r/ in syllabic position, that is, as a vowel, the turned-r symbol is modified with the subscripted vertical diacritic mark, defined by the IPA as denoting syllabicity: /ɹ̩/. This symbol was selected over other traditional symbols, such as rhotacized schwa (ɚ) and rhotacized turned-epsilon (ɝ), because it did not carry the implication of a mid-central vowel 'colored' by rhoticity. As Chapters 2 and 3 will show, syllabic /ɹ̩/ patterns with the higher-back vowels in its first and second formants.

In final position, the non-syllabic diacritic is used, as in /ɹ̯/. This is something of a departure from strict IPA conventions, but as initial and final /r/ appear to be different phonetic objects (in the sense that they are characterized by different formant frequencies, involved in different kinds and degrees of contextual effects, and only initial /ɹ/ was subject to segmental fortition — see Chapter 5), some manner of distinguishing the two was desirable. The non-syllabic mark correctly suggests a relationship between syllabic and final /r/, separate from initial /ɹ/, which other combinations of symbols and diacritical marks did not.

<u>Chapter 2. Sex differences in the southern Californian English vowel space</u>[1]

2.1 Introduction

This chapter has two immediate goals. The first is to describe sex-specific asymmetries in the distribution of vowels in the acoustic vowel space of a single dialect of American English. In general, women's formants are higher than men's. This is often regarded as a simple, linear transformation, the result of relatively shorter vocal tracts in women. Shorter vocal tracts modeled as a simple tubes produce higher neutral resonances, as predicted by general acoustic theory. Fant (1973) showed that in fact calculating women's vowel formants from men's formant frequencies was somewhat more complicated, involving different scaling factors depending on which formant is being scaled and which vowel is being calculated. Fant concluded, however, that vocal tract size factors are the fundamental determinant of relative vowel formant scaling. Comparison of Fant's data with Peterson & Barney's (1952) study of American English vowels suggests that, while non-linear and multidimensional, relationships among vowel categories are similar for men and women. The data presented in this study suggest that the situation in southern California English is still more complicated, with differential distribution of vowel categories within the men's and women's vowel spaces.

The second goal is to set up a more detailed study of variation in the formant frequencies of /r/ to follow. Syllabic /ɹ̩/ is unquestionably a vowel in this dialect of American English, but is often overlooked in descriptions of vowels. As noted by Peterson & Barney (1952) and Lehiste (1962), among others, American /r/ sounds are characterized by an extremely low third formant. However, the literature contains little discussion of the first and second formants of syllabic /ɹ/ (Peterson & Barney 1952 being a notable exception) and their relationship to the rest of the vowel space. In this chapter, the F1 and F2 values of /ɹ/ will be shown to coincide with the backer, higher vowels /u/, /ʊ/ and /o/ in this dialect. The differences in their F3 values will be seen as critical to distinguishing these vowels from /ɹ̩/. The baseline F3 values of the plain vowels will serve as the standard of comparison with the "lowered" F3 of syllabic /ɹ̩/.

---

[1]Some of the data in this chapter were presented in Hagiwara (1994b).

2.2 Procedures for the studies in this and later chapters

2.2.1 Subjects

Students at UCLA were asked to respond to a Speaker Survey Form if they were willing to participate in a phonetic study of /r/ in dialects of American English. The survey form is represented in facsimile in Appendix A. From the respondents to the survey, six men and nine women were selected for their similarity in age and geographic background. All were between 18 and 26 years of age, had lived all or most of their lives in southern California, and were monolingual. Each was compensated $10 US for participating in the study.

2.2.2 Tokens

Sixty-nine monosyllabic words were selected to illustrate the plain (non-rhoticized) vowels and three allophones of /r/ in southern California English. Thirty words illustrate plain vowels in three consonantal environments (discussed in more detail below). Three exemplify syllabic /ɹ̩/ in the same environments. These thirty-three words together form the database for the present chapter. The remaining thirty-six words illustrate initial /ɹ/ (as in 'reed' and 'rude') and final /ɹ̯/ (as in 'beer' and 'bear') and will be presented in later chapters.

Table 2.1 lists the words used to illustrate the ten plain vowels in this dialect of English (excluding diphthongs) and syllbic /ɹ̩/ in three environments: /b_t/, /t_k/, and /h_d/. Real English words and proper nouns were used; where a word of the appropriate phonological shape did not exist a word as close in shape as possible to the target was substituted, as with 'put'. The word 'hoed' was respelled as a proper noun ('Hode') to avoid its relatively odd-looking spelling.

Table 2.1. Words illustrating the 11 vowels of Southern Californian English.

beat	teak	heed
bit	tick	hid
bate	take	hate
bet	tech	head
bat	tack	had
boot	duke	hoot
put	took	hood
boat	toke	Hode (hoed)
bought	tock	hod
but	tuck	hut
Bert	Turk	herd

2.2.3 *Recording and measurement techniques*

The words presented in Table 2.1 were added to 36 others illustrating /r/ in initial and final positions. Each word was presented in the frame 'Cite ___ twice.' Each of the 69 sentences randomized together and included three times in a single recording script consisting of a total of 207. Each speaker was recorded reading from the script in a sound-treated room on professional quality equipment.

The subjects' speech was digitized from the audio cassette tape of the recording session at 10 kHz using Kay Elemetric's Computerized Speech Laboratory (CSL). Frequencies were measured for the first three formants of each syllabic nucleus in the words illustrating syllabic [ɹ̩] and other vowels. Formants were determined by simultaneous evaluation of wide band spectrograms and narrow band FFT spectra averaged over a 30 msec window through the steady state portion of the vowel (if there was one). If no steady state was present, the 30 millisecond window was placed in the center of the vowel. Bandwidths for spectrograms and narrowband spectra were varied to achieve the best formant resolution for each token. Generally, bandwidths were 200 Hz (wideband) and 59 Hz (narrowband) for men, and 293/59 Hz for women.

The spectrogram and FFT spectra were further supplemented by an LPC formant history superimposed over the spectrogram and/or an LPC slice taken in the center of the FFT window superimposed over the FFT spectrum. The number of LPC poles used varied between 10 and 14 depending on the sex of the speaker, the number of formants visible in the spectrogram, and whether or not more poles were needed to resolve two formants which were close together.

A sample CSL analysis screen is shown, considerably reduced, in Figure 2.1. Across the top of the figure is the waveform of the token BUT11.S5 (that is, the token "BUT" produced in utterance set 11, produced by Speaker 5. On the lower left is a wide band spectrogram with LPC formant history overlaid. On the lower right is the narrowband FFT spectrum and LPC slice calculated at the point marked by the cursor in the top window.

It should be noted that static formant frequencies are not necessarily the best representation of these vowels. This method of measurement facilitates comparison with other studies, notably Peterson & Barney (1952), in which similar measures were made. However, static formant frequencies do not take into account the many dynamic characteristics of vowels, such as diphthongization, vowel duration, pitch variations, etc., which may be necessary to a complete description of the vowels.

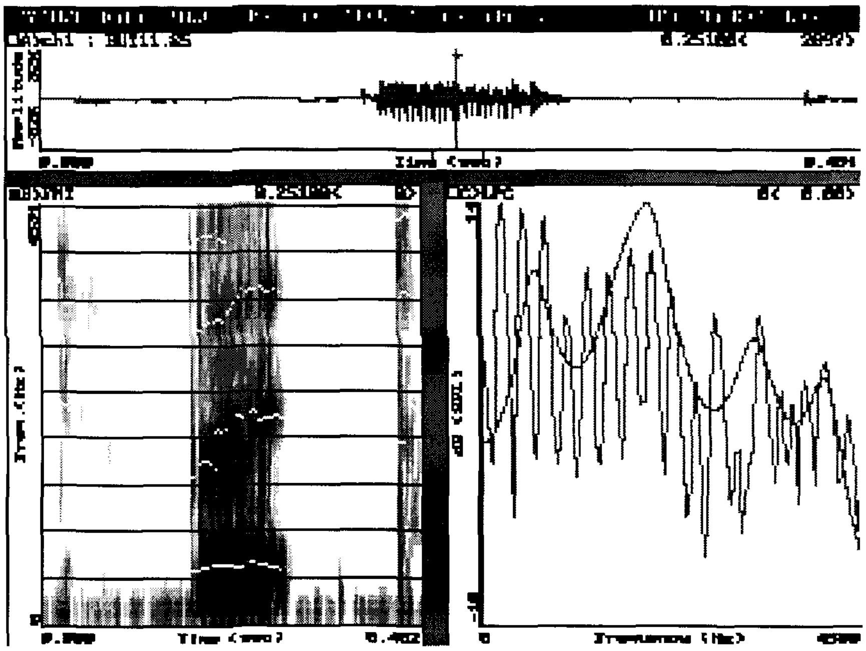


Figure 2.1. Sample analysis window.

2.3 Results

In this section, formant averages are discussed for each speaker in the study. More general conclusions to be drawn for these data are discussed in Section 2.4. In this and the following chapters, female speakers are designated numerically (i.e., Speakers 1-9, or S1-S9) and male speakers are designated alphabetically (Speakers A-F, or Sa-Sf).

2.3.1 F1xF2 vowel spaces for the fifteen speakers in this study

Speaker 1

Speaker 1's formant averages are given in Table 2.2. In the tables that follow, units are in Hertz, standard deviations are in parentheses. N=9 for each vowel unless otherwise noted.

S1's F1xF2 vowel space is illustrated in Figure 2.2. In Figure 2.2 and the figures that follow in this section, the first formant (F1) is plotted down the vertical axis and the second formant (F2) is plotted right-to-left along the horizontal axis. Units are in Hertz, but both axes are plotted in Bark distances.

Ellipses enclose areas defined by two standard deviations along the first two principal components of the distribution.

Table 2.2. Formant averages (and standard deviations) for Speaker 1.

	F1	*F2*	*F3*	
i	316 (22)	3109 (127)	3601 (344)	i
ɪ	487 (35)	2503 (61)	3309 (71)	ɪ
e	470 (45)	2778 (97)	3359 (95)	e
ɛ	932 (112)	2174 (80)	3208 (54)	ɛ
æ	1112 (45)	1912 (58)	2948 (131)	æ
u	365 (32)	1670 (396)	3169 (86)	u
ʊ	550 (66)	1759 (202)	3180 (35)	ʊ
o	587 (81)	1302 (120)	3273 (36)	o
ɑ	1004 (41)	1326 (52)	2680 (56)	ɑ
ʌ	942 (49)	1802 (170)	3037 (156)	ʌ
ɹ̩	547 (49)	1528 (59)	1925 (78)	ɹ̩

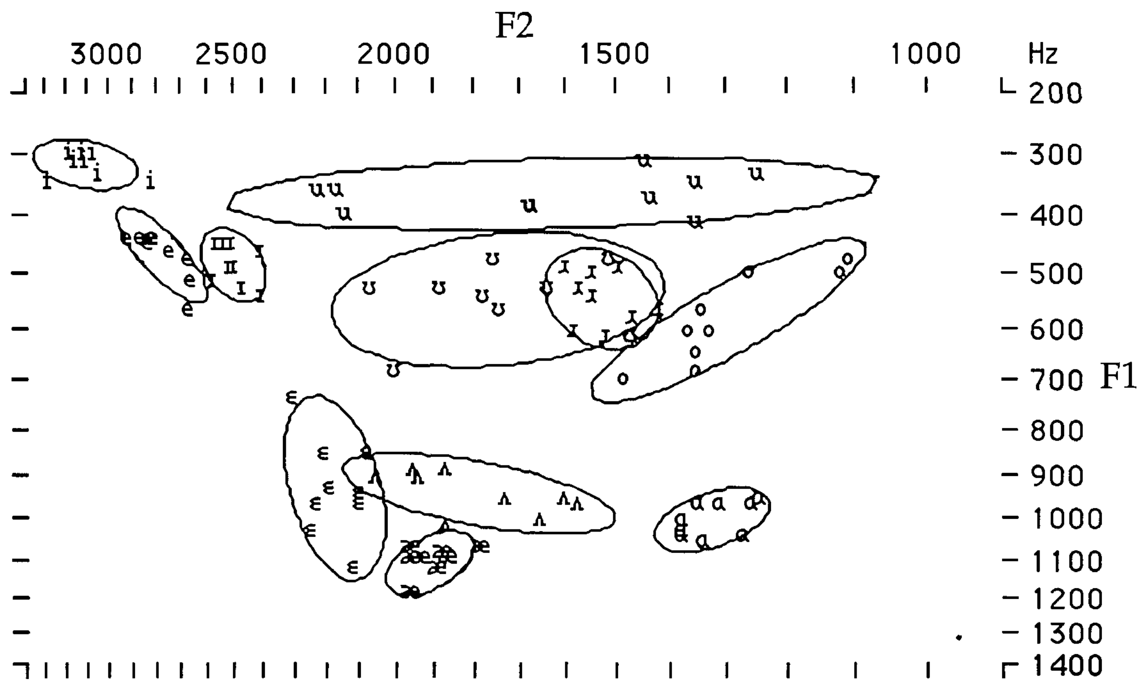


Figure 2.2. Speaker 1's vowels, plotted in an F1xF2 space.

Johnson, Ladefoged and Lindau (1993) suggested that token-to-token variation in vowel formants is quite limited within an individual speaker. For Speaker 1, this appears to be true of the /i/, /ɪ/, /ɛ/, /æ/, /ɑ/ and /ɹ̩/ categories. However the remaining five categories seem to show considerable variation. In the case of /u/, three tokens have F2 above 2000 Hz (see Figure 2.1) as a result of the fronting of /u/ after coronals. That is, this is a reflex of the /ju/ diphthong after coronals in other dialects. In the word "duke", S1 has a front on-glide, resulting in a higher measured second formant than the other /u/ tokens.

However, the remaining six /u/ tokens are still relatively widely distributed in the higher-back portion of the space. This, as well as the relatively wide distribution of /ʊ/, /ʌ/ and /o/ tokens particularly in the F2 domain, may be the result of variation in lip rounding. It is typical in southern California speech for the back vowels to be unrounded (i.e. "good" is often pronounced [gɯd]) in spontaneous speech, even though they may be fully round in isolation. In the non-natural laboratory environment, some variation in rounding may be expected. Note that in S1's /o/ category, backness and height co-vary, in the sense that the tokens with the lower F1's are also the ones with the lower F2's, suggesting a correlation between height and backing/rounding.

However, variable rounding is not a viable explanation for the relatively disparate productions of /ɛ/ for Speaker 1. /ɛ/ varies a great deal in F1.

Speaker 2

Speaker 2's formant averages (and standard deviations) are given in Table 2.3. Her F1xF2 vowel space is illustrated in Figure 2.3.

Table 2.3. Formant averages (and standard deviations) for Speaker 2.

	F1	*F2*	*F3*	
i	359 (30)	2692 (128)	3448 (110)	**i**
ɪ	494 (78)	2338 (25)	3138 (200)	**ɪ**
e	445 (35)	2626 (76)	3216 (258)	**e**
ɛ	901 (125)	2153 (58)	2975 (270)	**ɛ**
æ	1050 (34)	1650 (86)	2673 (95)	**æ**
u	364 (38)	1697 (378)	2527 (95)	**u**
ʊ	504 (48)	1652 (237)	2583 (140)	**ʊ**
o	540 (66)	1322 (75)	2528 (39)	**o**
ɑ	999 (37)	1315 (52)	2551 (106)	**ɑ**
ʌ	882 (41)	1809 (175)	2793 (247)	**ʌ**
ɹ̩	534 (97)	1419 (123)	1733 (140)	**ɹ̩**

Speaker 2 shows a similar pattern to S1, but S2 has broader variation in F1 and F2 of /ɹ̩/, resulting in greater overlap with /ʊ/ and /o/ in the F1xF2 space. She also shows more variation in F1 of /ɪ/, but less variation in F2 of that vowel.

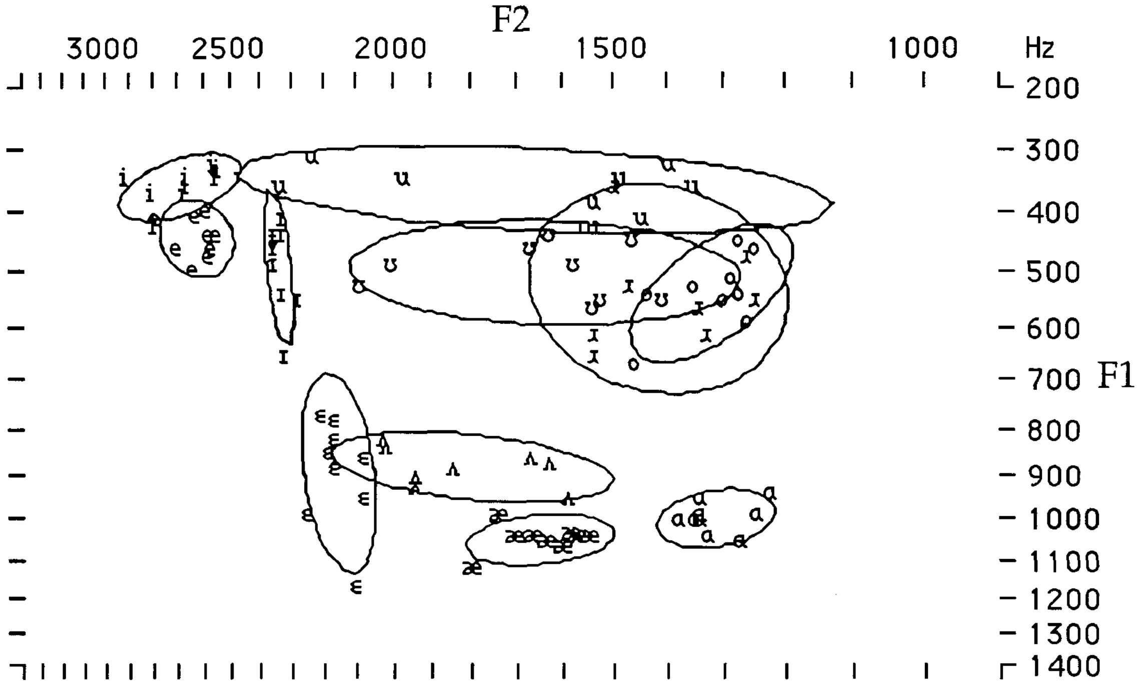


Figure 2.3. Speaker 2's vowels, plotted in an F1xF2 space.

Speaker 3

Speaker 3's formant averages are given in Table 2.4. Her F1xF2 vowel space is illustrated in Figure 2.4.

Table 2.4. Formant averages (and standard deviations) for Speaker 3.

	F1		F2		F3		
i	387	(29)	2664	(102)	3392	(231)	i
ɪ	544	(37)	2298	(59)	2960	(253)	ɪ
e	473	(17)	2567	(62)	3086	(445)	e
ɛ	927	(33)	2135	(174)	2837	(338)	ɛ
æ	1076	(35)	1652	(80)	2515	(57)	æ
u	467	(17)	1799	(323)	2697	(119)	u
ʊ	687	(122)	1601	(75)	2564	(119)	ʊ
o	723	(207)	1511	(98)	2632	(73)	o
ɑ	1014	(49)	1388	(35)	2507	(95)	ɑ
ʌ	942	(37)	1712	(97)	2656	(131)	ʌ
ɹ̩	507	(63)	1643	(96)	2141	(124)	ɹ̩

Speaker 3 is similar to the first two speakers in showing relatively little variation in many vowels. However, her /ʊ/ and /o/ categories vary widely in F1. The F1 and F2 of /o/ covary in such a way that suggests diphthongization; that is, due to the movement of the formants in /o/, S3 does not always strike the same values in the vowel center. However, the since F1 and F2 covary, this does not seem like variation in vowel quality so much as variation in the timing of the vowel (diphthong) as a whole. Unlike the previous speakers, S3's /ɛ/ category shows relatively little variation in F1, but one token of /ɛ/ has a very low second formant, producing a relatively large standard deviation in what is otherwise a vowel with relatively little variation.

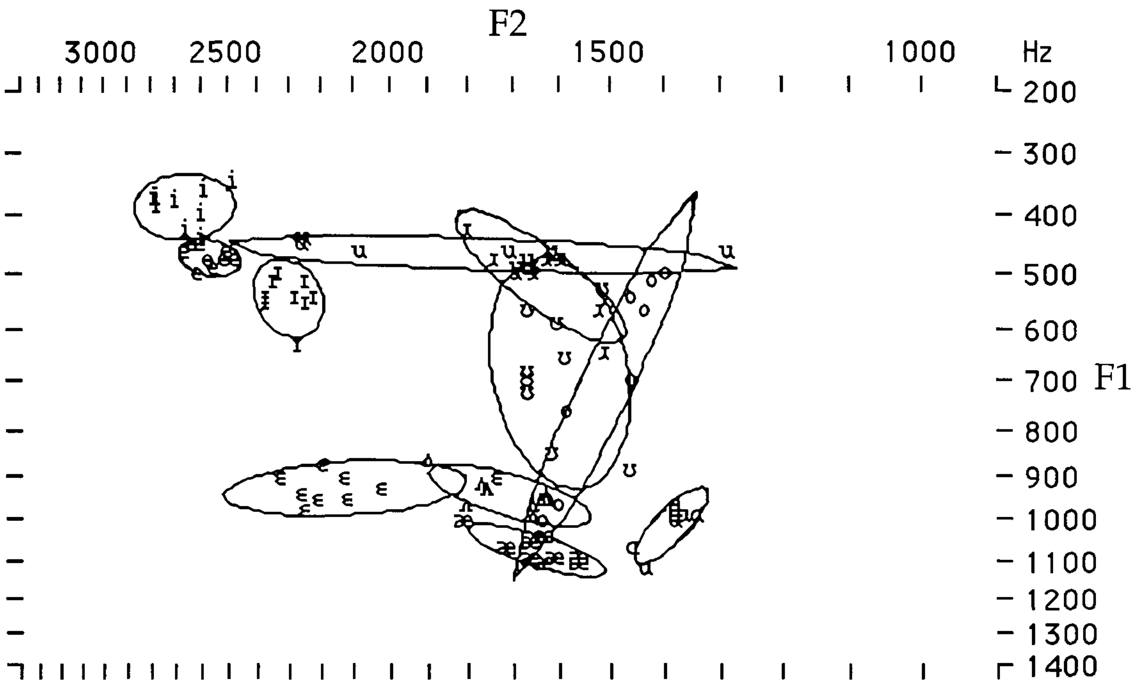


Figure 2.4. Speaker 3's vowels, plotted in an F1xF2 space.

Speaker 4

Speaker 4's formant averages are given in Table 2.5. Her F1xF2 vowel space is illustrated in Figure 2.5.

Speaker 4 shows extremely disparate tokens of /ɛ/, particuarly in comparison to /æ/, to the point that the relatively small /æ/ space is completely encompased by the /ɛ/ space. This variation is not the result of the three different contexts in which the vowel appeared; that is, it is not the case that three tokens of /ɛ/ are relatively higher than or backer than the other six. It looks almost as if S4 is producing tokens randomly in the lower-front space for /ɛ/ instead of producing a vowel with formants at particular, specific frequencies. Note also that S4 does show clear separation between the 'fronted' tokens vs the other tokens of /ʊ/, as did S1-3. S4 also differs from the preceeding speakers in that she shows very little variation in F1 of /ʊ/ and /o/. This in turn produces a clear separation of the higher vowels from the lower ones. This trend is less obvious in the preceding speakers.

Table 2.5. Formant averages (and standard deviations) for Speaker 4.

	F1	F2	F3	
i	362 (28)	2824 (66)	3569 (94)	i
ɪ	428 (39)	2433 (84)	3184 (216)	ɪ
e	412 (23)	2619 (160)	3186 (144)	e
ɛ	963 (152)	2081 (267)	2933 (263)	ɛ
æ	1079 (76)	1858 (59)	2766 (174)	æ
u	371 (27)	1482 (253)	2811 (43)	u
ʊ	419 (51)	1588 (128)	2854 (218)	ʊ
o	412 (29)	1218 (82)	2866 (69)	o
ɑ	1020 (58)	1375 (104)	2825 (150)	ɑ
ʌ	934 (96)	1674 (97)	2878 (154)	ʌ
ɹ̩	408 (33)	1389 (53)	1680 (62)	ɹ̩

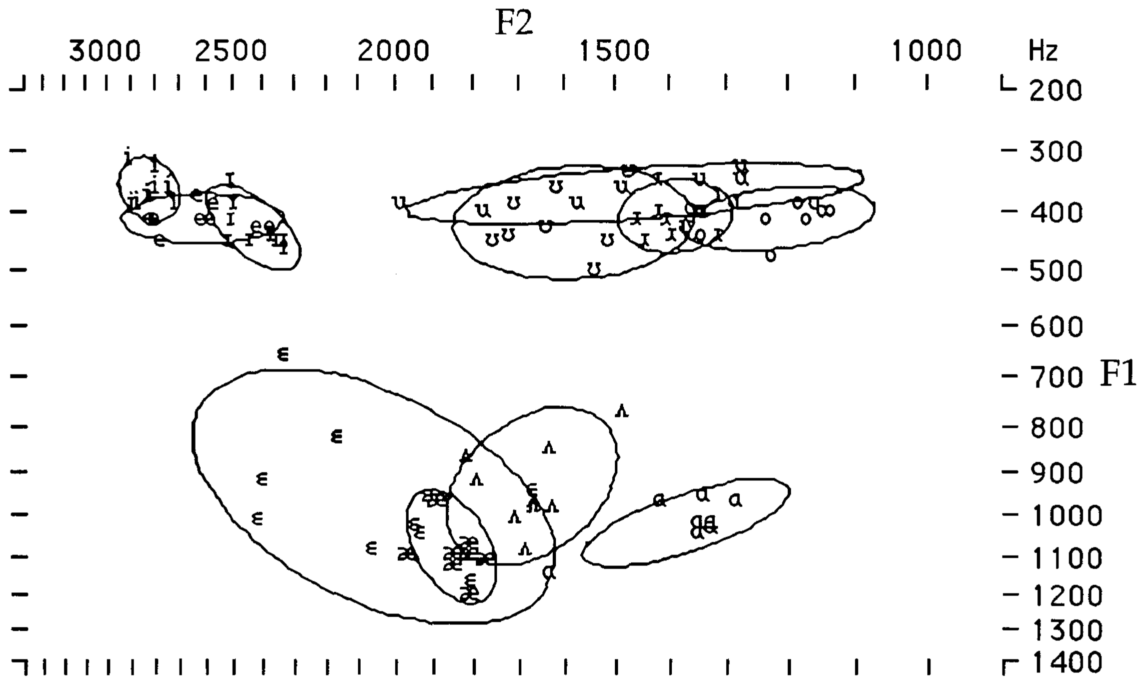


Figure 2.5. Speaker 4's vowels, plotted in an F1xF2 space.

Speaker 5

Speaker 5's formant averages are given in Table 2.6. Her F1xF2 vowel space is illustrated in Figure 2.6.

Speaker 5's /u/, /ʊ/, and /o/ tokens all have second formants above 1500 Hz, suggesting that these vowels are never fully back or round. Further, she has nearly complete overlap between her /ʊ/ and /o/ tokens whereas the preceding speakers had much more separated /ʊ/ and /o/ categories. However, these vowels could probably be distinguished by dynamic (i.e. transitional) factors not recorded in this study. Similar to S4, S5 had relatively wide variation in her /ɛ/ category. Unlike the preceding speakers, she also has a lot of variation in her /ɑ/ tokens. This may be due, at least in part, to a knowledge of a distinction between /ɑ/ and /ɔ/, which is not normally maintained in this dialect (but see Speaker E). Moonwomon (1991) discusses the phonetic maintenance (and phonological loss) of the /ɑ-ɔ/ distinction over time by English speaking women in San Francisco.

Table 2.6. Formant averages (and standard deviations) for Speaker 5.

	F1	*F2*	*F3*	
i	365 (42)	2946 (91)	3774 (126)	i
ɪ	491 (33)	2567 (107)	3719 (220)	ɪ
e	469 (71)	2813 (111)	3732 (247)	e
ɛ	691 (119)	2352 (177)	3481 (309)	ɛ
æ	961 (79)	1939 (72)	3063 (388)	æ
u	427 (41)	2163 (338)	3132 (164)	u
ʊ	543 (62)	1811 (118)	3289 (143)	ʊ
o	546 (50)	1884 (93)	3163 (211)	o
ɑ	918 (137)	1454 (118)	2931 (170)	ɑ
ʌ	733 (84)	1959 (97)	3416 (226)	ʌ
ɹ̩	544 (78)	1871 (73)	2725 (85)	ɹ̩

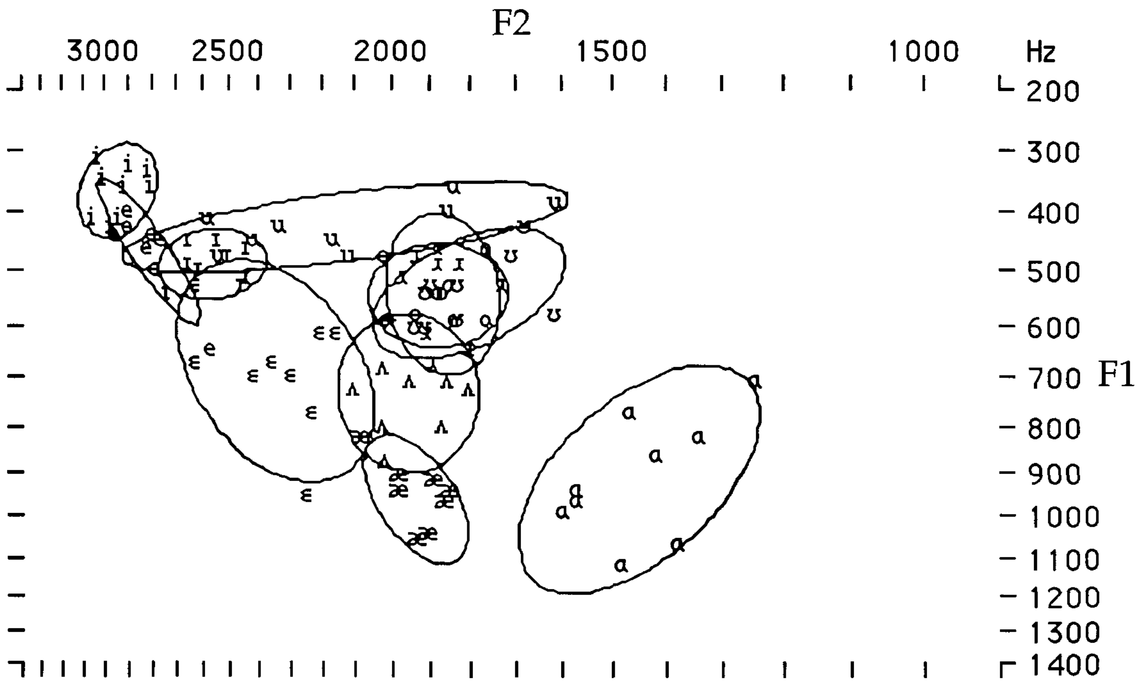


Figure 2.6. Speaker 5's vowels, plotted in an F1xF2 space.

Speaker 6

Speaker 6's formant averages are presented in Table 2.7. Her F1xF2 vowel space is illustrated in Figure 2.7.

Table 2.7. Formant averages (and standard deviations) for Speaker 6.

	F1	*F2*	*F3*	
i	400 (13)	2902 (105)	3286 (129)	**i**
ɪ	415 (20)	2561 (88)	3075 (67)	**ɪ**
e	412 (19)	2773 (70)	3219 (112)	**e**
ɛ	835 (102)	2394 (164)	3150 (95)	**ɛ**
æ	1071 (82)	1809 (108)	2942 (151)	**æ**
u	409 (18)	1615 (103)	2920 (112)	**u**
ʊ	393 (28)	1650 (182)	2916 (108)	**ʊ**
o	429 (49)	1294 (79)	3053 (70)	**o**
ɑ	1092 (59)	1501 (111)	2968 (157)	**ɑ**
ʌ	974 (133)	1751 (78)	3057 (76)	**ʌ**
ɹ̩	431 (43)	1689 (60)	2343 (87)	**ɹ̩**

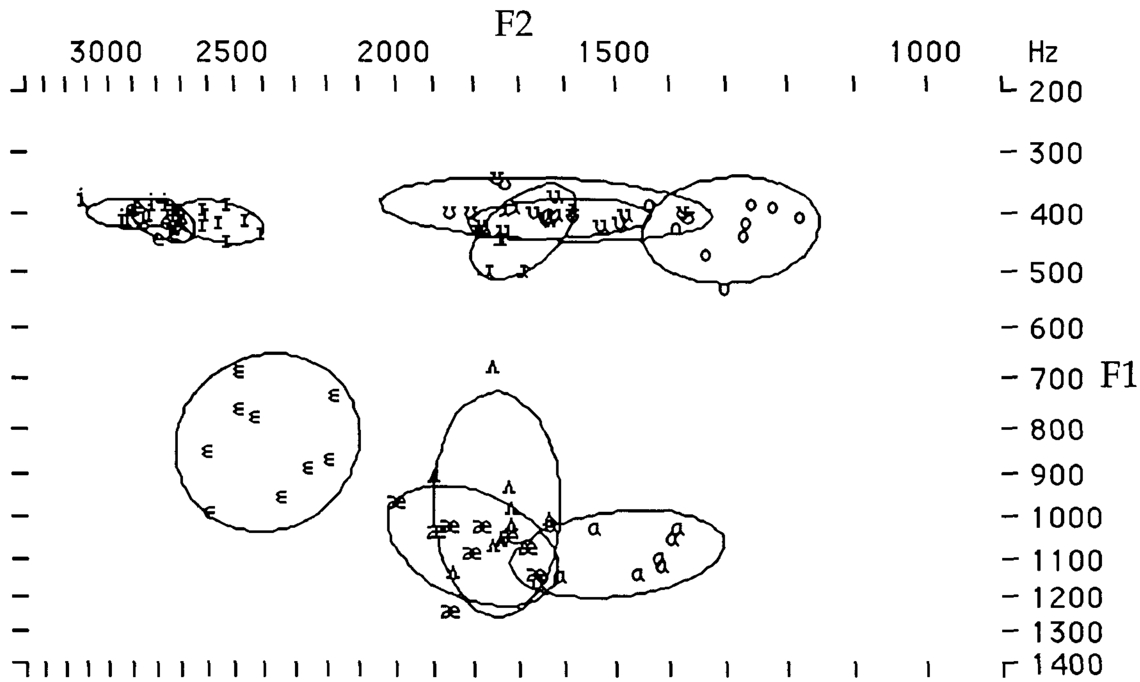


Figure 2.7. Speaker 6's vowels, plotted in an F1xF2 space.

Speaker 6 shows a clear distinction between the acoustically high vowels, including /e/ and /o/, and the lower vowels. This is an extreme realization of the general trend seen in some previous speakers: that, with the exception of some instances of /ɛ/, /o/ or /ʌ/, the women appear to avoid using the middle-frequency F1 values. In some women, such as S6, this takes the form of no measured F1 values in the middle frequencies. In others, such as S3, middle-frequency F1 values appear only in one or two categories, and not necessarily the traditionally described 'mid vowels'.

The apparent merger of the high front vowels, particularly /i/ and /e/, and to a lesser degree the high back vowels, is probably somewhat misleading. Recall that Figure 2.7 represents static formant frequencies. While this speaker's /e/ is quite high, it may be more easily distinguishable from her /i/ by virtue of its dynamic properties than their static F1 and F2 values may imply.

S6 futher illustrates the relative centrality of /æ/, seen to varying degrees in other speakers, to the point that her /æ/ category has largely merged with her /ʌ/ category insofar as mean formant frequency is concerned.

Speaker 7

Speaker 7's formant averages are presented in Table 2.8. Her F1xF2 vowel space is illustrated in Figure 2.8.

Table 2.8. Formant averages (and standard deviations) for Speaker 7.

	F1	*F2*	*F3*	
i	339 (27)	2923 (144)	3445 (265)	**i**
ɪ	394 (33)	2447 (96)	2996 (102)	**ɪ**
e	371 (25)	2744 (141)	3119 (83)	**e**
ɛ	816 (61)	2065 (205)	2879 (207)	**ɛ**
æ	1126 (99)	1711 (57)	2757 (89)	**æ**
u	355 (44)	1664 (323)	2834 (62)	**u**
ʊ	328 (48)	1581 (93)	2906 (54)	**ʊ**
o	391 (58)	1287 (73)	2840 (51)	**o**
ɑ	1068 (45)	1345 (46)	2847 (38)	**ɑ**
ʌ	951 (105)	1648 (54)	2851 (97)	**ʌ**
ɹ̩	369 (59)	1379 (49)	1670 (53)	**ɹ̩**

Speaker 7's F1xF2 space again illustrates the relatively sparse distribution of middle F1 values. That is, she distributes her vowels into two F1 ranges: the low F1 range (the high vowels, including /o/), and the high F1 range (the low vowels, including /ɛ/). She also appears to be merging /æ/ and /ʌ/, at least in terms of static formant frequencies.

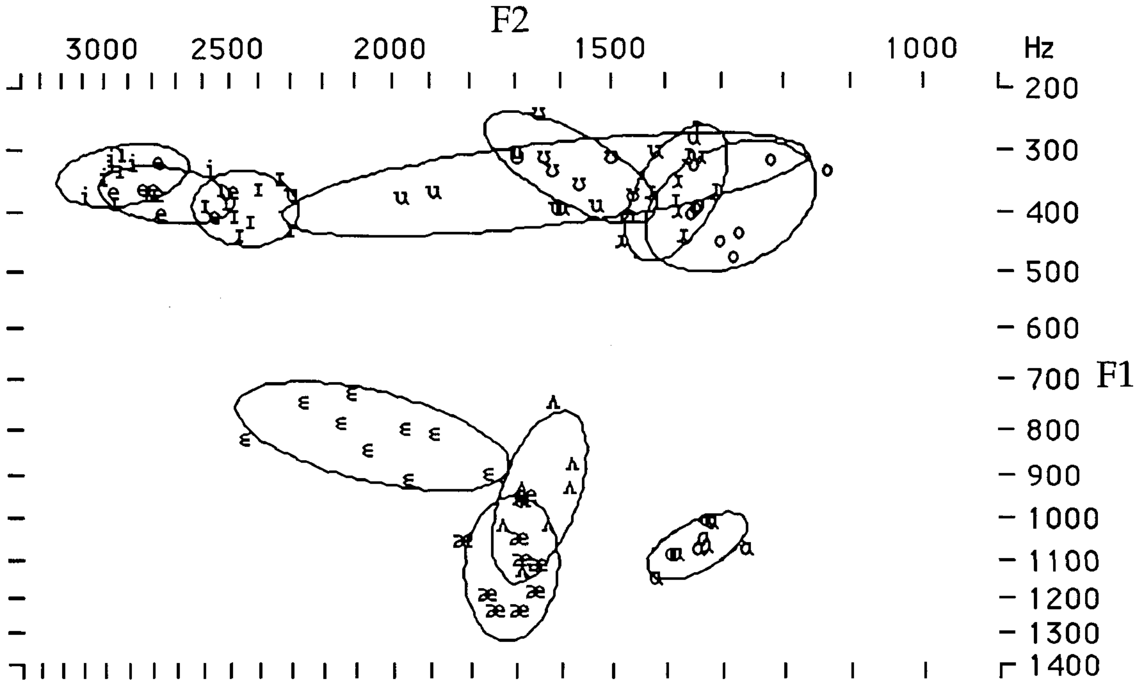


Figure 2.8. Speaker 7's vowels, plotted in an F1xF2 space.

Speaker 8

Speaker 8's formant averages are presented in Table 2.9. Her F1xF2 vowel space is illustrated in Figure 2.9. N=9 for all vowels but /ɛ/, where n=8. One token of "head" was misread as "herd" and went uncorrected until spectrographic analysis began. It was eliminated from the database.

Table 2.9. Formant averages (and standard deviations) for Speaker 8.

	F1	*F2*	*F3*	
i	348 (30)	3029 (104)	3577 (243)	i
ɪ	509 (40)	2152 (76)	3154 (81)	ɪ
e	475 (25)	2374 (229)	3196 (197)	e
ɛ	638 (57)	2008 (57)	3046 (146)	ɛ
æ	852 (127)	1942 (74)	2933 (129)	æ
u	387 (58)	1589 (425)	2959 (100)	u
ʊ	520 (29)	1647 (150)	3088 (122)	ʊ
o	522 (86)	1322 (96)	3036 (194)	o
ɑ	861 (120)	1412 (88)	2637 (140)	ɑ
ʌ	666 (50)	1733 (72)	3094 (224)	ʌ
ɹ̩	492 (28)	1570 (111)	1856 (113)	ɹ̩

Unlike the previous speakers, Speaker 8 appears to distribute her vowels more evenly through the range of F1 values. Further, the /æ/ category occupies a front position in the space, hardly overlapping with /ʌ/ in the F2 range at all.

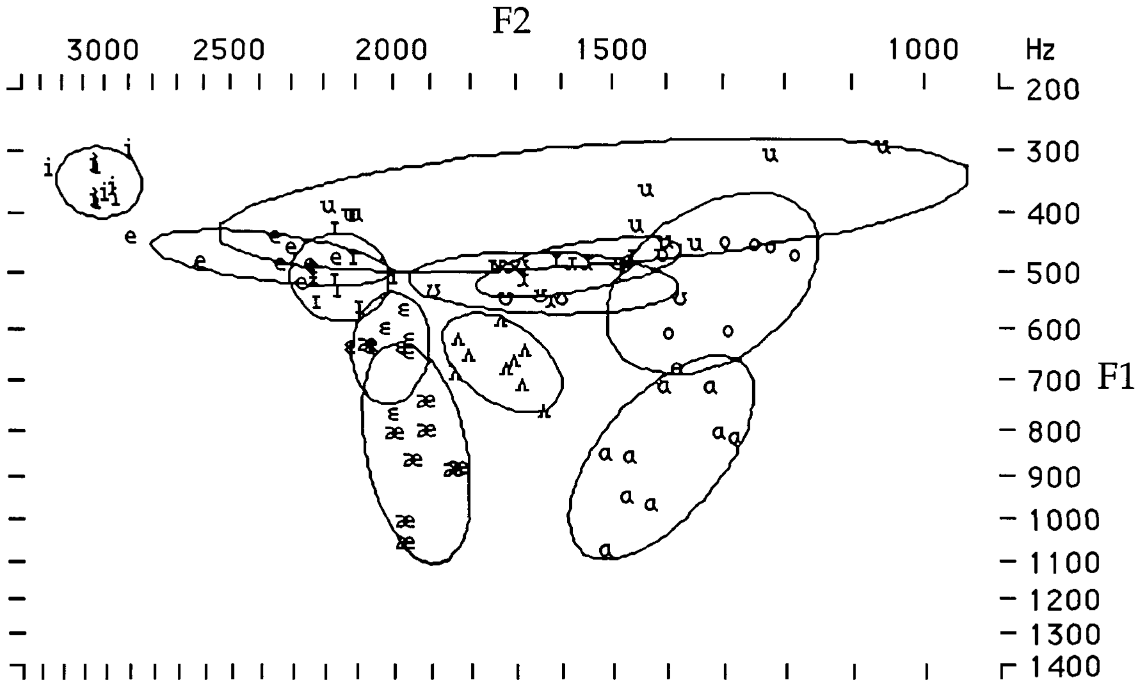


Figure 2.9. Speaker 8's vowels, plotted in an F1xF2 space.

Speaker 9

Speaker 9's formant averages are presented in Table 2.10. Her F1xF2 vowel space is illustrated in Figure 2.10.

Table 2.10. Formant averages (and standard deviations) for Speaker 9.

	F1	*F2*	*F3*	
i	386 (18)	2987 (127)	3366 (129)	**i**
ɪ	440 (40)	2301 (75)	3150 (80)	**ɪ**
e	437 (28)	2603 (204)	3151 (97)	**e**
ɛ	547 (34)	2089 (106)	3072 (162)	**ɛ**
æ	829 (143)	1817 (68)	2833 (160)	**æ**
u	411 (15)	1618 (330)	2745 (212)	**u**
ʊ	435 (16)	1697 (153)	2954 (106)	**ʊ**
o	496 (58)	1384 (140)	2741 (191)	**o**
ɑ	551 (91)	1391 (53)	2580 (155)	**ɑ**
ʌ	598 (53)	1689 (116)	3115 (94)	**ʌ**
ɹ̩	465 (38)	1530 (79)	1882 (149)	**ɹ̩**

Speaker 9's low vowels, particularly /ɑ/ and /æ/, presented ambiguous cues to the location of the first formant. The values presented above are derived primarily from low-frequency peaks in the LPC slice. The second LPC peak was often located above 1400 Hz.

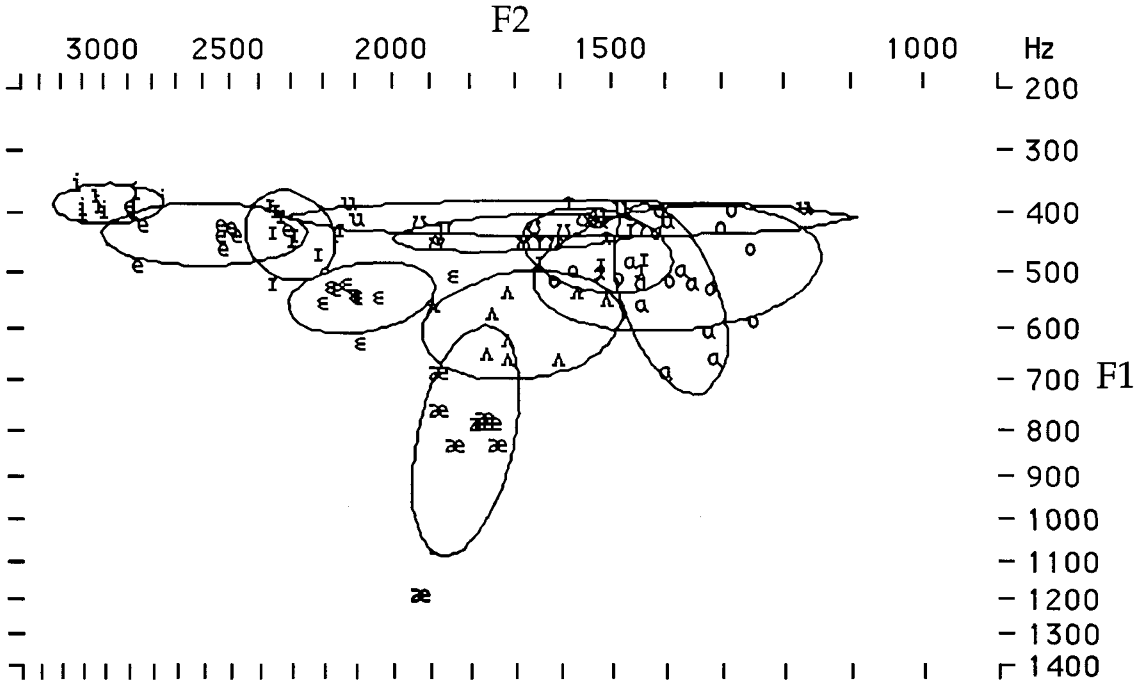


Figure 2.10. Speaker 9's vowels, plotted in an F1xF2 space.

Speaker A

As predicted by acoustic theory as well as previous research in sex-differences in vowel production (e.g. the classic studies by Peterson & Barney, 1952, and Fant, 1973, among others), Speaker A shows lower formants over all than the women speakers, resulting in a smaller overall space located slightly 'up and right' of the women's space (in an F1xF2 plot with the origin in the upper right, such as those used in this work). Sa's formant averages are given in Table 2.11. His F1xF2 vowel space is illustrated in Figure 2.11.

Table 2.11. Formant averages (and standard deviations) for Speaker A.

	F1	*F2*	*F3*	
i	262 (27)	2422 (38)	3003 (171)	**i**
ɪ	385 (21)	1831 (62)	2503 (89)	**ɪ**
e	359 (27)	2215 (135)	2643 (132)	**e**
ɛ	573 (78)	1692 (61)	2440 (113)	**ɛ**
æ	782 (94)	1636 (54)	2437 (105)	**æ**
u	286 (23)	1379 (210)	2383 (56)	**u**
ʊ	400 (17)	1306 (81)	2363 (73)	**ʊ**
o	402 (11)	1080 (57)	2450 (34)	**o**
ɑ	782 (45)	1217 (44)	2389 (74)	**ɑ**
ʌ	611 (73)	1414 (94)	2372 (77)	**ʌ**
ɹ̩	416 (25)	1321 (60)	1656 (29)	**ɹ̩**

Speaker A shows very little variation in F1 in the higher vowels, but more in /ɛ/, /æ/ and /ʌ/. Some variation in F2 is observable in several vowels, but not to the degree as in /u/, which is primarily the product of fronted /u/ after coronals.

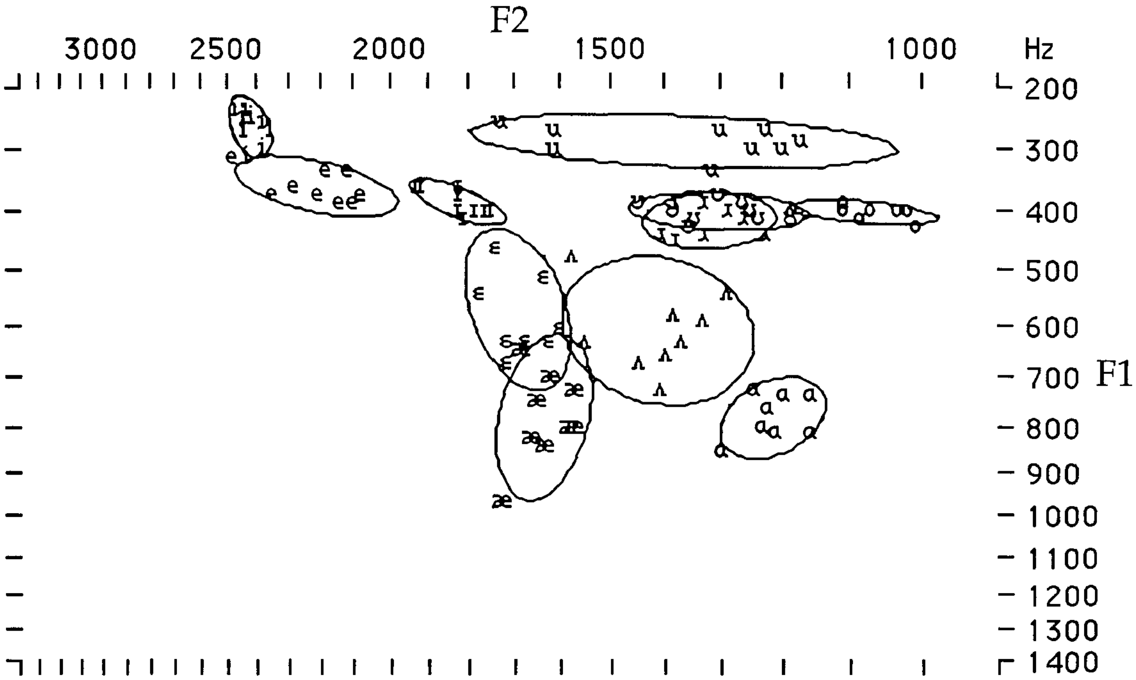


Figure 2.11. Speaker A's vowels, plotted in an F1xF2 space.

Speaker B

Speaker B's formant averages are given in Table 2.12. His F1xF2 vowel space is illustrated in Figure 2.12.

Table 2.12. Formant averages (and standard deviations) for Speaker B.

	F1	*F2*	*F3*	
i	293 (21)	2710 (62)	3251 (100)	i
ɪ	398 (27)	1866 (38)	2651 (45)	ɪ
e	386 (31)	1967 (64)	2629 (89)	e
ɛ	498 (37)	1727 (26)	2620 (52)	ɛ
æ	532 (13)	1640 (44)	2740 (302)	æ
u	323 (29)	1545 (216)	2665 (354)	u
ʊ	428 (13)	1500 (63)	2606 (135)	ʊ
o	418 (13)	1338 (128)	2442 (253)	o
ɑ	548 (52)	1226 (59)	2564 (155)	ɑ
ʌ	509 (41)	1540 (64)	2570 (53)	ʌ
ɹ̩	396 (13)	1439 (54)	1725 (55)	ɹ̩

Speaker B shows verly little separation of vowels in the F1 dimension, producing relatively high first formant values even for the 'low' vowels /ɑ/ and /æ/. That is, Sb does not appear to exploit as full a range of first formant values as possible. The unusually high F2 of /i/ is consistent across tokens, and may represent an idiosyncratic zero of the natural second formant in this speakers voice; that is, this measured formant may be his natural third formant.

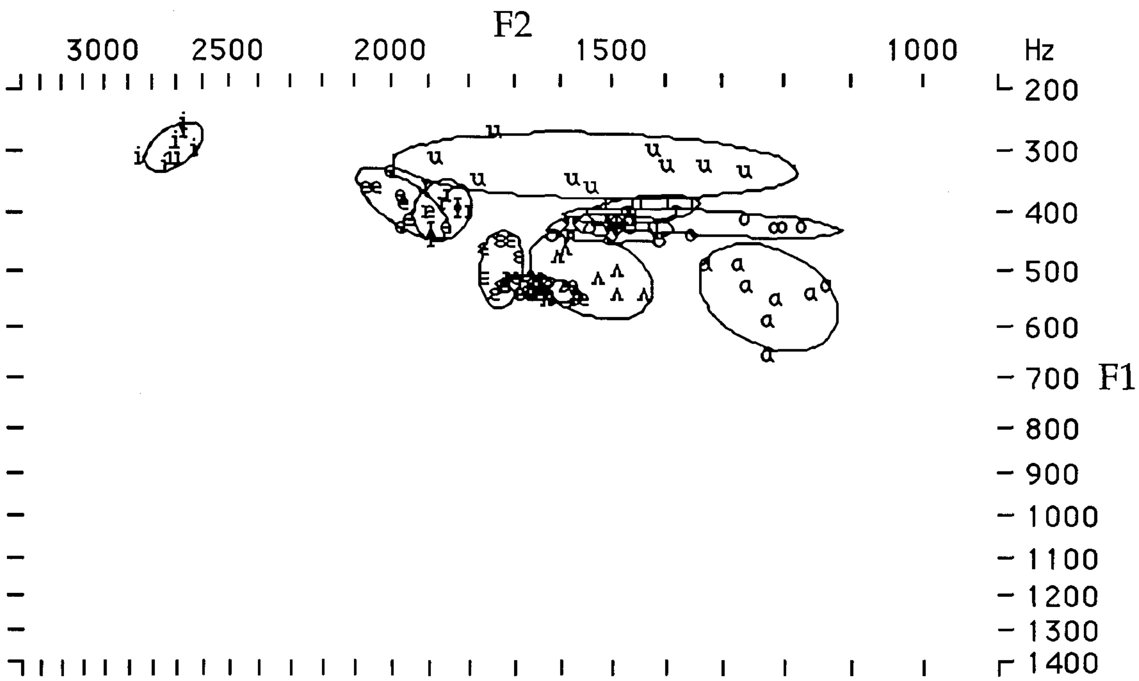


Figure 2.12. Speaker B's vowels, plotted in an F1xF2 space.

Speaker C

Speaker C's formant averages are given in Table 2.13. His F1xF2 vowel space is illustrated in Figure 2.13.

Table 2.13. Formant averages (and standard deviations) for Speaker C.

	F1	*F2*	*F3*	
i	296 (30)	2216 (42)	2858 (76)	i
ɪ	406 (19)	1829 (82)	2670 (103)	ɪ
e	412 (37)	2007 (91)	2884 (235)	e
ɛ	530 (48)	1676 (51)	2632 (142)	ɛ
æ	644 (63)	1639 (65)	2761 (432)	æ
u	336 (21)	1412 (243)	2409 (163)	u
ʊ	437 (22)	1385 (132)	2548 (228)	ʊ
o	435 (25)	1128 (51)	2629 (357)	o
ɑ	719 (31)	1235 (62)	2369 (313)	ɑ
ʌ	551 (60)	1399 (50)	2673 (399)	ʌ
ɹ̩	429 (41)	1335 (61)	1656 (22)	ɹ̩

With the exception of the fronted /u/ tokens and the variation in F2 of /ʊ/, there does not appear to be anything particularly odd or remarkable in the vowels of Speaker C.

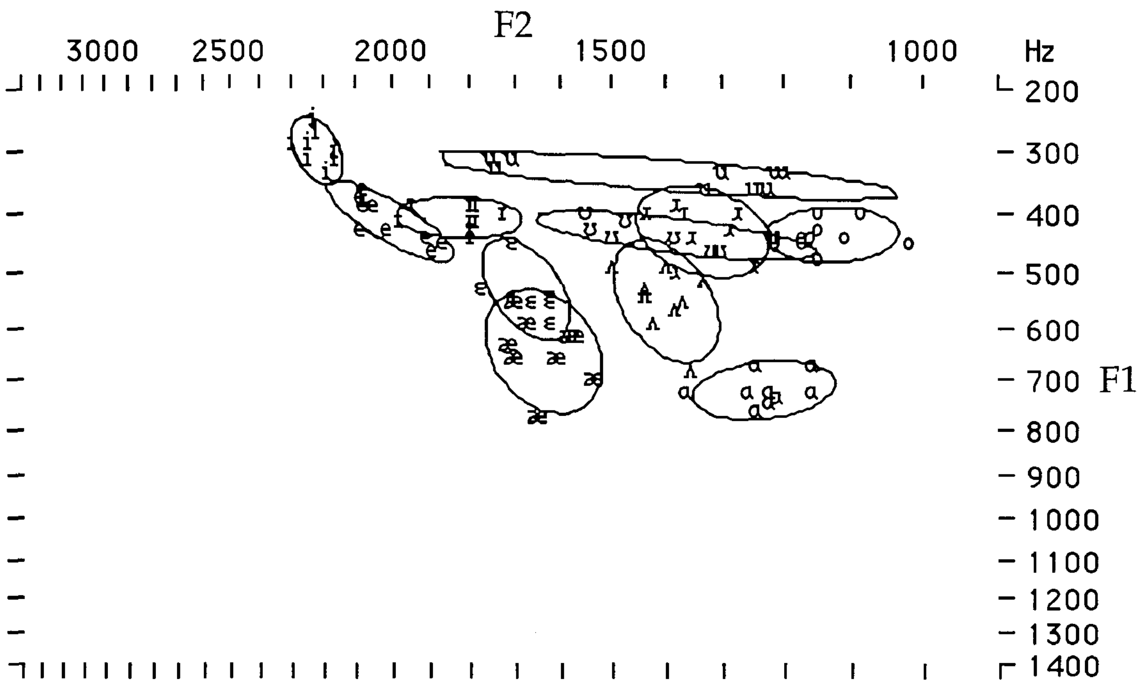


Figure 2.13. Speaker C's vowels, plotted in an F1xF2 space.

Speaker D

Speaker D's formant averages are given in Table 2.14. His F1xF2 vowel space is illustrated in Figure 2.14.

Table 2.14. Formant averages (and standard deviations) for Speaker D.

	F1	*F2*	*F3*	
i	273 (9)	2160 (31)	2736 (105)	i
ɪ	450 (18)	1765 (86)	2518 (63)	ɪ
e	432 (32)	1972 (111)	2571 (73)	e
ɛ	522 (57)	1633 (50)	2457 (74)	ɛ
æ	704 (55)	1563 (42)	2428 (59)	æ
u	318 (21)	1366 (211)	2256 (59)	u
ʊ	447 (6)	1401 (66)	2339 (87)	ʊ
o	455 (38)	1170 (58)	2314 (47)	o
ɑ	754 (34)	1269 (35)	2362 (83)	ɑ
ʌ	601 (44)	1445 (41)	2401 (92)	ʌ
ɹ̩	457 (22)	1448 (63)	1788 (88)	ɹ̩

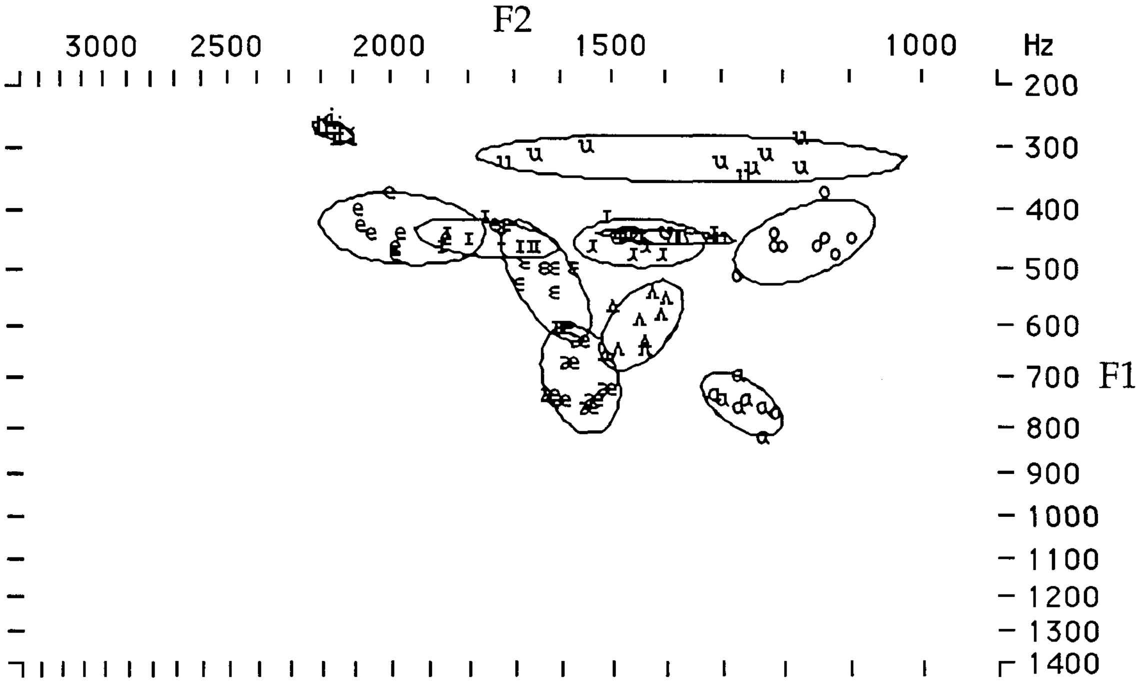


Figure 2.14. Speaker D's vowels, plotted in an F1xF2 space.

Speaker D's vowel space is generally similar to Sc's.

Speaker E

Speaker E's formant averages are given in Table 2.15. His F1xF2 vowel space is illustrated in Figure 2.15.

Table 2.15. Formant averages (and standard deviations) for Speaker E.

	F1	*F2*	*F3*	
i	333 (22)	2346 (118)	2846 (269)	**i**
ɪ	468 (25)	1709 (63)	2571 (163)	**ɪ**
e	442 (48)	2077 (151)	2676 (54)	**e**
ɛ	594 (56)	1602 (55)	2509 (156)	**ɛ**
æ	782 (25)	1557 (41)	2425 (70)	**æ**
u	357 (9)	1364 (170)	2500 (52)	**u**
ʊ	502 (45)	1298 (85)	2493 (131)	**ʊ**
o	487 (28)	1194 (63)	2496 (77)	**o**
ɑ	727 (126)	1202 (116)	2430 (56)	**ɑ**
ʌ	670 (44)	1355 (62)	2428 (87)	**ʌ**
ɹ̩	477 (41)	1306 (41)	1689 (48)	**ɹ̩**

Speaker E's /ɛ/ tokens are fairly broadly scattered, unlike this vowel for the other men (Sa-d). This does not appear to be particularly the result of phonological context. Like female Speaker 4, Se does not appear to clearly differentiate fronted /u/ in "duke" from the other, more back /u/ used in "hoot" and "boot". Se is the only speaker in this study who claimed to maintain a consistent distinction between the /ɑ/ of "tock" and "hod" and the vowel in "bought", which for Se should be transcribed as [ɔ]. It may be misleading to collapse Se's /ɑ/ and /ɔ/ categories, but no more so than to discard his productions of [ɔ]. Again, see Moonwomon (1991) for a discussion of these two categories in an apparently related dialect.

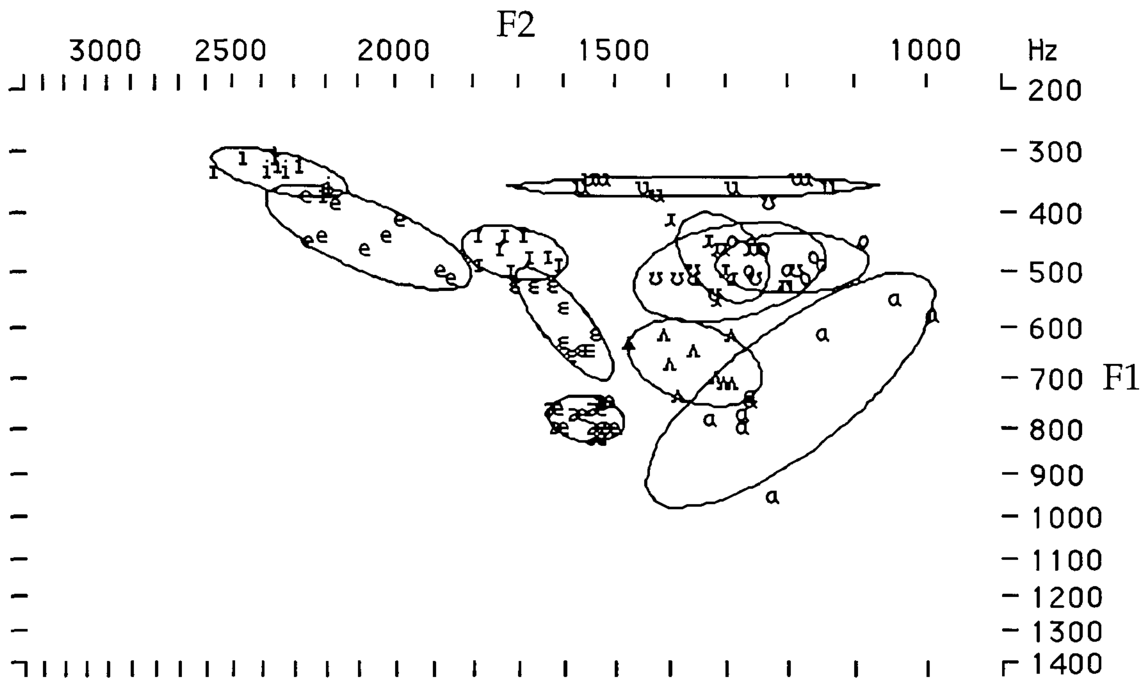


Figure 2.15. Speaker E's vowels, plotted in an F1xF2 space.

Se shows wider covariation in F1 and F2 of /ɛ/ than many of the other speakers, but this variation occurs for the most part outside the areas bounded by other vowel categories. That is, it does not lead to any overlap with other categories.

Speaker F

Speaker F's formant averages are presented in Table 2.16. His F1xF2 vowel space is illustrate in Figure 2.16.

Speaker F shows a large variance in F2 values of /ʊ/ and /o/, resulting in nearly complete overlap of those two categories.

Table 2.16. Vowel formants (and standard deviations) for Speaker F.

	F1	*F2*	*F3*	
i	290 (18)	2174 (102)	2826 (38)	i
ɪ	401 (16)	1845 (68)	2618 (115)	ɪ
e	386 (20)	2114 (93)	2739 (161)	e
ɛ	459 (35)	1693 (75)	2511 (180)	ɛ
æ	668 (84)	1568 (32)	2351 (93)	æ
u	320 (29)	1437 (238)	2181 (278)	u
ʊ	430 (31)	1306 (157)	2327 (136)	ʊ
o	425 (25)	1220 (136)	2252 (89)	o
ɑ	731 (45)	1179 (46)	2316 (156)	ɑ
ʌ	502 (60)	1338 (28)	2530 (184)	ʌ
ɹ̩	398 (15)	1324 (54)	1562 (90)	ɹ̩

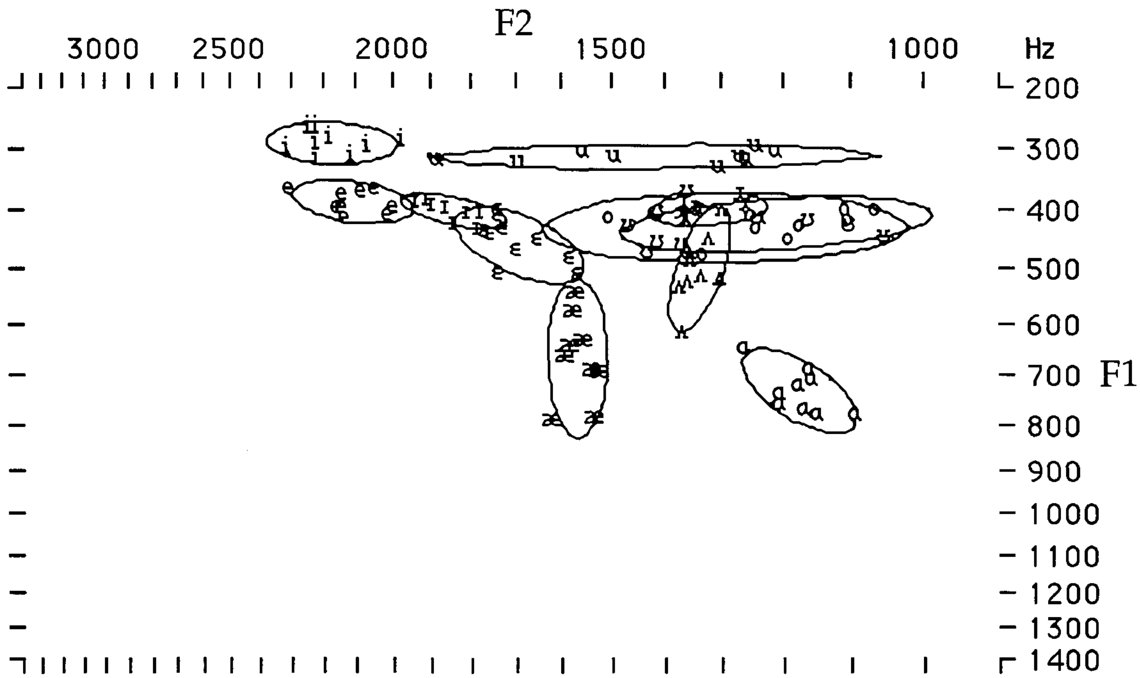


Figure 2.16. Speaker F's vowels, plotted in an F1xF2 space.

2.3.2 Summary of F1xF2 vowel space results

Table 2.17 summarizes the first and second formant frequency measurements (averages and standard deviations) for the speakers in this study. In each column, the average for female speakers is given on the left, and for males on the right. (Speaker 9's F1 values of /ɑ/ were excluded from this analysis.)

These averages and distributions are presented graphically in Figure 2.17. Figure 2.17 illustrates the F1xF2 vowel space determined by the women's formant data and the F1xF2 space determined by the men's data.

Table 2.17. First and second formant averages (and standard deviations).

	F1			F2		
	W	*M*		*W*	*M*	
i	362 (36)	291 (31)	i	2897 (176)	2338 (205)	i
ɪ	467 (62)	418 (36)	ɪ	2400 (151)	1807 (85)	ɪ
e	440 (48)	403 (43)	e	2655 (187)	2059 (138)	e
ɛ	808 (167)	529 (68)	ɛ	2163 (195)	1670 (67)	ɛ
æ	1017 (134)	685 (105)	æ	1810 (131)	1601 (59)	æ
u	395 (48)	323 (31)	u	1700 (364)	1417 (215)	u
ʊ	486 (115)	441 (40)	ʊ	1665 (166)	1366 (122)	ʊ
o	516 (130)	437 (37)	o	1391 (212)	1188 (118)	o
ɑ	997 (102)	710 (97)	ɑ	1390 (99)	1221 (69)	ɑ
ʌ	847 (154)	574 (80)	ʌ	1753 (140)	1415 (88)	ʌ
ɹ̩	477 (82)	429 (40)	ɹ̩	1558 (170)	1362 (79)	ɹ̩

As can be seen in Figure 2.17, the women in this study appear to vary a great deal more than the men. However, much of that impression is the result of the large standard deviations associated with the /ɛ/ and /o/ categories, than other vowels. The comparatively large variations in /ɛ/ and /o/ are more important, reflecting as they do real variation within and across speakers. Speaker 4 in particular seemed not to have an /ɛ/ target, in the way she clearly had one for /i/.

Among the men, however, the disagreements appear to be a matter of individual detail among specific targets. True, some men varied one formant of one vowel while others varied another, but this kind of disagreement among speakers was relatively small. Each of the male speakers appears to have settled, more or less, on some kind of acoustic target for each vowel, and the variation among them is mostly a matter of individual differences, or of token-to-token variation in the timecourse of formant movements across vowels, resulting in apparent steady states at different points during the vowel or of different formant values at vowel center.

However, in the /ɛ/ and /o/ categories many of the women appear *not* to have settled on a particular target, resulting in wider variation overall for /ɛ/ and /o/. The female speakers (S1-9) seemed to disagree even on the relative stability of particular formants. Recall Speaker 3, whose F2 of /ɛ/ varied more than her F1, where Speakers 1 and 2 had more variation in F1 than F2. Like the men (Sa-e), the female speakers *have* selected individual targets for /i/, which vary little from one speaker to the next, resulting in relatively smaller standard deviations.

It should be noticed that with the exception of S8, the women's vowel data suggests a trend skewing F1 values away from the 'middle' frequencies, resulting in relatively sparse distribution of vowel tokens in the mid-vowel range. That is, the 'mid' vowel categories /e/, /ɛ/, and /o/ get displaced either toward the high-vowel range or toward the low-vowel range. None of the men appeared to use this pattern.

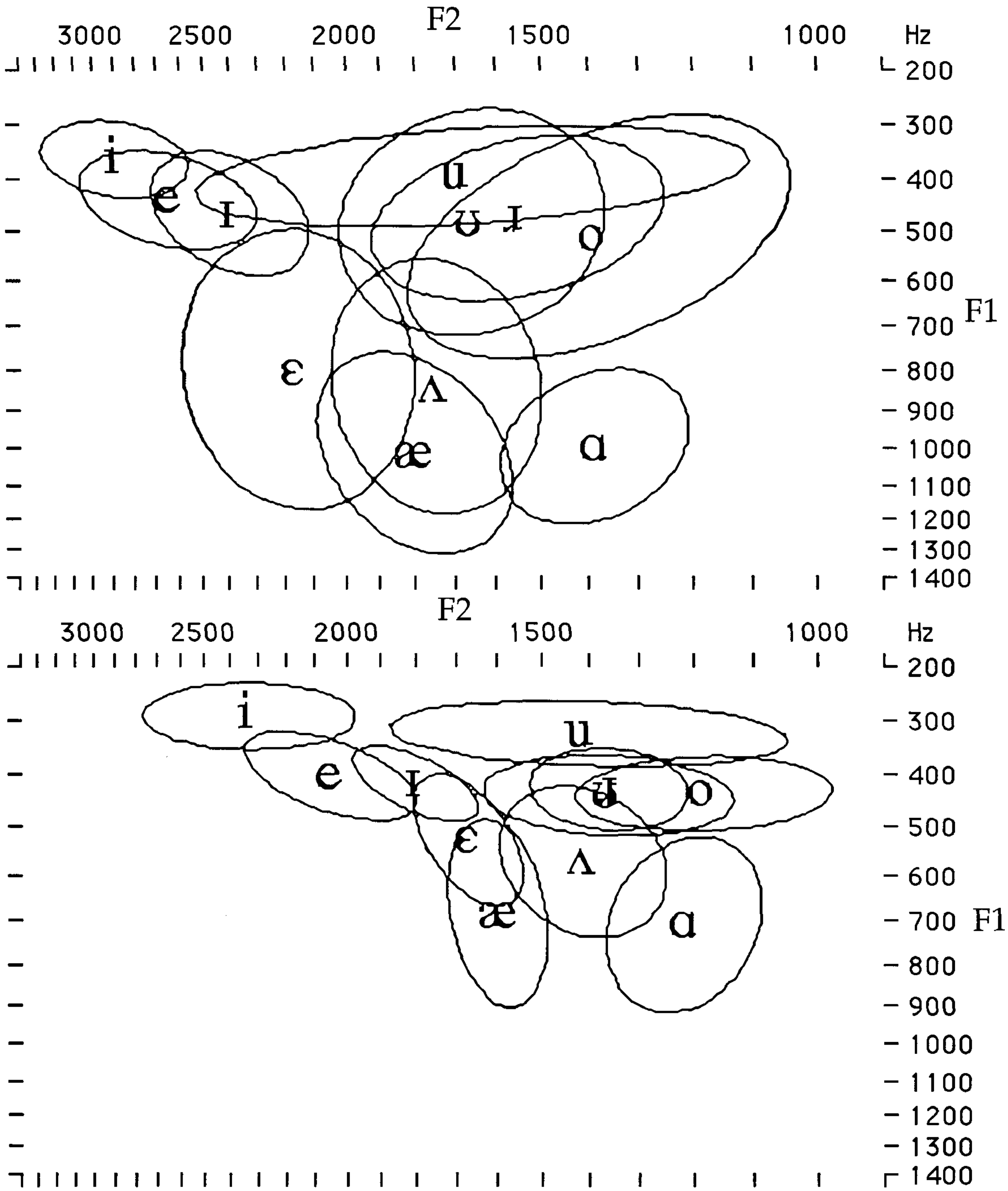


Figure 2.17. The women's F1xF2 vowel space (top) and the men's F1xF2 space (bottom). Ellipses enclose regions determined by two standard deviations. S9's /ɑ/ vowel is excluded from this plot. Note the near coincidence of the /ʊ/ and /ɹ̩/ category centers.

Statistical tests run on the formant data will be discussed in more detail later.

2.3.3 The vowels and F3

Vowels are often described in terms of the frequencies of the first two formants. As can be seen in the data above, the first two formants are insufficient to distinguish /ɹ̩/ from the other back round vowels. However, American /ɹ/ is generally regarded as distinguished by its third formant. The formant tables for the individual speakers above make it clear that the third formant of /ɹ̩/ is generally quite a bit lower than for the other vowels. This is further illustrated graphically in the following figures. Figures 2.19 through 2.27 illustrate the women's F1xF3 spaces.

Speaker 1's third formant is relatively stable for the plain vowels, suggesting little interaction with other formants (Figure 2.18). Her F3 of /ɹ̩/ is usually more than a thousand Hz lower than in plain vowels. The third formant of /ɹ̩/ regularly appears below 2000 Hz.

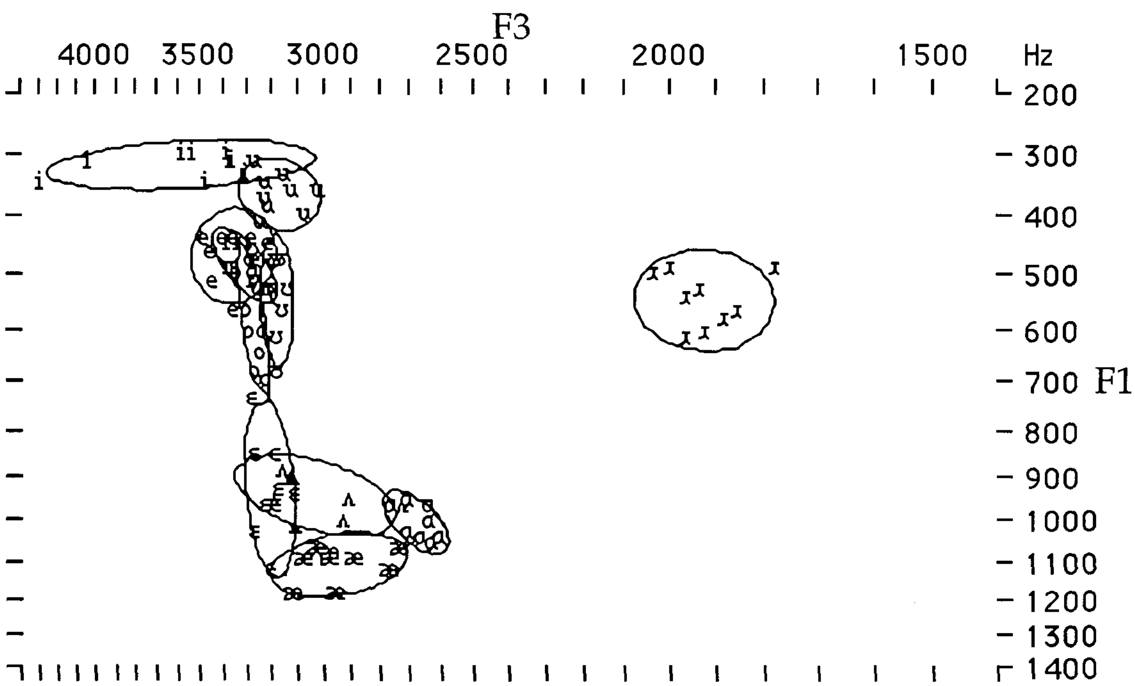


Figure 2.18. Speaker 1's vowels, plotted in an F1xF3 space.

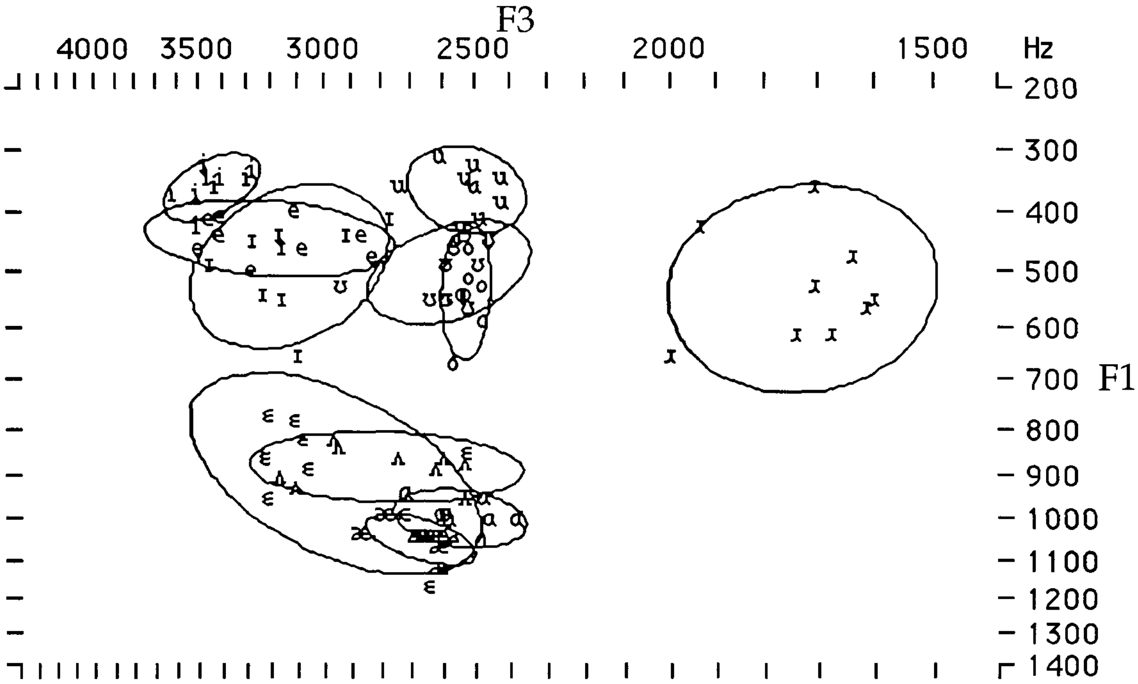


Figure 2.19. Speaker 2's vowels, plotted in an F1xF3 space.

Speaker 2's F3 offers a different pattern than S1's (Figure 2.19). S2's F3 appears to correlate with her F2; front vowels /i, ɪ, e, ɛ/ have higher F3's than back vowels. Note that the F3 of /u/ is consistent with that of a central-to-back vowel, in spite of the relatively front tokens exhibited in her F1xF2 space. Her F3 of /ɹ̩/ varies rather widely, as does her F1 of /ɹ̩/. In spite of this variation, she appears to maintain a distance of at least 500 Hz between the lowered F3 of /ɹ̩/ and the F3 of the plain vowels. Again, the average F3 of /r/ is below 2000 Hz.

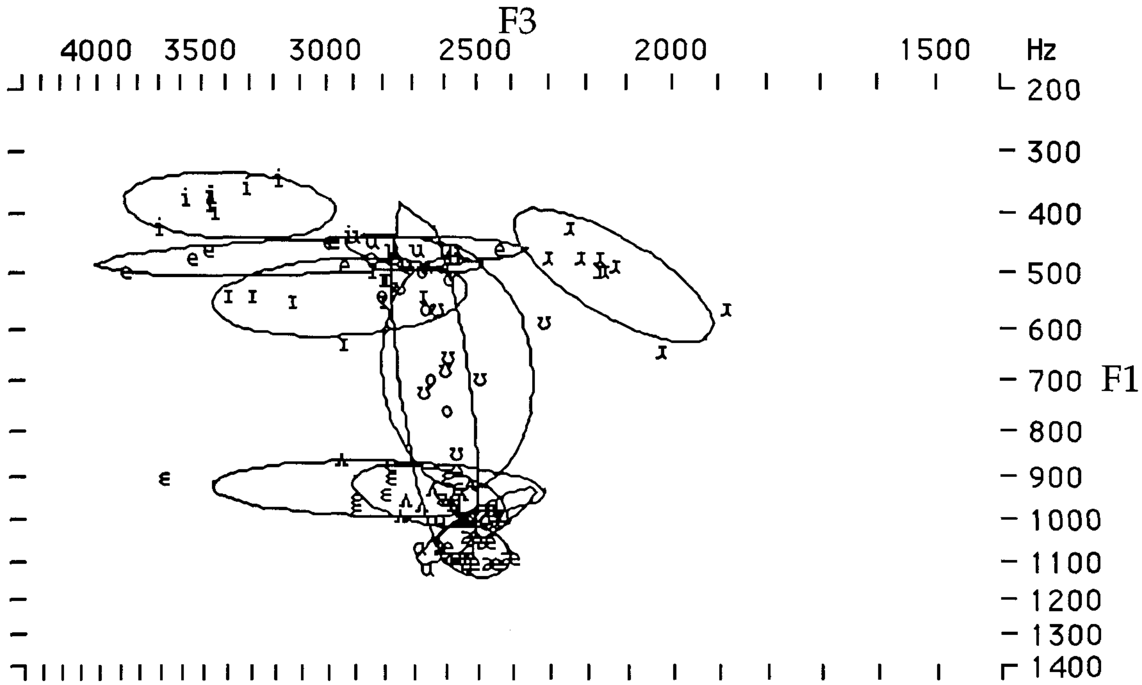


Figure 2.20. Speaker 3's vowels, plotted in an F1xF3 space.

Speaker 3's F3 of the front vowels /i, ɪ, e, ɛ/ vary rather widely, but average higher than for her back and central vowels (Figure 2.20). Her /ɹ/ third formant rarely drops below 2000 Hz, and is relatively close to the F3 of many of her other vowels.

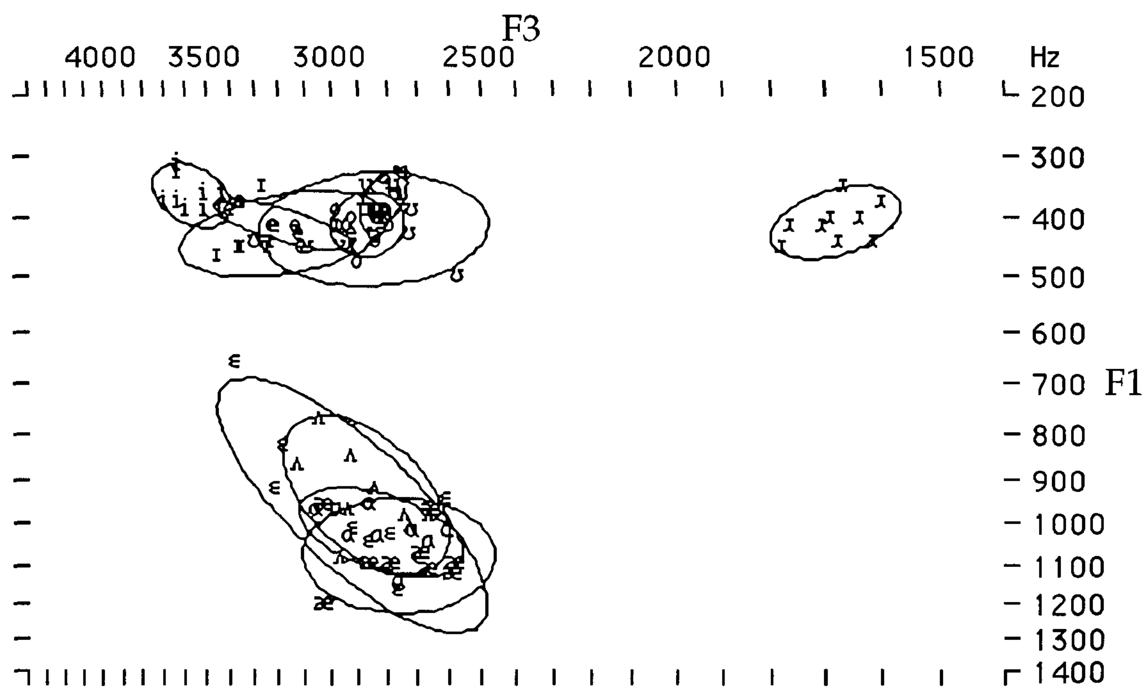


Figure 2.21. Speaker 4's vowels, plotted in an F1xF3 space.

Speaker 4 consistently places F3 of /ɹ̩/ below 2000 Hz, as can be seen in Figure 2.21.

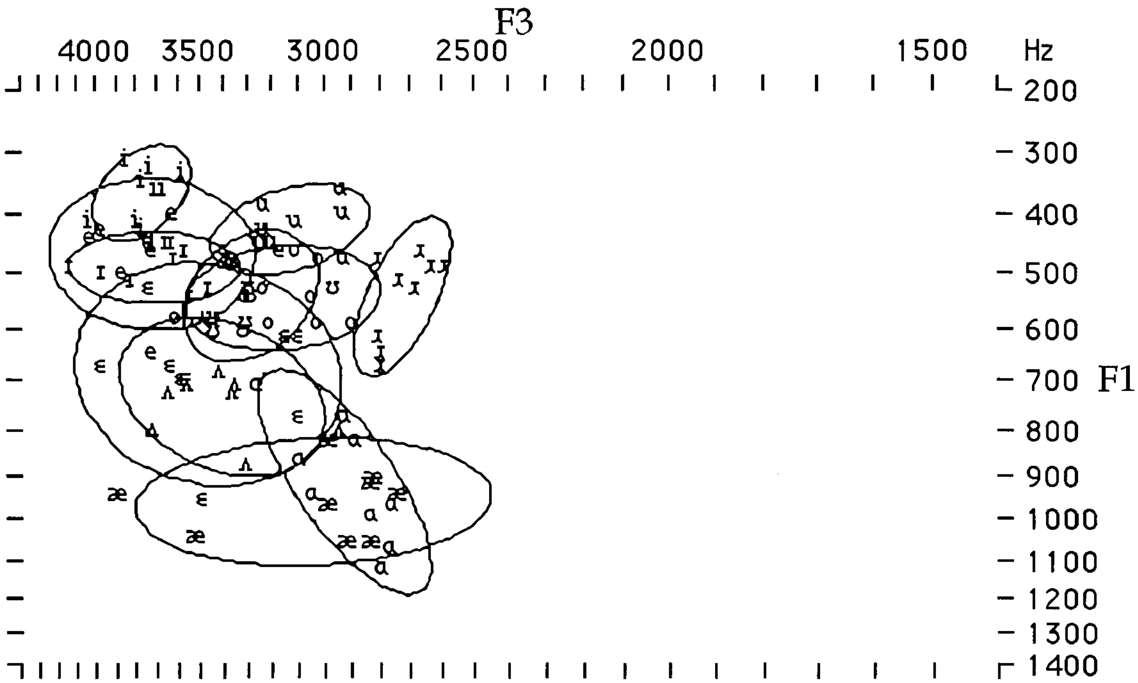


Figure 2.22. Speaker 5's vowels, plotted in an F1xF3 space.

Speaker 5 (Figure 2.22) consistently places her F3 of /ɹ̩/ *above* 2500 Hz. While generally lower than the F3 of the plain vowels, she does not maintain a consistent distance between the F3 of /ɹ̩/ and that of the plain vowels. Her /ɹ̩/ productions are auditorily weaker than for the other speakers in this study.

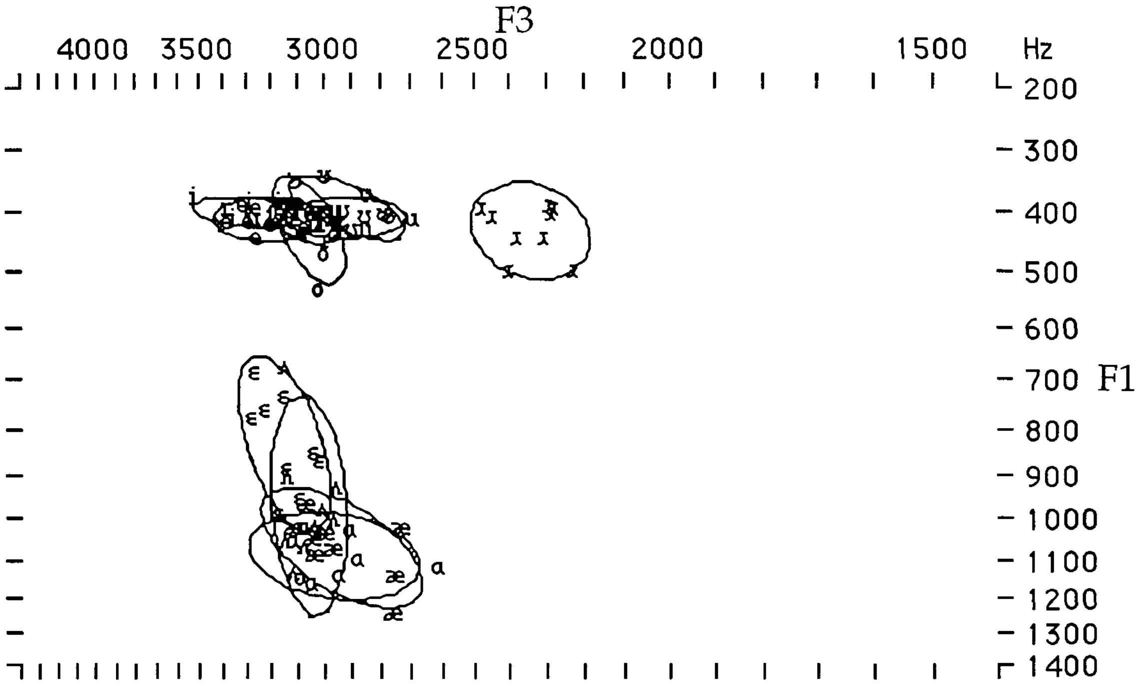


Figure 2.23. Speaker 6's vowels, plotted in an F1xF3 space.

Like S1, Speaker 6 maintains a relatively narrow range in which the F3 of the plain vowels must appear (Figure 2.23). She maintains a short distance, about 200 Hz, between her highest F3 of /ɹ̩/ and her lowest F3 of the plain vowels.

Speaker 7's F3 of /ɹ̩/ consistenty appears below 2000 Hz, with a significant distance between the F3 of /ɹ̩/ and that of the other vowels (Figure 2.24).

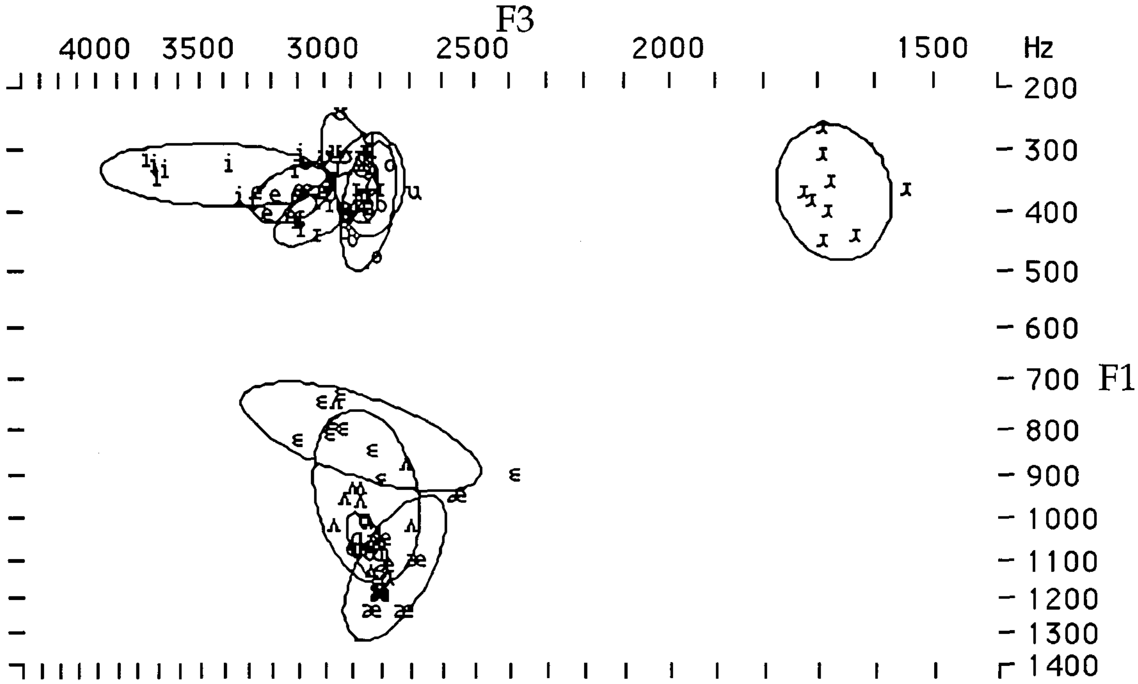


Figure 2.24. Speaker 7's vowels, plotted in an F1xF3 space.

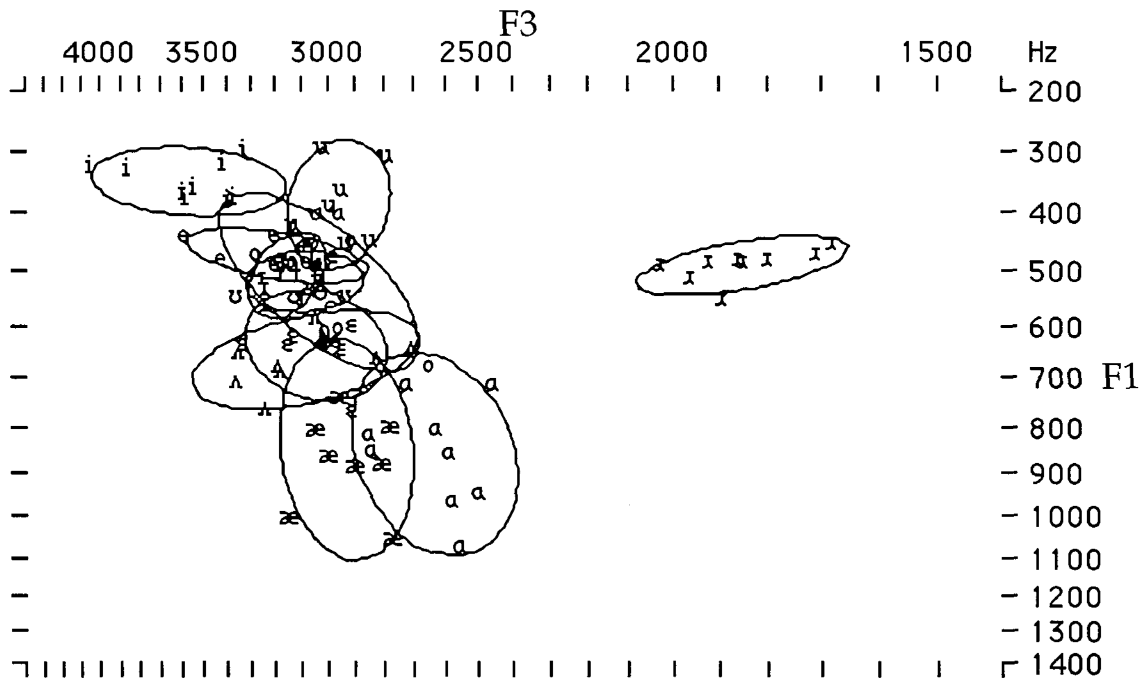


Figure 2.25. Speaker 8's vowels, plotted in an F1xF3 space.

As can be seen in Figure 2.25, Speaker 8's third formant appears to correlate both with F2 (fronter vowels have a higher F3 than backer vowels) and

F1 (higher vowels have a higher F3 than lower vowels). Most of her F3's of /ɹ̩/ appear below 2000 Hz.

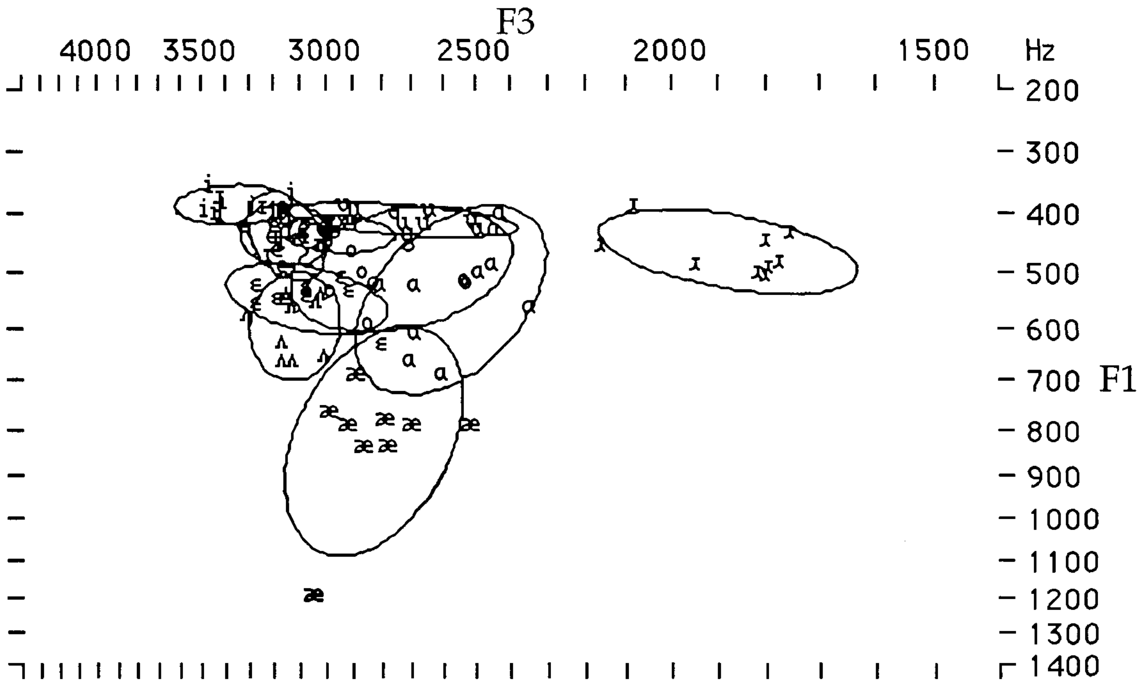


Figure 2.26. Speaker 9's vowels, plotted in an F1xF3 space.

Figure 2.26 includes Speaker 9's productions of /ɑ/. S9 maintains a distance of several hundred Hertz between the F3 of the plain vowels and that of /ɹ̩/, although not all her tokens of /ɹ̩/ have an F3 below 2000 Hz.

The men's F1xF3 plots are shown in Figures 3.27-3.32.

Speaker A's F1xF3 space is show in Figure 2.27. Sa places most of his third formants around 2500 Hz. This is consistent with the neutral third resonance of a uniform tube approximately 17.5 cm long. The third formant of /ɹ̩/ is quite a bit lower, between 1600 and 1800 Hz; that is, well below the 2000 Hz threshhold widely regarded as typical for men's /ɹ̩/.

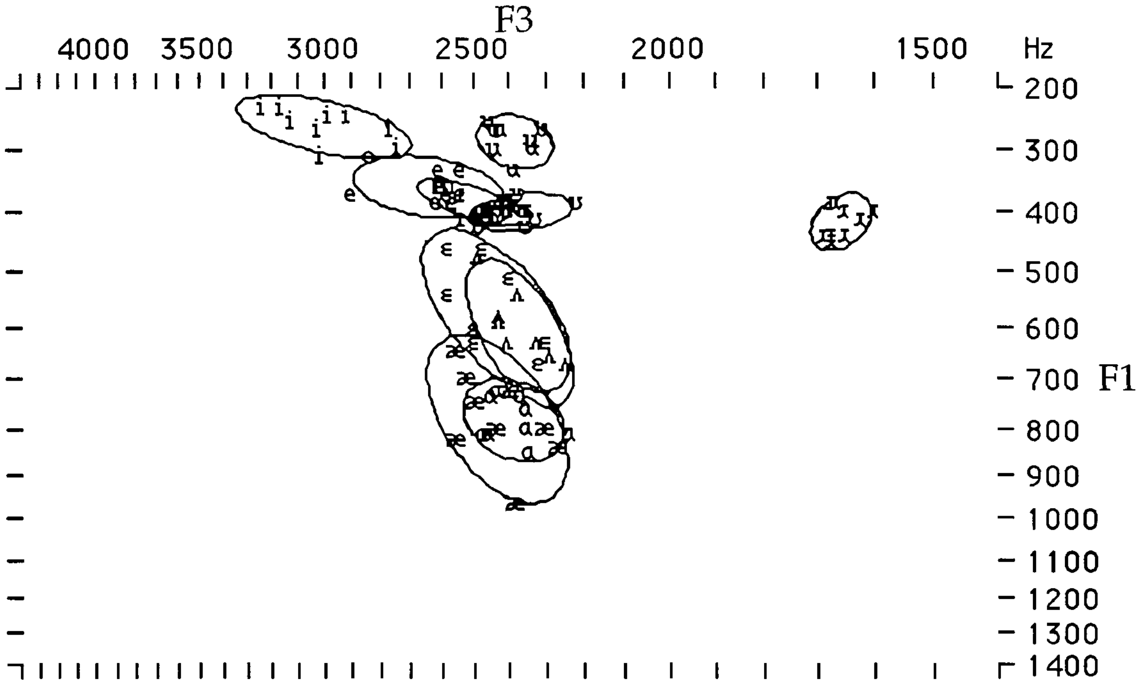


Figure 2.27. Speaker A's vowels, plotted in an F1xF3 space.

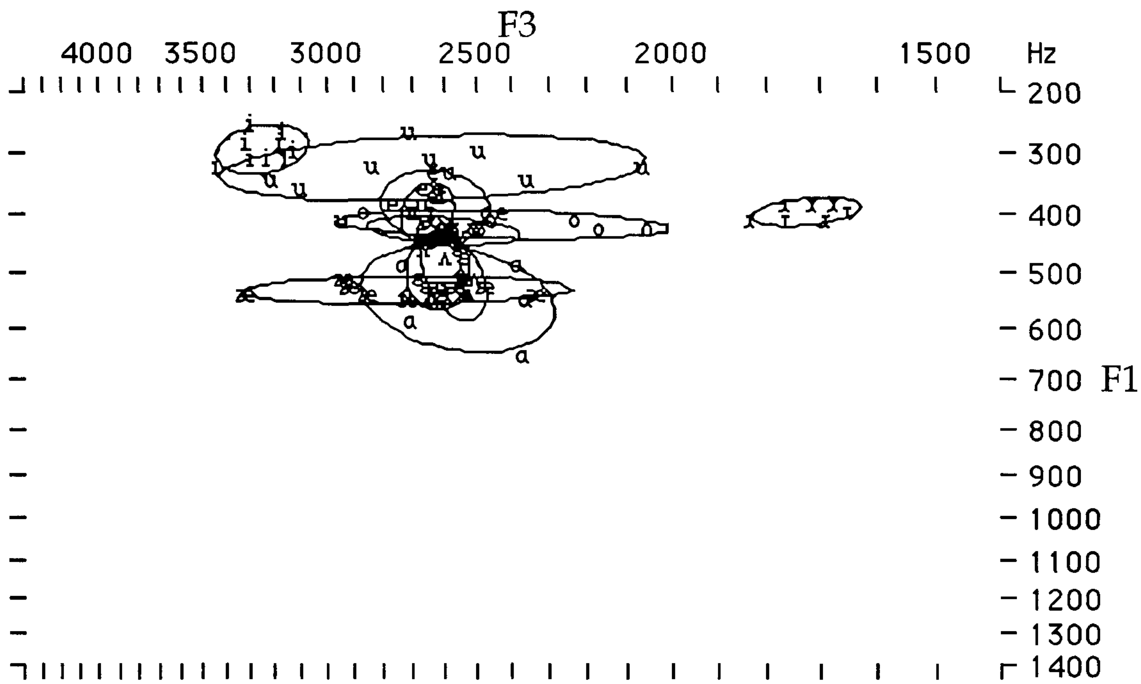


Figure 2.28. Speaker B's vowels, plotted in an F1xF3 space.

Speaker B's F3 showed large token-to-token variance in /u/, /o/, /æ/ and /ɑ/ (Figure 2.28). While his F3 of /i/ was higher than for the other plain vowels (perhaps as a function of the higher F2 seen in /i/), those remaining vowels had

F3 values which cluster around 2750 Hz. His F3 of /ɹ̩/ well separated from the other vowels.

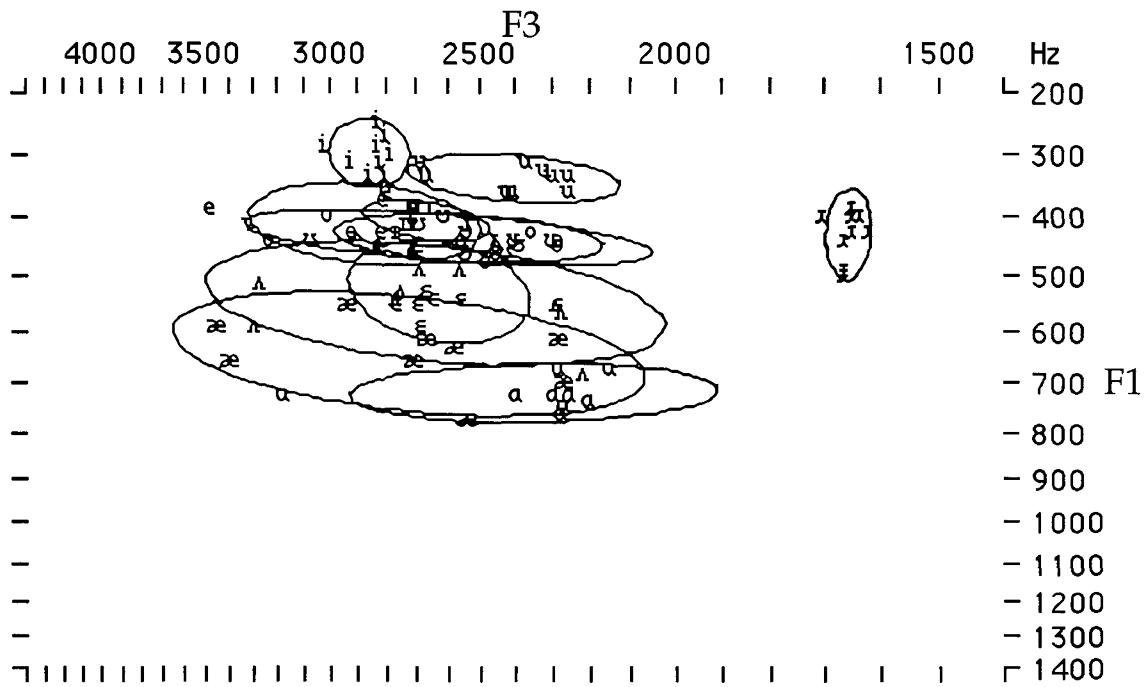


Figure 2.29. Speaker C's vowels, plotted in an F1xF3 space.

Speaker C shows fairly wide token-to-token variance in F3 of all vowel categories except /i/ and /ɪ/ (Figure 2.29). In contrast, his standard deviation of F3 of /ɹ̩/ is only 22 Hz.

Speaker D (Figure 2.30) and Speaker E (Figure 2.31) show a similar pattern, with fairly tight clustering of F3 values (except for extreme cases like /i/ and /u/), and clear separation from /ɹ̩/'s F3.

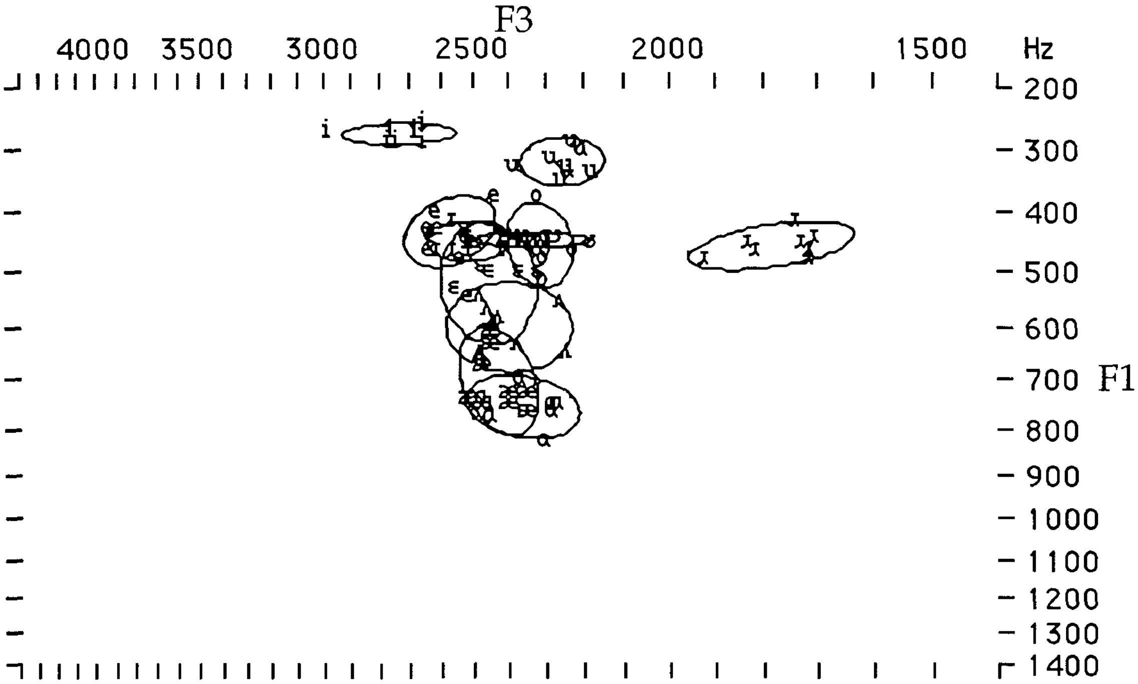


Figure 2.30. Speaker D's vowels, plotted in an F1xF3 space.

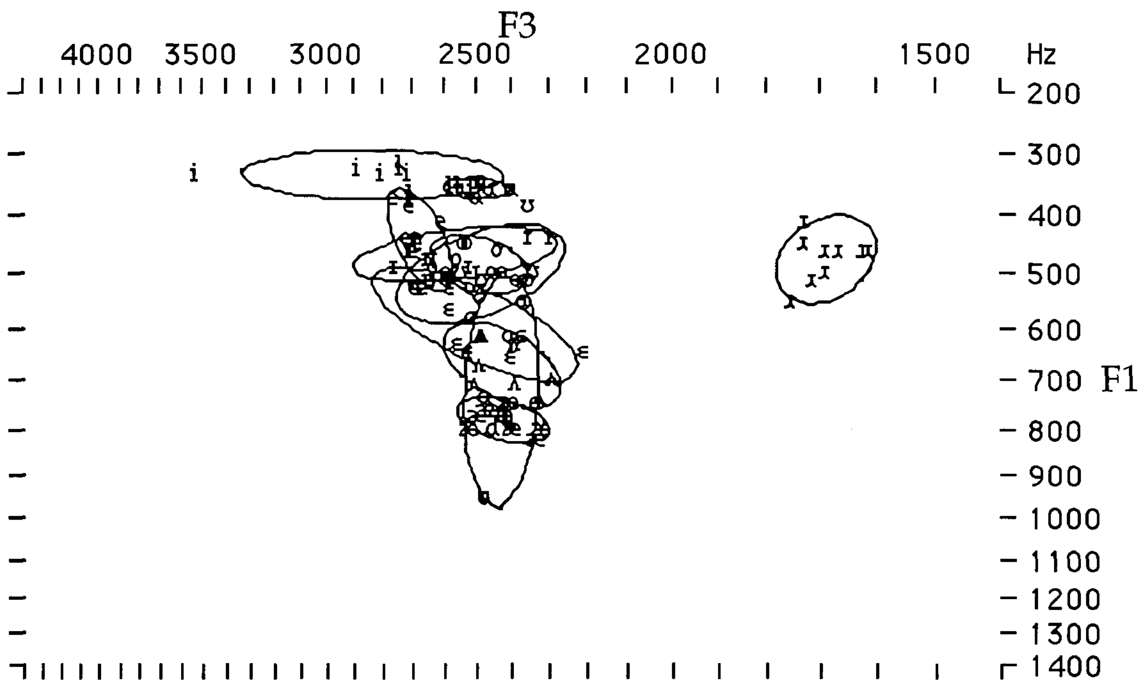


Figure 2.31. Speaker E's vowels, plotted in an F1xF3 space.

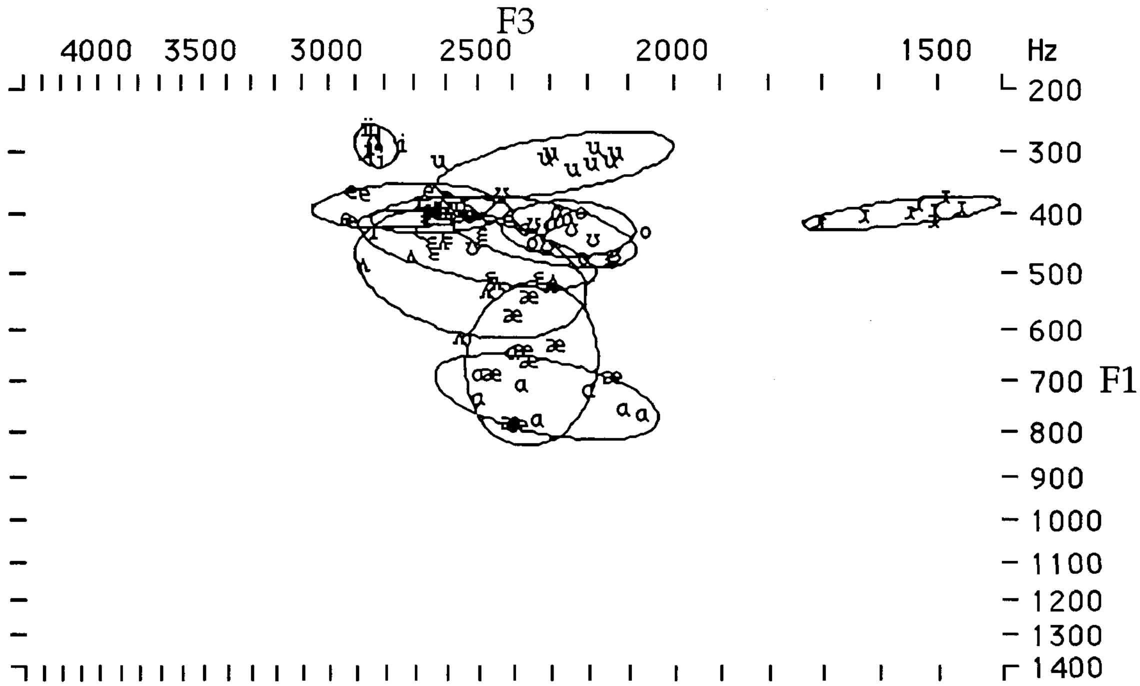


Figure 2.32. Speaker F's vowels, plotted in an F1xF3 space.

Speaker F consistently had the lowest F3 of /ɹ̩/ in the study. With the exception of /i/ and /æ/, within-category variation in F3 is large, relative to variation in F1.

The point to be learned here is that the traditional view of /ɹ̩/ being distinguished from the other vowels primarily by its extremely low F3 is vindicated for most speakers. All but one speaker (S5) maintain a clear separation between the range of F3 values they used for /ɹ̩/, and the range used for the other vowels. All six of the male speakers lower F3 well below 2000 Hz, where at least two of the 9 female speakers use F3 values above 2000 Hz.

Third formant frequencies for individual speakers are available in the tables above. Third formant frequency averages are presented in Table 2.18. F3 of /ɹ̩/ will be discussed in more detail in the next chapter.

Table 2.18. Third formants of the vowels, by sex.

	W		M		
i	3495	(239)	2920	(219)	i
ɪ	3187	(262)	2589	(117)	ɪ
e	3252	(277)	2690	(166)	e
ɛ	3065	(285)	2528	(143)	ɛ
æ	2826	(231)	2524	(271)	æ
u	2866	(225)	2399	(248)	u
ʊ	2926	(261)	2446	(173)	ʊ
o	2904	(263)	2430	(216)	o
ɑ	2743	(201)	2405	(175)	ɑ
ʌ	2989	(264)	2496	(211)	ʌ
ɹ̩	1995	(347)	1679	(91)	ɹ̩

2.4 General discussion

2.4.1 Sex differencs in between- category and within-category variance

Table 2.19 summarizes the results of F-tests of the difference in variance between the women's and men's data in this study. The Numerator of the Degrees of Freedom is 80 in most cases; the Denominator is 53 in all cases. For /ɑ/, the elimination of S9's formant values give a Numerator of 71. For /ɛ/, the missing token (in S8's data) produces a Numerator of 78. These tests were run over the raw data in Hertz; parallel analysis on Bark-converted formant measures did not result in any substantive changes in the interpretation of the underlying facts. (Bark-converted data will be discussed in more detail in Chapter 7.)

Some interesting patterns emerge from the F-tests which are not readily apparent from the Bark-scaled formant plots seen previously. In four of the eleven vowel categories (/ɪ, ɛ, ʊ, ɹ̩/), significant between-sex differences were found in the variance of all three formants, with the women varying more. In only three of the thirty-three possible cases did the men appear to vary more than the women, and never significantly.

The /i/ category is the only category which never showed significantly more variation among the women than the men in any formant. /e/, which for many speakers is as high or nearly as high a vowel as /i/, does not vary more in F1 among women than among men. /æ/ and /ɑ/, the lowest vowels in the spaces, also do not show different variance in F1. This probably reflects a ceiling/floor effect in F1 values. That is, the relative invariance of F1 values among these vowels is the product of their extreme positions, high or low, in the available formant space. The relative invariability of /i/ in all formants suggests a ceiling effect in F2 and F3 as well.

Table 2.19. Results of F-tests of men's and women's formant frequencies (significant F-values in bold; F-values less than one indicated by *).

	F1		F2		F3		
	F-value	*P-value*	*F-value*	*P-Value*	*F-value*	*P-Value*	
i	1.365	.2168	.739*	.2296	1.182	.5058	i
ɪ	**2.868**	**<.0001**	**3.163**	**<.0001**	**4.977**	**<.0001**	ɪ
e	1.247	.3797	**1.826**	**.0176**	**2.790**	**<.0001**	e
ɛ	**6.011**	**<.0001**	**8.451**	**<.0001**	**3.999**	**<.0001**	ɛ
æ	1.620	.0565	**4.886**	**<.0001**	.730*	.2113	æ
u	**2.468**	**.0004**	**2.856**	**<.0001**	.829*	.4557	u
ʊ	**8.485**	**<.0001**	**1.837**	**.0165**	**2.285**	**.0012**	ʊ
o	**12.586**	**<.0001**	**3.253**	**<.0001**	1.479	.1211	o
ɑ	1.092	.7339	**2.060**	**.0056**	1.312	.2931	ɑ
ʌ	**3.746**	**<.0001**	**2.533**	**.0003**	1.576	.0717	ʌ
ɹ̩	**4.129**	**<.0001**	**4.602**	**<.0001**	**14.547**	**<.0001**	ɹ̩

2.4.2 *Dissimilar distribution of women's and men's mean vowel positions*

Comparing the means in Tables 2.17 and 2.18, the women's formant frequencies are always higher than the men's. The mean differences range from a low of 39 Hz (F1 of /ɛ/) to a high of 599 Hz (F3 of /ɪ/). All three formants of every vowel category showed significant differences as a function of speaker sex. Table 2.20 summarizes the results of unpaired t-tests to which the data were subjected. In Table 2.20, the Degrees of Freedom=132 and p≤.0001 unless otherwise noted.

Table 2.20. Mean differences between women's and men's formants.

	F1		F2		F3		
	Mean Diff.	*t-Value*	*Mean Diff.*	*t-Value*	*Mean Diff.*	*t-Value*	
i	71	11.878	559	16.890	575	14.168	**i**
ɪ	49	5.226	592	26.216	599	15.762	**ɪ**
e	37	4.594*	597	20.091	561	13.352	**e**
ɛ	278	11.587	493	17.849	537	12.780	**ɛ**
æ	332	15.308	209	11.013	301	6.937	**æ**
u	72	9.715	282	5.133	467	11.335	**u**
ʊ	46	2.805	299	11.347	480	11.885	**ʊ**
o	79	4.367	203	6.397	473	10.980	**o**
ɑ	287	15.923*	168	10.748*	338	9.871*	**ɑ**
ʌ	273	11.965	338	15.751	493	11.484	**ʌ**
ɹ̩	48	4.028	195	7.876	316	6.529	**ɹ̩**

* For /ɛ/, DF=132; for F1 of /ɛ/, p<.0058. For /ɑ/, DF=124.

As noted above, many of the women appear to divide the vowels into two groups, using either relatively high or relatively low F1 values. The middle F1 range is much more sparsely populated with vowel tokens than the upper and lower regions.

More striking in the F1xF2 vowel space is the distribution of the lower vowels in the F2 dimension. Note that for both men and women /ɑ/ is quite low and back. /æ/ has a higher F2 (i.e., is more front) than /ɑ/. However, in the men's vowel space (Figure 2.18), /æ/ is clearly a front vowel, having F2 values similar to the /ɛ/ category and being considerably more front than /ʌ/. This is not the case for the women's vowel space in Figure 2.17, where /æ/, /ʌ/, and /ʊ/ have simlar F2s, making /æ/ acoustically a central vowel. Moonwomon (1991) notes a similar centralization of the /æ/ category in her speakers. However, those speakers had a relatively central /æ/ only before fricatives, not before stops generally. Since fricative environments were not included in the present study, it is not clear whether the women in this study represent an extension of the trend in Moonwomon's data.

Note also that the highly variable F1s of /ɛ/ seem to be expanding into the low front space 'vacated' by /æ/, as well as into the sparsely populated middle frequency region.

For both the women and men, the relatively central position of /u/ (i.e., its relatively high F2) is not particularly surprising. As noted earlier, at least part of the variation in the F2 of this vowel comes from the 'duke' tokens. In addition to this alternation, however, is a more general change affecting this segment, as well as the other back vowels. In southern California, the back vowels are often unround. Without lip rounding, the formants, particularly F2, may be higher than expected if the vowel were fully rounded. In general, the back vowels in this dialect are much more central than has been reported in other dialects.

The dissimilarity of the men's and women's vowel spaces is further exemplified in Figures 2.33 and 2.34. Figure 2.33 is the men's and women's F1 and F2 means overlaid in the same plot. Figure 2.34 is the men's and women's F1 and F2 means from Peterson & Barney (1952), plotted to the same scale. For better visual comparisons, only the vowels /i, ɪ, ɛ, æ, ɑ, ʊ, u/ and /ʌ/ are included. /e/ and /o/ were omitted because the Peterson & Barney study did not include them. /ɹ̩/ was omitted because it overlapped so closely with /ʊ/. /ɔ/, included in the Peterson & Barney study, is not generally maintained as a seperate category in Southern California and is omitted from Figure 2.34.

The most striking difference is that the back vowels of the speakers in the present study are acoustically quite central compared with those of Peterson & Barney's speakers. The speakers in this study seem to avoid F2 frequencies below 1100 Hz, where even Peterson & Barney's female speakers appear quite happy to produce F2 frequencies lower than this.

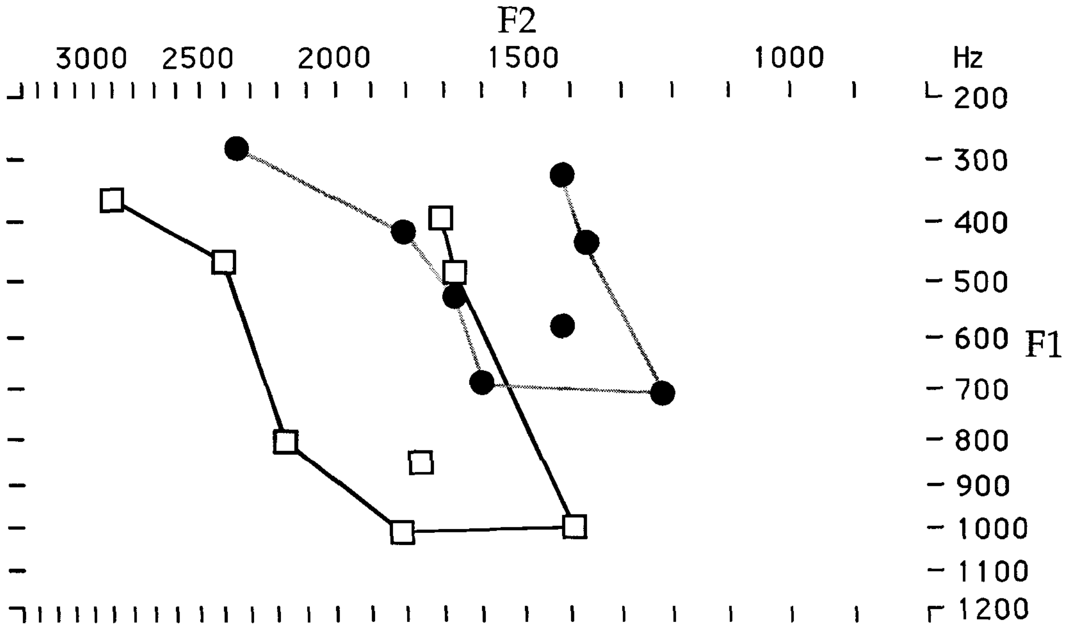


Figure 2.33. Women's (open squares) and men's (filled circles) vowel spaces from the present study. Note the relatively high F2 values, and relative positions of the lower vowels.

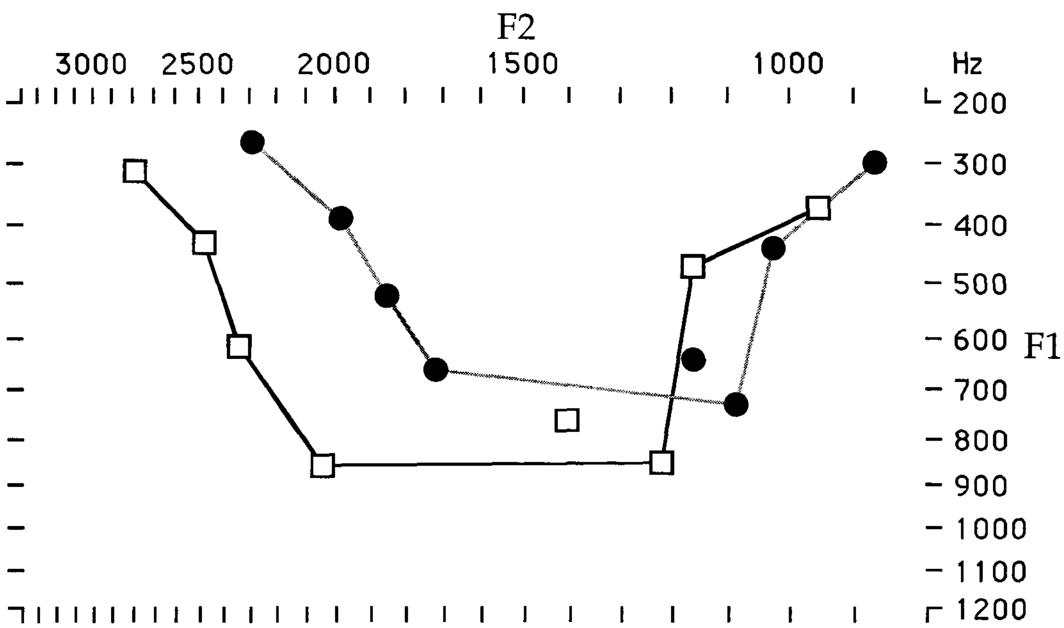


Figure 2.34. Women's (open squares) and men's (filled circles) vowel spaces from data reported by Peterson & Barney (1952).

The distribution of mean vowel positions in the present study is quite different for men than for women; in contrast, Peterson & Barney's data look more like the same linear relationships being expressed over a larger area. That is, 'normalizing' for speaker sex in Peterson & Barney's data set is a matter of scaling. However, the present data are more difficult for the problem of normalization.

The asymmetry found in the distribution of vowel categories within the men's and the women's vowel spaces should not come as particular surprise. The present data are at least impressionistically comparable to Disner's (1983) findings that phonologically similar vowel spaces in different languages can differ in idiosyncratic ways, although certain points of similarity, notably at the 'point vowels' /i, ɑ, u/, are likely. Disner found this to be true in different languages, but it is not unexpected that such differences should also appear across dialects of the same language. The relative stability of /i/ and /ɑ/ in this dialect of American English for both sexes is probably related to their peripherality in the F1 and F2 dimensions. The observed differences in vowel mean distributions might be parts of a more general trend. It remains to be seen if any of these differences are the result of social or historical pressures, or if they can somehow be derived from the different physiological shape of men's and women's vocal tracts. The problem of vowel identification in this dialect appears not to be merely a matter of scaling or normalization, but the location of a given set of formant frequencies relative to the vowel system of the language or dialect in question — and men and women may have quite different dialects.

2.4.3 *Vowel formant scaling and Fant's "K"*

Modeling the 'average' male vocal tract as a uniform tube 17.5 cm in length, and taking the speed of sound to be 35,000 cm/sec, the first three neutral resonances of the vocal tract can be estimated to be 500, 1500, and 2500 Hz. As estimated in Chapter 1, the average male vocal tract is approximately 16 cm long. Adding 1.5 cm to account for lip radiation and other factors approximates the 17.5 cm effective length. Women, with a vocal tract approximately 13 cm long, would by analogy have an effective vocal tract length of 14.5 cm. The first three natural resonances of a uniform tube of 14.5 cm can be estimated to be 603, 1810, and 3017 Hz. These frequencies are approximately 20% greater than 500, 1500, and 2500.

Fant (1973) expresses the relationship between men's and women's formants as a percentage of the men's formant frequency. That is, the scaling factor "K" is defined by the following formula:

$$\mathbf{K} = 100(\text{Frequency}_f/\text{Frequency}_m - 1)$$

In words, **K** is the difference between a target (female) formant frequency and a standard (male) formant frequency, descibed as a percentage of the standard. Using the uniform tuble calculations above, K should aproximately 20 at all frequencies.

Fant has discussed male-to-female vowel scaling, noting that, while in general, women's formants are approximately 20% higher than men's,

> "A range of typical and substantial deviations from this rule is concealed if the data are averaged over the whole vowel system.... [T]he female-to-male relations are typically different in the three groups of (1) rounded back vowels, (2) very open unrounded vowels, and (3) close front vowels." (Fant 1973:84).

Fant sought a physiological explanation as to why the three vowel groups he mentioned in the quoted passage should behave differently.

The K-factors for all three formants of each of the plain vowels in this study are presented in Table 2.21.

Table 2.21. K-scaling factors for the plain vowels in the present study.

	K of F1	*K of F2*	*K of F3*
i	24.4	23.9	**19.7**
ɪ	11.7	32.8	**23.1**
e	9.2	28.9	**20.9**
ɛ	52.7	29.5	**21.2**
æ	48.5	13.1	**12.0**
u	22.3	20.0	**19.5**
ʊ	10.2	21.9	**19.6**
o	18.1	17.1	**19.5**
ɑ	40.4	13.8	**14.1**
ʌ	47.6	23.9	19.8
Average:	**28.5 (17.1)**	**22.5 (6.7)**	**18.9 (3.3)**

Fant's (1973) observation that male-to-female vowel formant scaling is not a single, simple procedure but one that differs vowel to vowel (and even formant to formant) is well taken for the present data. It is not clear that the K-values in Table 2.21 divide neatly into the three groups Fant describes. For instance, there seems to be nothing 'regular' about the K-values for F1 of the higher front vowels /i, ɪ, e/. The most consistent set of K-factors is the F3 values, which appear near 20%, except in the case of the vowels /æ/ and /ɑ/. The standard deviation (3.3) is an indication of how tightly the K-values cluster around the average of 18.9. Compare these figures with the 22.5 (6.7) values in F2 — a slightly more divergent figure (from 20) with a slightly wider scatter. The average K of F1 is not at all near Fant's expected 20%, and the standard deviation is exceptionally very large.

However, if the vowels are divided into two groups by their individual K-values relation to the mean, the groups which emerge correlate with the height-groups suggested by the women's data. That is, the higher vowels /i, ɪ, e, u, ʊ, o/ form one group, with K-values lower than 28.5, and the lower vowels /ɛ, æ, ɑ, ʌ/ have the higher K-values. This is clear evidence that the differences in relative placement of the vowel cateogories in the women's and men's vowel spaces, at least in the F1 dimension, contributes greatly to the problem of scaling the men's and women's data.

To get a sense of the global properties of the women's and men's vowel productions, it may be useful to consider the global average formant frequencies. In Table 2.22 are presented the women's and men's F1, F2, and F3 values, averaged across all plain vowels (as in Table 2.21, S9's productions of /ɑ/ are omitted from this calculation).

Table 2.22. Global average formant values for plain values, by speaker sex.

	F1	*F2*	*F3*
Women's average:	**629**	1989	3028
Men's average:	**481**	1600	2453

The global averages are very similar to the calculated neutral resonances of uniform tubes. (The relatively higher global F2 averages in the present data are a function of the relative centrality of the "back vowels" in this dialect.) Since the expected neutral formant values are similar to the global averages, it seems appropriate (at least in F1 and F3) to use the global averages as an arbitrary standard in discussing modifications of formant frequency, in particular the lowering of F3 in /r/.

2.5 Conclusion

This study has yielded evidence that significant differences exist between the vowel spaces of women and men in this dialect of English. Women's formant frequencies are generally higher than men's, as predicted by their relatively smaller vocal tracts, but the women also showed greater within category variance, as well as different distribution of categories within their vowel space. Thus, women and men appear to have vowel spaces which differ arbitrarily as a function of gender, though at least partially in the direction predicted purely on grounds of vocal-tract size. Both these dialects are similar, however, in their centralization of back vowels compared to other dialects of English. This centralization results in almost complete overlap between the /ɹ̩/ and /ʊ/ categories in the F1 and F2 dimensions, though [ɹ̩] can be distinguished from [ʊ] and the other vowels generally by its relatively lower third formant.

The greater variance associated with women's vowel productions suggests that the notion of an acoustic phonetic target for a vowel is not a particular set of frequencies, but a set of frequencies within some range, particularly for women. That is, the "targets" are not points, but windows, in the sense of Keating (1990). For men, these ranges are quite small, often giving the impression of targets at specific frequencies.

In short, sex-specific differences were noted in the domain of vowel formant frequencies, and these were mostly compatible with a model which accounts for such variation as a function of vocal tract size. However, such a model alone could not account for all the differences noted; even in the domain of formant frequency, some sex differences (though not necessarily these) are unquestionably the result of learned speech behaviors, differentiating a 'social group of women' from a 'social group of men'. That the vowel spaces of men and women can differ in arbitrary ways should not be surprising. Similar arbitrary differences have been found across languages with phonologically similar vowel system (Disner 1983). Taking speaker gender as a social dimension distinguising two groups of speakers, it is not surprising that their phonologically identical vowel systems might differ in phonetic detail as a matter of social dialect.

Chapter 3. The formant frequencies of syllabic /ɹ̩/

3.1 Introduction

In the previous chapter, syllabic /ɹ̩/ was considered as a vowel, which is appropriate for the southern Californian dialect under consideration. It was seen that, as has been reported for other dialects (Peterson & Barney 1952, Hillenbrand, Getty, Clark & Wheeler 1995), /ɹ̩/ overlapped the higher back vowels, particularly /ʊ/, in its first and second formant values, but could be distinguished by its comparatively lower F3. In this chapter, the syllabic /ɹ̩/ will be considered on its own terms. The lowered F3 associated with American /ɹ̩/ will be demonstrated as well, although it will be noted that not all the female speakers utilize an F3 lower than 2000 Hz.

The principal question to be answered in this chapter is whether the formant values of syllabic /ɹ̩/ produced by the female speakers, or a subset of the female speakers, can be trivially computed as a scaling-function of the men's formant values. In the case that they cannot, what can be said about the relationship of women's formant values to men's? These questions will also be addressed for non-syllabic allophones of /r/ in later chapters.

3.2 Review of syllabic /ɹ̩/ data from the vowel study

3.2.1 Subjects and procedures

The subjects and procedures for this section are addressed in Chapter 2. The syllabic /ɹ̩/ data were extracted from the more general vowel data. As noted in Chapter 2, nine women and six men were recorded reading 'Bert', 'herd' and 'Turk', in the frame "Cite ___ twice.". Each token was presented three times along with other words illustrating the southern California vowels and non-syllabic allophones of /r/, in random order. N=9 for each speaker. Formant frequencies were measured by simultaneous evaluation of wide band spectrograms and narrow band FFT spectra averaged over 30 ms during the steady state of [ɹ̩]. Spectrograms and spectra were supplemented by LPC formant histories and LPC slices respectively. Examples showing the mostly monophthongal structure of syllabic /ɹ̩/ are presented in Figure 3.1.

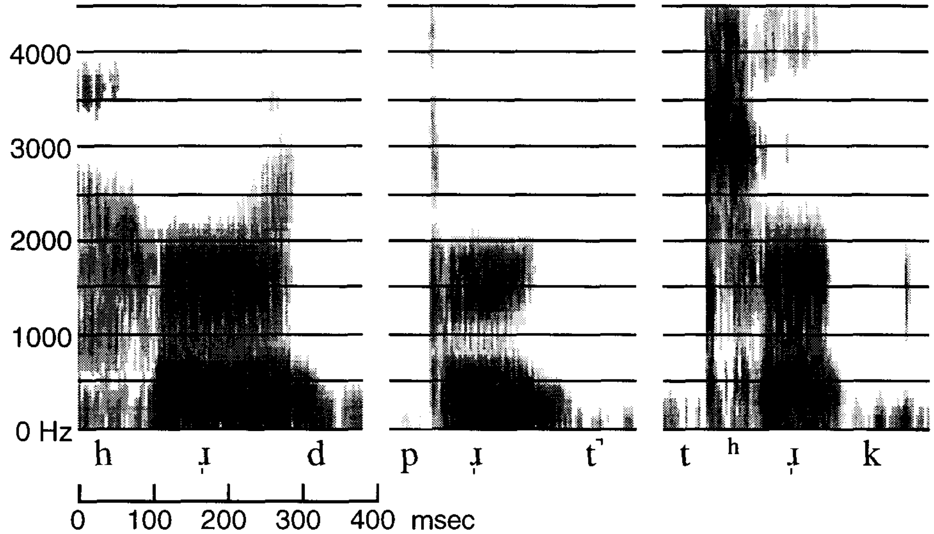


Figure 3.1. Sample spectrograms of syllabic /ɹ̩/. From left to right, tokens are HERD (Speaker 2), BERT (Sb), and TURK (S7).

3.2.2 *Results*

Table 3.1 summarizes the results for the syllabic /r/ data for each speaker.

Table 3.1. Formant frequencies of syllabic /ɹ̩/ for the fifteen speakers in this study. Units are Hz, standard deviations in parentheses.

	F1		*F2*		*F3*		
S1	547	(49)	1528	(59)	1925	(78)	S1
S2	534	(97)	1419	(123)	1733	(140)	S2
S3	507	(63)	1643	(96)	2141	(124)	S3
S4	408	(33)	1389	(53)	1680	(62)	S4
S5	544	(78)	1871	(73)	2725	(85)	S5
S6	431	(43)	1689	(60)	2343	(87)	S6
S7	369	(59)	1379	(49)	1670	(53)	S7
S8	492	(28)	1570	(111)	1856	(113)	S8
S9	465	(38)	1530	(79)	1882	(149)	S9
All women:	**477**	**(82)**	**1558**	**(170)**	**1995**	**(347)**	
Sa	416	(25)	1321	(60)	1656	(29)	Sa
Sb	396	(13)	1439	(54)	1725	(55)	Sb
Sc	429	(41)	1335	(61)	1656	(22)	Sc
Sd	457	(22)	1448	(63)	1788	(88)	Sd
Se	477	(41)	1306	(41)	1689	(48)	Se
Sf	398	(15)	1324	(54)	1562	(90)	Sf
All men:	**429**	**(40)**	**1362**	**(79)**	**1679**	**(91)**	

3.3 Discussion

3.3.1 Distribution of formant measurements

In this section, the distribution of measurements will be discussed. This is to note any trends in the distribution of formant measurements. For convenience, formant measurements are considered in a linear (Hertz) scale only. Thus the observations made may not represent auditorily meaningful formant frequency distributions. These observations are only intended to describe the underlying data in more detail or more meaningfully than either the averages in Table 3.1 or lists of individual measurements (provided in Appendix B.

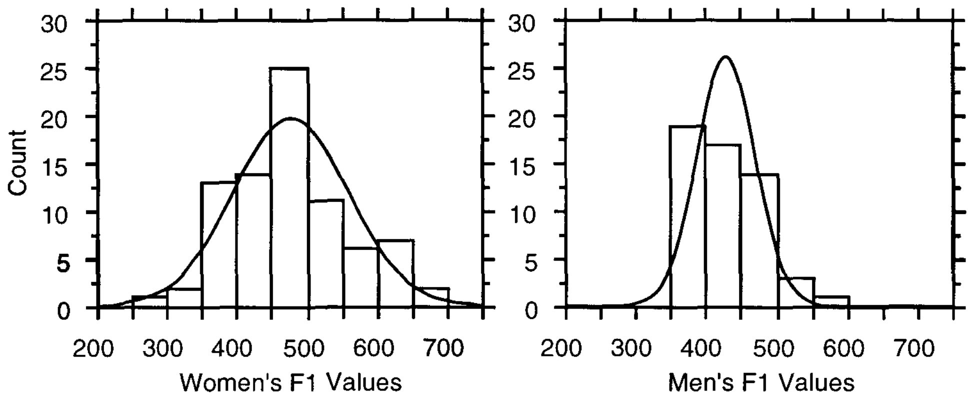


Figure 3.2. Histograms of women's (left) and men's (right) F1 measurements, in Hz.

Figure 3.2 is composed of bar charts representing the number of measurements of the first formant of [ɹ] that fell within a particular range of frequencies (50 Hz bins). The women's tokens are counted on the left, the men's on the right. Comparing the distribution of F1 values in each graph to the normal distribution described by a bell curve with the same mean and standard deviation (for the women, 477 (82) Hz; for the men, 429 (40) Hz), it can be seen that the women's F1 values appear to follow normal distribution, where the men's values are distributed unevenly, extending upward from a high at the 350-400 Hz bin. It is interesting to note that the women's values, while higher on average than the men's average, include some lower measurements than the men's. The men's F1 measurements appear to be distributed upward from a 'floor' near 350 Hz.

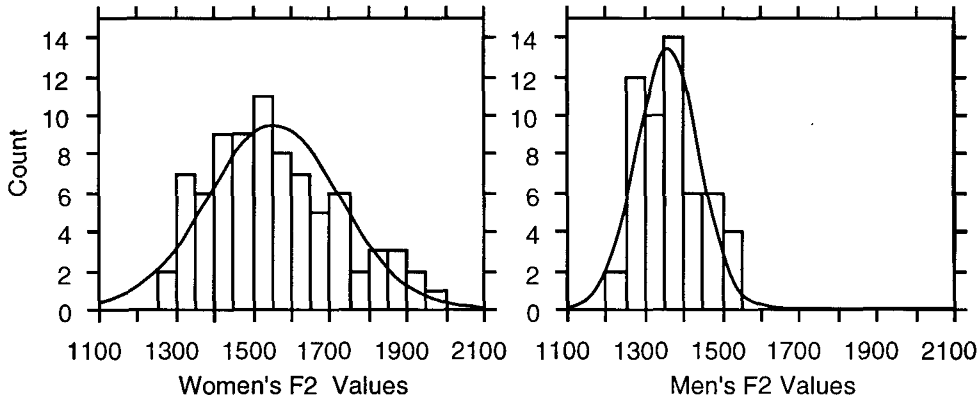


Figure 3.3. Histograms of women's (left) and men's (right) F2 values, in Hz.

The distribution of F2 values in Figure 3.3, while not perfect, appears grossly to follow a normal distribution for both the men and the women. The mean for the women was 1558 Hz, with a standard deviation of 170 Hz. For the men, the average was 1362 Hz, and the standard deviation was 79 Hz. It is easier to see in F2, where both distributions approach normal, that the additional female speakers (nine, to only six men) do not account for the different distribution. While it is true that including additional speakers will introduce more outliers, it should also be the case that they will introduce more values near the mean. This is not the case here. The female speakers in this study appear to differ more from one another than the men.

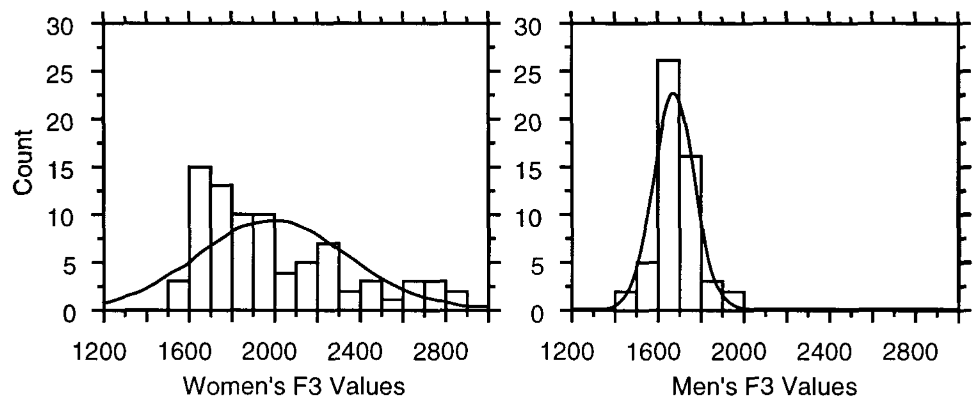


Figure 3.4. Histograms of women's (left) and men's (right) F3 values, in Hz.

The women's F3 values, illustrated in Figure 3.4 appear to exhibit a frequency "floor" around 1600. The distribution of values above this floor is not like the upper half of a normal distribution. Recall that three female speakers (S3, S5, S6) had F3 averages above 2000 Hz. The remaining six speakers do not seem to agree on a center frequency below 2000 Hz in the way that the men do. Note in Figure 3.4 that the number of men's tokens in the 1600-1700 Hz bin is over 25; n=9 for each speaker. That is, just under half of the tokens in the men's sample fall into a single 100 Hz bin. In contrast, the greatest number of women's tokens falling into a single bin is 15. In spite of having three more speakers, the women provide no evidence of a group consensus on a modal formant frequency, even as they approach a 1600 Hz floor on possible F3 values.

It may fairly be asked if the women's data would look any cleaner of the apparently divergent speakers (S3, S5, and S6, whose F3 average was greater than 2000 Hz) were excluded from the sample. Figure 3.5 repeats the information in Figure 3.4, but excluding Speakers 3, 5 and 6 from the women's histogram.

As can be seen in Figure 3.5, excluding female speakers S3, S5, and S6 lowers both the mean and the range for the women's data. However, while the subsetted women's data more closely approximates a normal distribution than the full set of women's data, the distribution is still, at best, a loose approximation of normal. Results of t-tests and f-tests on the effect of sex on the frequency of F3 were performed on both the complete dataset and the subsetted dataset. The results are summarized in Table 3.2.

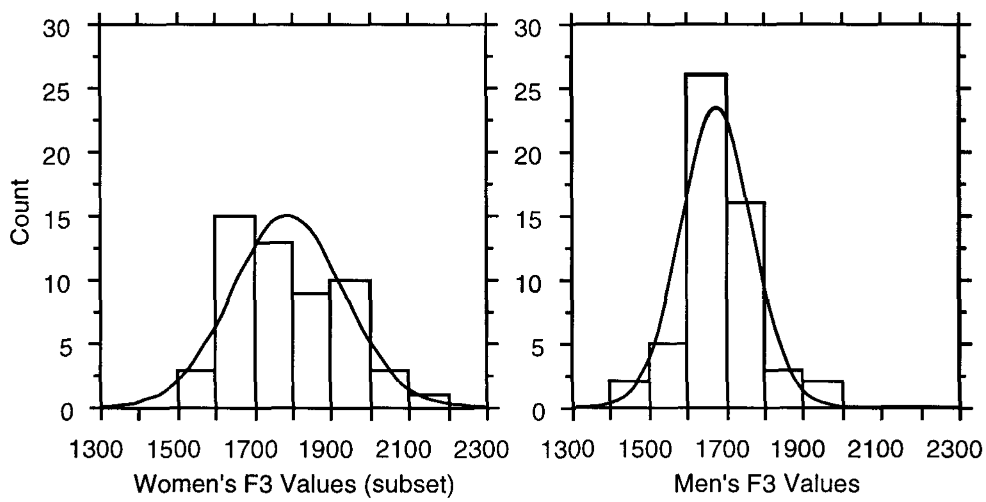


Figure 3.5. Histograms of women's (left) and men's (right) third formant values, excluding S3, S5, and S6 from the women's data.

While the effect of sex is apparently larger in the larger dataset, in both cases, the effect for sex was significant. This was true of the t-tests on means, and the F-tests on the variance.

Table 3.2. Results of t- and f-tests on the data.

All Data	*Excluding S3, S5, S6*
t (df=133) = 6.529 (p<.0001)	t (df=106) = 4.846 (p<.0001)
F (80,53) = 14.547 (p<.0001)	F (53,53) = 2.473 (p=.0012)
Men's Mean = 1679 (91)	Men's Mean = 1679 (91)
Women's Mean = 1995 (347)	Women's Mean (subset) = 1791 (143)
Mean difference = 316 Hz	Mean difference = 112 Hz

It should be noted at this point that excluding any subset of the female speakers in this study is not a principled move. Simply because three of the speakers did not produce expected results, there is nothing in their linguistic or socioeconomic profiles to suggest that these three, and only these three, are different from the other six female speakers. The fact that they apparently differ from the rest of the female population in producing F3 of /ɹ̩/ values above 2000 Hz is not, in itself, an acceptable reason to exclude them. These three speakers further do not appear to represent a second modal category in the data — that is, they appear as different from each other as the other speakers — and thus treating them separately does not provide a better representation of the underlying data.

Linguistically, it would make much more sense to exclude S8. As was seen in Chapter 2, her distribution of vowels in the F1 space differed from the rest of the women in this study. The three speakers under discussion here consistently produce their F3 values, and thus they cannot be discounted on grounds of 'speaker error'. The measurement technique used for all nine speakers was identical, so insofar as this technique is successful in extracting the information it does (except for F1 of S9's /ɑ/ tokens which were excluded as unmeasureable), measurement error is not available as an explanation of the divergent data.

In short, it is essential that these three women be *included* in the data set, precisely because their data is apparently divergent. If phonetic theory is to accurately reflect phonetic fact, it must have access to *all* the facts. The fact in the present case is that some of the women in this study produced F3 of syllabic /ɹ̩/ *above* 2000 Hz. This variation is 'real', and the model must account for it, or find a principled reason to exclude it cipled reason for exclusion is apparent; the data must be included.

In the present data, the men more consistently place their formants at some agreed-upon frequency, where the women have a much broader range of acceptable formant values. Put another way, if Johnson *et al.* (1993) are correct in suggesting that vowel targets are auditorily controlled, it appears that the preferred target for men is most often an extremely narrow range of frequencies, so narrow as to approach particular frequency. This frequency is either a 'target' around which measured values distribute randomly, or a 'boundary', which skews the distribution of values heavily. In contrast, the while individual women may have narrow target windows (in the sense of Keating 1990), as a group the women's target range is much wider. Insofar as the men and women in this study are speaking a particular dialect of American English, it must be said that variation across individuals appears to be a property of the women's sub-dialect in a way that it is not for the men.

3.3.2 *Comparison with other reports of syllabic /ɹ̩/*

While Peterson & Barney's (1952) study included syllabic /ɹ̩/ tokens of only one type ('herd'), Lehiste's (1962) landmark study of semivowels included many more tokens of syllabic /ɹ̩/ in different contexts from male speakers. Some comparison of the present data to these classic studies is called for.

Table 3.3 presents the men's and women's averages for the formants of syllabic [ɹ̩] in the present study, along with the analogous averages from Peterson & Barney (for both male and female speakers) and Lehiste (male speakers only). Also included in Table 4.2 are the averages from the recent replication and expansion of Peterson & Barney's study conducted by Hillenbrand *et al.* (1995).

Table 3.3. Comparison of the present data with data from two classic studies.

	F1	*F2*	*F3*	*source*
Female speakers				
Speakers 1-9	477	1558	1995	present study, all
Speakers 1-9	465	1586	2000	present study, herd' tokens only (n=81)
P&B(f)	500	1640	1960	Peterson & Barney's average ('herd')
HGCW(f)	523	1588	1929	Hillenbrand *et al.*'s average ('herd')
Male speakers				
Speakers A-F	429	1362	1679	present study, all
Speakers A-F	417	1383	1668	present study, 'herd' tokens only (n=54)
P&B(m)	490	1350	1690	Peterson & Barney's average ('herd')
HGCW	474	1379	1710	Hillenbrand *et al.*'s average ('herd')
Lehiste(m)	435	1253	1550	Lehiste's classes III and IV

The F1 values for both the men and the women in this study are lower than in the other studies represented in Table 3.3. F2 values are lower for the women and for the men studied by Lehiste, but the present men's data are higher than either the Peterson & Barney or the Hillenbrand *et al.* data. The women's

F3 values are higher, and the men's lower than in those two studies, but again they are higher than the Lehiste data.

At least some of the differences may be the result of the differing data sets used in the studies summarized. Perhaps the best comparison is between the 'herd' tokens in this study, and those same tokens in the Peterson & Barney (1952) and Hillenbrand *et al.* (1995) studies. Even here, some differences, as described above, obtain.

The women in the present study produced the highest average F3, followed by the Peterson & Barney speakers, with the Hillenbrand *et al.*'s female speakers producing the lowest. Precisely the opposite relations apply to the men's data: the men in the present study produced the lowest average F3, with the Peterson & Barney speakers producing a slightly higher F3, and the Hillenbrand et al speakers the highest of all. These differences are rather small, and may result from differing measurement techniques, different numbers of speakers, and real, perhaps dialectal, differences between the populations studied.

3.3.3 *Formant scaling functions*

At this point, it may be useful to revisit the notion of formant scaling functions. Recall from Chapter 2 that Fant (1973) expressed the relationship between women's and men's formant frequencies as an implied constant K, defined as the difference between the target (woman's) frequency and the standard (men's) frequency, expressed as a percent of the standard. Fant's discussion makes it clear that K is not constant across vowel classes, nor even across formants within a vowel class. Thus, the predictive value of such a computation is questionable. However, as a descriptive tool it merits some discussion. The K-values computed over the syllabic /ɹ̩/ formant data are presented in Table 3.4.

Table 3.4. K-values (scaling factors) for syllabic /ɹ̩/ in this study.

	F1	*F2*	*F3*
Men's formants	**429**	1362	1679
Women's formants	477	1558	1995
K	**= 11.2**	**= 14.4**	**= 18.8**

As Table 3.4 demonstrates, the K-factor is not a uniform 20 at all frequencies, but increases with the number of the formant. (Note that this trend is the opposite of the global vowel data, discussed in Chapter 2.) Thus, the differences between men's and women's formant values for syllabic /ɹ̩/ increases with frequency. The computed K-values and their relationships will become more meaningful in Chapter 7, where the trends across allophones of /r/ are addressed in more detail.

3.4 Conclusion

American /r/, unlike the plain vowels, is rarely described as having formants *at* particular frequencies. Rather, it is described as having a third formant *usually below* 2000 Hz (e.g., Boyce & Espy-Wilson 1993, 1994). In the face of the present evidence, it is possible to refine that figure.

First, it is necessary to define 'usually below'. Interpreting 'usually' as something less than 'always' (more than 95% of the time, given a standard 5% acceptable error rate), but something more than a simple majority of cases, the frequency which F3 of /r/ is 'usually below' can be defined as the mean, plus one standard deviation. Assuming a normal distribution (perhaps a misleading assumption, particularly in the case of the present data), this would include over 80% of the cases. Given a positive skew, as when the frequencies distribute *above* a frequency floor, the absolute percentage would be higher.

This interpretation allows the observation that F3 of syllabic /ɹ̩/ usually drops below 1770 Hz for the men (1679 + 91) and 2340 Hz for the women (rounded from 1995 + 347). Using the mean plus one standard deviation as a metric is, of course, an arbitrary decision, but one based on real, quantifiable observations. This can only be an improvement over a very vague figure such as 2000 Hz.

Whether this is the best definition of a cut-off frequency for American [ɹ] is, of course, open to discussion. It was simply a convenient formula, easily calculated from the present data and easy to interpret. Formulae using percentiles, standard errors, and other methods of describing the distribution of measurements might be equally useful. The purpose of presenting these figures is not to suggest that they are the result of the best possible method of describing the 'critical' frequency, but merely to replace the less principled value of 2000 Hz with something more empirically defensible. That is, empirically valid figures of 1770 and 2340 Hz can be *tested* in a way that arbitrary values such as 2000 Hz cannot. Further, refining this 'critical' frequency in this way provides a way of describing how much higher women's formant can be, compared to men's.

Chapter 4. Formant frequencies of final /ɹ̯/

4.1 Introduction

The principal goal of this chapter is to expand the corpus of women's speech data by exploring formant frequencies of a non-syllabic allophone of /r/ in American English. /r/ also has syllabic (i.e. vocalic) and non-syllabic allophones and thus the available literature on vowel-formant differences can be brought to bear on segments which are not strictly speaking vowels. Further, syllabic /ɹ̩/ (described in the previous chapter) is historically related to post-vocalic /ɹ̯/. Thus, immediate comparisons between the formant frequency patterns in final /ɹ̯/ with those of syllabic /ɹ̩/ will be of historical as well as sociophonetic importance.

4.2 Procedures and tokens

The subjects and procedures used to gather the final /ɹ̯/ data are the same as described in Chapter 2. The words used in this study are listed in Table 4.1. These words illustrate /ɹ̯/ after five contrastive vowel categories. The ten plain vowels in this dialect of English reduce to five before final /ɹ̯/. The quality of these five categories will not be addressed in this study. Real English words were used whenever possible. The word "tear" was respelled as a proper name, "Tare", to avoid pronunciation ambiguity. These words illustrate /ɹ̯/ after five vowels with two distal consonants, /b/ and /t/. In order to test for possible effects of the distal consonant, additional words were added to illustrate a variety of distal consonants with a single adjacent vowel category. These additional words are marked with an asterisk (*). These words were excluded from all statistical analyses except when the effect of distal consonant was being tested.

Table 4.1. Words illustrating final /ɹ̯/.

beer			tier		
bear			Tare		
boor			tour		
bore	pour*	door*	tore	gore*	core*
bar			tar		

The 14 words presented in Table 4.1 were added to 55 others illustrating vowel phonemes and initial /ɹ/ in a variety of contexts. Details of the recording set up and measurement techniques are provided in Chapter 2. Each of the words in Table 4.1 appear three times in the recording script, and thus n=3 for each word for each speaker.

4.3 Results

The results obtained for each speaker are summarized in Table 4.2. The raw data are included in Appendix B. Table 4.2 presents averages across vowel contexts; that is, the averages of /ɹ̯/ in words presented in the 'bVɹ̯' and 'dVɹ̯' columns in Table 4.1. Table 4.2 excludes tokens gathered to test only for the effect of the distal consonant (those words marked with an asterisk in Table 4.1). Including those words would otherwise artificially weight the average toward the allophone of /ɹ̯/ following *o*.

Table 4.2. Formants frequencies (and standard deviations) of /ɹ/ by speaker.

	F1	*F2*	*F3*	
S1	606 (138)	1635 (213)	2080 (138)	**S1**
S2	595 (119)	1551 (129)	2084 (94)	**S2**
S3	645 (150)	1639 (126)	2189 (73)	**S3**
S4	399 (42)	1523 (158)	1956 (258)	**S4**
S5	568 (63)	1890 (106)	2799 (129)	**S5**
S6	467 (108)	1700 (168)	2466 (109)	**S6**
S7	492 (148)	1517 (181)	1975 (206)	**S7**
S8	537 (55)	1608 (151)	2022 (72)	**S8**
S9	489 (48)	1583 (120)	2053 (118)	**S9**
All women:	**532 (128)**	**1628 (186)**	**2181 (298)**	
Sa	408 (57)	1359 (126)	1743 (57)	**Sa**
Sb	426 (53)	1422 (154)	1795 (96)	**Sb**
Sc	435 (28)	1419 (91)	1827 (95)	**Sc**
Sd	457 (29)	1451 (137)	1844 (120)	**Sd**
Se	470 (28)	1342 (52)	1720 (45)	**Se**
Sf	424 (48)	1360 (143)	1679 (102)	**Sf**
All men:	**437 (47)**	**1392 (127)**	**1768 (106)**	

4.4 Discussion

4.4.1 No effect of distal consonant

A two-factor ANOVA was run over a subset of the database to determine if the identity of the distal (i.e. word-initial) consonant had any effect on the formants of the word-final /ɹ̯/. As expected, no such effect was noted. The results of the ANOVA are summarized in Table 5.3.

Table 4.3 Results of ANOVA on final /ɹ/. Main effects are speaker sex and distal consonant.

	F1		**F2**		**F3**	
Effect	*F-value*	*p-value*	*F-value*	*p-value*	*F-value*	*p-value*
Sex	50.383	<.0001	226.886	<.0001	180.715	<.0001
Distal C	.112	.9896	.672	.6454	.136	.9838
Sex * Distal C	.097	.9926	.419	.8355	.054	.9981

As Table 4.3 indicates, there is a main effect for speaker sex in each formant, but no significant effect for either the distal consonant, or the interaction between the two.

4.4.2 Effect of adjacent (preceding) vowel

In general, final /ɹ̺/ was found to have energy in at least three formants. Formants above F3, if they were visible at all, were much weaker. Where the syllabic /ɹ̩/s disucussed in the previous chapter were characterized by considerable steady states, such steady states were relatively uncommon in the final /ɹ/ data. The measurements of final /ɹ̺/ were taken around the F3 minimum, which was taken to be the center of the segment, into which the formants had to transition from the vowel, and out of which they had to transition toward the following consonant. As a result of these factors, it was often noticed that F2 and F3 had different timecourses through spectrogram.

As the spectrograms in Figure 4.1 suggest, F3 typically moved toward a minimum toward the end of the word, where presumably an /ɹ̺/ segment was centered. In BEER (the left most example) in Figure 4.1, the F2 during the vowel is higher than the F3 of the final [ɹ̺], and thus reaches a minimum in [ɹ̺] simultaneously with the F3. In the other examples, the F2 begins at or reaches some kind of vowel target, and then transitions smoothly through the [ɹ̺] to the end of the word. That is, F2, was not always 'steady' at the time of the F3 minimum, instead seeming to move from a frequency 'set' by the preceding vowel toward a frequency required by the following context ("twice" in the frame). This suggests that F2 is unspecified for a particular frequency 'target' in the sense of Keating (1990).

A two-factor ANOVA was run over a subset of the database, the /bVɹ̺/ and /tVɹ̺/ series, to test for effect of the adjacent vowel on the formants of /ɹ̺/. The results of this ANOVA are summarized in Table 4.4.

The ANOVA summarized in Table 4.4 indicates that there is a main effect of speaker sex, and another main effect for adjacent vowel in all three formants. There is also a statistically significant effect in F1 of the interaction between sex and vowel. By far the largest effect for vowel context, as indicated by the F-values in Table 4.4, was in F2.

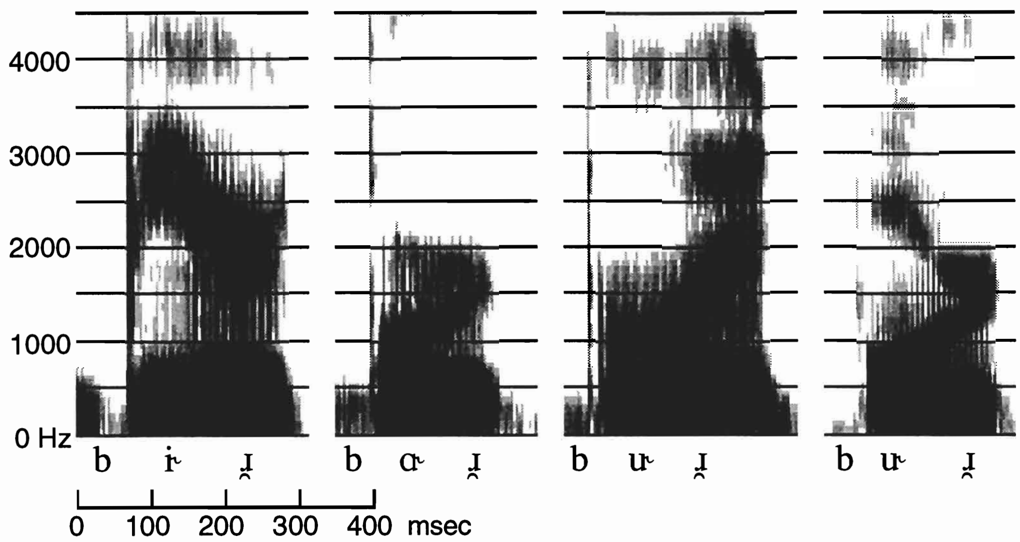


Figure 4.1. Wideband spectrograms of final /ɹ̯/. From left to right, tokens are BEER (Speaker 7), BAR (Sb), BOOR (S5), and BOOR (Se)

Table 4.4. Results of ANOVA on final /ɹ̯/. Main effects are speaker sex and adjacent vowel.

	F1		*F2*		*F3*	
Effect	*F-Value*	*p-value*	*F-Value*	*p-value*	*F-Value*	*p-value*
Sex	116.053	<.0001	384.531	<.0001	325.846	<.0001
Vowel	22.112	<.0001	80.959	<.0001	5.436	.0003
Sex*Vowel	2.591	.0362	.836	.5128	.100	.9825

Scheffe's F tests were performed on the pairwise differences between vowel contexts. The results of these tests are presented in Table 4.5. The precise qualities of these rhotacized vowels in this context were not measured, and will not be discussed here. This imprecision in both phonetic detail and phonological identity makes the use of particular phonetic symbols either inconvenient or misleading, and thus lower case, bold, italic letters are used to denote the vowel contexts in these tables and discussion which follows.

In F1, /ɹ̯/ after ***a***, differs significantly from all other contexts. Significant differences among the ***a***, ***e***, and ***i*** contexts indicate an effect for adjacent vowel height, at least among the non-back vowel contexts. A possible effect for backness or rounding of the vowel context is indicated by the significant differences between the ***i*** context on the one hand, and the ***o*** and ***u*** contexts on the other. However, the ***e*** context does not differ significantly from the back vowel contexts, making that explanation questionable.

In F2, again /ɹ̯/ the ***a*** context differs from all other contexts. The remaining significant effects suggest a strong effect of vowel-context backness on the F2 of /ɹ̯/. That is, the ***e*** context does no differ from the ***i*** context, nor the ***o*** context from the *u* context. However, vowel contexts that differ in backness lead to significant differences in the frequency of F2 of /ɹ̺/. This suggests a degree of assimilation of F2 values between /ɹ̺/ and the adjacent vowel context.

Table 4.5. Results of Scheffe's F-tests on preceding vowel contexts. P-values are listed by formant and context of pairwise comparison. Significant p-values are in boldface.

F1	*e*	*i*	*o*	*u*
a	**<.0001**	**<.0001**	**<.0001**	**<.0001**
e		**.0030**	.9866	.3438
i			**.0193**	.4551
o				.6716
F2	*e*	*i*	*o*	*u*
a	**<.0001**	**<.0001**	**<.0001**	**.0001**
e		.6716	**<.0001**	**<.0001**
i			**<.0001**	**<.0001**
o				.8430
F3	*e*	*i*	*o*	*u*
a	.2349	.0607	.9900	.9985
e		.9802	.0784	.1249
i			**.0139**	**.0256**
o				.9997

In F3, the only significant effects are in the ***i* - *o*** comparison and the ***i* - *u*** comparison. *i*, in these tokens is quite front, with a fairly high F2. By extension, it must also have a high F3, which appears to force the F3 of a following /ɹ̺/ upward. If the backness or rounding of the ***o*** and ***u*** contexts forces the F3 of the following /ɹ̺/ downward, then the frequencies being compared represent the extremes of a range of F3 values.

4.4.3 Effect of speaker sex and distribution of formant values

As seen in the previous sections, speaker sex has a significant effect on all three formants of /ɹ̺/, independent of contextual effects. On average, the women's formant values are significantly higher than the men's average.

Table 4.6. Scaling (K-) factors for final /ɹ̺/.

	F1	*F2*	*F3*
Men's formants:	**437**	1392	1768
Women's formants:	532	1628	2181
K	= 21.7	= 17.0	= 23.4

The K-scaling factors are presented in Table 4.6. In F1 and F3, the women's average was more than 20% higher than the men's formants. In F2, the difference was slightly less, 17%. These scaling factors (K-values) are higher than those found in the syllabic /ɹ̩/ data in Chapter 3, where none of the factors were greater than 20%. As a group, these K-values, more than the K-factors of syllabic /ɹ̩/, are near the neutral 20% mark predicted generally for men's and women's 'neutral' K-values.

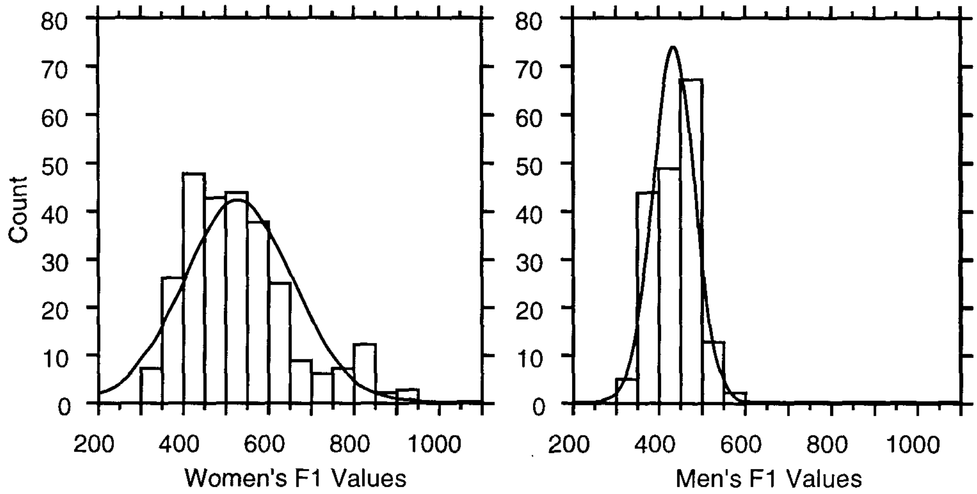


Figure 4.2. Histograms of women's (left) and men's (right) F1 values, in Hz.

Figure 4.2 illustrates the distribution of F1 values. The women's mean was 532 (128) Hz; the men's was 437 (47) Hz. Neither the women's nor the men's F1 values follow a strictly normal distribution. The women's F1 values exhibit a slight positive skew. On the other hand, the men's values are so narrowly distributed it is difficult to tell whether they exhibit a leptokurtic distribution or are distributed toward a ceiling near 500 Hz.

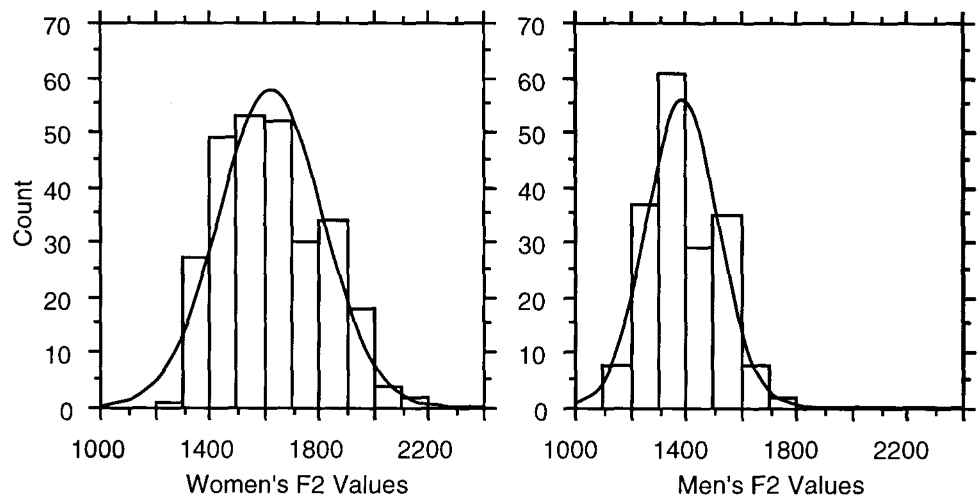


Figure 4.3. Histograms of women's (left) and men's (right) F2 values, in Hz.

The F2 histograms in Figure 4.2 show similar distributions. There is much less disparity between the distribution of tokens near the mean between the sexes in F2. The women show a slightly larger standard deviation and a higher mean than the men, but both curves appear to approach a normal distribution.

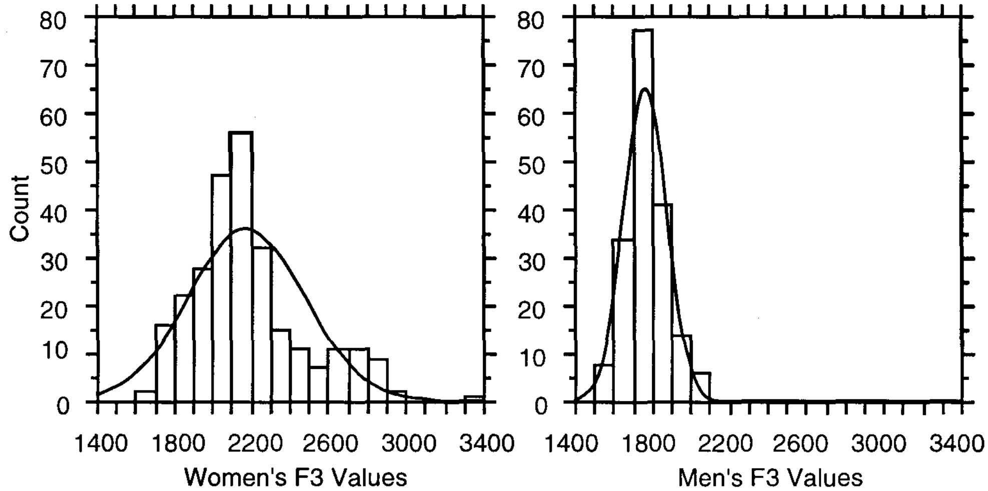


Figure 4.4. Histograms of women's (left) and men's (right) F3 values, in Hz.

The women's distribution of F3 values appears to be bimodal, with one mean just below the grand mean, and a second mean around 2700 Hz. This second, higher mean represents principally the tokens produced by Speaker 5, whose individual mean was 2799 Hz. That is, the apparent second mode in the left half of Figure 4.4 represents a single speaker, and thus should not be thought of as a second mode so much as a particular, outlying speaker.

It should be noted that only two of the nine female speakers produced F3 averages below 2000 Hz. These two also exhibited the highest individual standard deviations. That is, the vast majority of women's tokens of /ɹ̺/ appear to have F3's distributed around a mean just above 2000 Hz, even taking into acount the extremely high F3 values routinely produced by Speaker 5.

These data illustrate again the apparent pattern of men agreeing on an extremely narrow target window for the formants of /ɹ̺/. The women's data are distributed over a broader range. Even though the women's database is larger, including three more speakers than the men's database, the women exhibit more inter-speaker variance than the men.

4.5 Conclusion

In the previous chapter, a definition of that frequency which F3 of /r/ 'usually' drops below was proposed: the mean, plus one standard deviation. Applying that metric to the final /ɹ̯/ data, the women's F3 usually drops below 2479 (2181 + 298) Hz; the men's F3 usually drops below 1874 (1768 + 106) Hz. Seven of the nine women have individual F3 averages of final /ɹ̯/ *above* 2000 Hz; the two speakers with F3 averages below 2000 Hz were within 50 Hz of the 2000 Hz mark, and had the largest inividual standard deviations of all the women in the study (S4, 1956 (258); S7, 1975 (206)). Thus, it would be inaccurate to describe the F3 of women's final /ɹ̯/ as 'usually' dropping below 2000 Hz.

On the other hand, the traditional 2000 Hz figure is still too high to describe the 'usual' tendency of the male speakers in this study. Thus the replacement with that vague, round figure with more accurate, empirically justified figure is a significant advance. To the degree that researchers include real or presumed women's data in citing the 2000 Hz figure (Espy-Wilson 1987; Boyce & Espy-Wilson 1993, 1994), the current data clearly indicate that the women's formants, even in F3 of /ɹ̯/, are generally higher than men's as predicted by general acoustic theory. Unlike the syllabic /ɹ̩/ case, the women's formants of final /ɹ̯/ are all near the 20% higher mark.

However, the greater speaker-to-speaker variation in the women's data makes it difficult to determine the degree to which this is true for individual speakers. Clearly Speaker 5 has a *much* higher F3 frequency than the rest of the women. However, most of the women have individual F3 have averages above 2000 Hz, near the frequency that might be expected if a 20% difference between the average men's F3 value is considered (1768 Hz * 1.20 = 2122 Hz.) Some of the women in this study appear to produce formant frequencies which are roughly analogous to the men's formants, given their shorter vocal tracts. However, others, particularly S5, appear to diverge from this pattern. The data clearly indicate a trend toward higher formant frequencies for women than for men, all else being equal. This is predicted under general acoustic theory in that women, as a population, have shorter vocal tracts than men.

Chapter 5. Formant frequencies of initial /ɹ/

5.1 Introduction

It is the goal of this chapter to further elucidate the issues of speaker sex differences in formant frequency, by turning attention to a clearly non-vocalic allophone of /r/. In this chapter, initial /ɹ/ data are considered. Like other allophones, initial /ɹ/ is characterized by a relatively low third formant. However, it exhibits variation in voicing, amplitude, and frequency which was not found in other allophones. These are argued to be the product of an enhancement of the boundary between the consonantal [ɹ] and the following vowel by 'strengthening' its consonantality. While some interaction with following vowels is observed, it is not the case that the F2 of /ɹ/ appears dependent on the F2 of the following vowel in the same sense that it was in final /ɹ̯/. Speaker sex is still the primary source of variation in formant frequency, although in this case the women's data clearly show a bimodal distribution.

5.2 Procedures and tokens

The subjects and procedures used to gather the initial /ɹ/ data are the same as described in Chapter 2. The words used in this study are listed in Table 5.1. These words illustrate /ɹ/ before nine contrastive vowel categories. All ten plain vowels in this dialect of English can, in principle, be found in monosyllabic words after word-initial /ɹ/. However, number of such words illustrating a /ɹʊ/ sequence is extremely limited. "Rook" is the only common monosyllabic word with that sequence of sounds; pronunciations of "room", "root" and "roof" with [ʊ] are available only occasionally in this dialect. It was determined by informal survey that these pronunciations could not be reliably be elicited from the southern California population.) The /ʊ/ quality was eliminated from this dataset because it could only be demonstrated in a word like "rook", and thus could further confound the balanced dataset(s) illustrated in Table 5.1.

Real English words and proper names were used whenever possible. The word "writ" was respelled as a proper name, "Ritt", to make it look less unusual in the recording script. Slang terms such as 'rep' and 'rad' were deemed to be common enough for this population to be acceptable. Occasionally, words with an appropriately voiced distal (final) consonant were not available. In such cases, words as close as possible were substituted. These are indicated by "⇒" and "⇐" in the appropriate column, pointing to the substituted word.

Table 5.1. Words illustrating initial /ɹ/.

reap			reed		
rip	rib*	Ritt*	rid	Rick*	rig*
rape			raid		
rep			red		
rap			rad		
⇒	rube		rude		
rope			rode		
⇒	rob		rod		
⇒	rub	**rut**	⇐		

Additional words, marked with an asterisk (*) in Table 5.1 were added to test for possible effect for place or voicing of the distal consonant. These were excluded from most statistical analyses, except when the effect of distal consonant was being tested.

5.3 Results

The results obtained for each speaker are summarized in Table 5.2. The raw data are included in Appendix B. Table 5.2 presents averages across vowel contexts; that is, the averages of /ɹ/ in words presented in the 'rVP' and 'rVD' contexts (supplemented as necessary with other words as indicated in Table 5.1). The effects of the different vowels will be discussed later. Table 5.2 excludes tokens gathered to test only for the effect of the distal consonant (those words marked with an asterisk in Table 5.1). Including those words would otherwise artificially weight the average toward the allophone of /ɹ/ preceding /ɪ/.

Table 5.2. Formant frequencies (and standard deviations) of /ɹ/ by speaker.

	F1		*F2*		*F3*		
S1	288	(39)	1082	(71)	2203	(163)	S1
S2	270	(35)	1159	(82)	2293	(142)	S2
S3	286	(52)	1180	(57)	2081	(255)	S3
S4	340	(58)	1248	(134)	1709	(189)	S4
S5	373	(76)	1527	(91)	2556	(123)	S5
S6	348	(60)	1216	(149)	2290	(208)	S6
S7	297	(38)	1053	(118)	2057	(324)	S7
S8	327	(63)	1081	(118)	1753	(117)	S8
S9	366	(53)	1266	(88)	1768	(130)	S9
All women:	**322**	**(64)**	**1201**	**(171)**	**2079**	**(335)**	
Sa	261	(19)	991	(67)	1489	(122)	Sa
Sb	309	(42)	1148	(138)	1599	(94)	Sb
Sc	305	(23)	1051	(74)	1540	(81)	Sc
Sd	295	(31)	993	(119)	1488	(96)	Sd
Se	323	(20)	979	(61)	1543	(80)	Se
Sf	290	(28)	957	(127)	1437	(87)	Sf
All men:	**297**	**(34)**	**1020**	**(120)**	**1516**	**(107)**	

5.4 Discussion

5.4.1 Factors effecting measurements of initial /ɹ/

Initial /ɹ/ proved to be more difficult to measure than the other allophones, since word- and perhaps syllable-initial /ɹ/s are subject to a variable process of *fortition.* If vowels are characterized by steady state formants and relatively long transitions, and consonants are typically characterized by abrupt changes in amplitude and frequency (Stevens 1980), *fortition* can be said to apply when a relatively 'weak', i.e. vowel-like, segment is made stronger by introducing sharper-than-usual changes in amplitude and/or frequency. Thus, under fortition, an approximant /ɹ/ will appear acoustically more quiet in its steady state, with a sudden increase in amplitude associated with the 'edge' of an adjacent vowel.

Fortition of initial /ɹ/ varies within and across speakers. Some tokens have very lenis initial /ɹ/s, with full voicing supporting the first three formants (and sometimes higher formants) in the wide-band spectrograms, as illustrated in Figure 5.1.

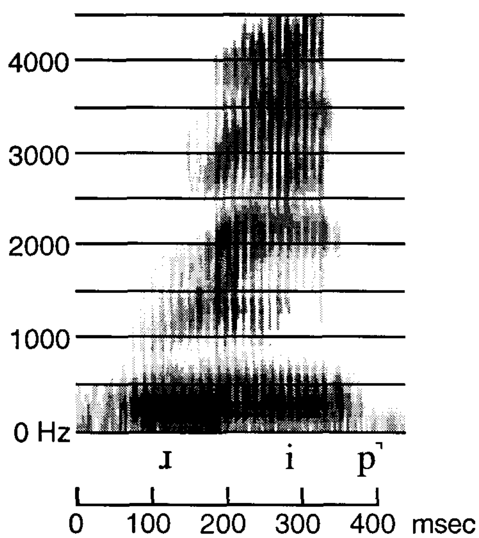


Figure 5.1. Wide-band spectrogram of lenis [ɹ] (REAP, Speaker C).

Other tokens exhibit relatively weaker higher formants, such that little or no energy can be discerned above F1 during the steady state portion of the initial /r/, as illustrated in Figure 5.2.

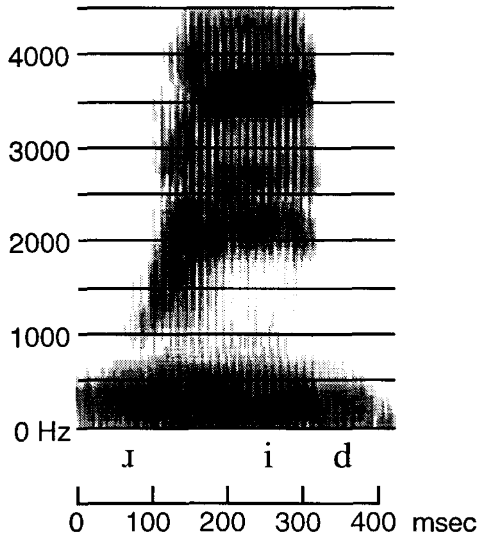


Figure 5.2. Wide-band spectrogram of a fortis [ɹ] (REED, Speaker C).

It is interesting to note that the examples in Figures 5.1 and 5.2 were produced by the same speaker; in fact, they were from adjacent utterances. Note that the token in Figure 5.2 appears to have a fully voiced initial [ɹ] as well as a fully voiced final [d], as indicated by the low-frequency 'voicing bar', taken to be the F1 of the /ɹ/.

Lehiste (1962), in describing her initial /ɹ/ data, refers to a similar state of affairs for one of her speakers: "... [A]ll informants used a sound that had a steady state and little or no friction; one of the informants (Ch) had very little intensity above the second formant region." (p. 61) However in the present data, if there is energy in F2 there is usually also energy in F3. Further, the weakening of energy in the formants here appears to be a feature of the dialect, rather than an idiolectal property of a particular speaker.

Initial /ɹ/ can also be represented by an apparently voiceless, but otherwise fully realized segment (Figure 5.3).

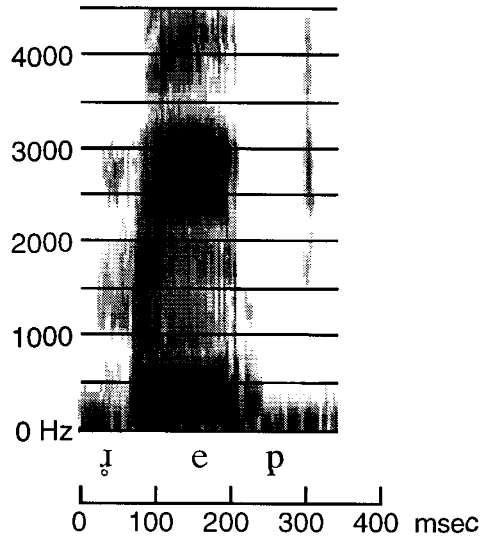


Figure 5.3. Wide-band spectrogram of a voiceless [ɹ̥] with aspiration noise supporting formant information (RAPE, Speaker 4).

Still other tokens exhibit almost no energy prior to the onset of full voicing and transitions into the vowel. That is, the initial /ɹ/ is represented not as a segment with an apparent steady state duration, but merely as a function of transitions at the onset of a vowel, as in Figure 5.4.

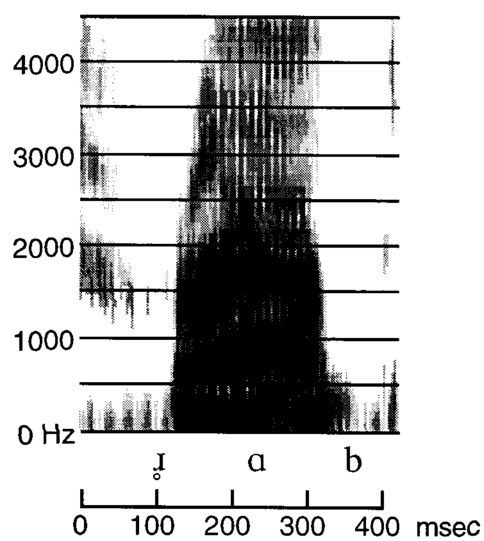


Figure 5.4. Wide-band spectrogram of a voiceless [ɹ̥] (the edge of a vowel; ROB, Speaker 5).

Note in Figure 5.4 that the aspirated release preceding the putative /ɹ/ segment is very strong, and shows lowering transitions. In contrast during the expected /ɹ/ steady state, neither voicing nor aspiration noise supports formant information, except weakly in F2.

These various manifestations of acoustic 'strengthening' of the consonantility of /ɹ/ may form a continuum. Until careful amplitude, spectral, and temporal measurements are made, this must be regarded as speculation.

It is clear, however, that as formant structure of a steady state /ɹ/ becomes less well represented in the signal, the formant frequencies of /ɹ/ become more difficult to measure. If a steady state was indicated, then an indication of any energy in the segment was taken as higher formant information, along with supplemental information from the following transitions. In cases where there was no higher energy apparent in the steady state, or where no steady state could be discerned, the frequency of the formants was determined by the frequency at the edge of the transitions.

In addition, it became apparent that the formants of an initial /ɹ/, even a high-amplitude, relatively lenis, /ɹ/ did not always seem to represent 'lowered' formants otherwise present. In the case of final /ɹ/, the time course of the formants suggested that the lowered formants of /ɹ/ were the result of perturbing the frequencies of the regular formants. That is, the F3 at the minimum was a point in a continuous, if time-varying, band of energy. It was relatively clear that in the vast majority of cases, the F3 in the vowel lowered into the /ɹ̯/, reached some minimum value, and then rose away from the minimum.

In initial /ɹ/, sometimes the F3 of /ɹ/ appeared continuous with the F3 of the vowel; other times, F3 appeared to be continuous with F2 in the vowel, and the second resonance of the /ɹ/ appeared to rise sharply, cross the higher resonance, and become the F3 of the vowel. It is not always clear which interpretation should be taken. The example in Figure 5.5 appears to be open to either interpretation.

Part of this effect is undoubtedly due to frequency of F2 in the following vowel. However, if this interpretation is correct, and the F3 of initial /ɹ/ should ever be taken to represent the 'neutral' second resonance of the vocal tract configuration, then the F2 of the /ɹ/ must be the result of some other acoustic resonance, perhaps a side cavity around the tongue as suggested by Boyce & Espy-Wilson (1994), or a sublingual (or pre-lingual) cavity in the anterior mouth formed by retroflexion of the tongue blade. The resolution to this problem must wait until dynamic (i.e. time-varying) measurements of these or similar data can be made, and the results modeled accurately.

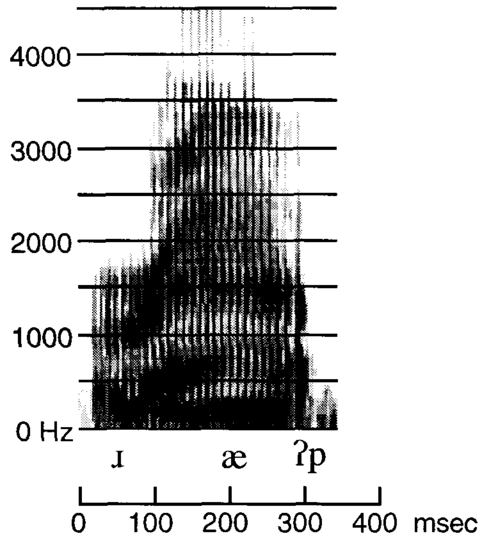


Figure 5.5. Wide-band spectrogram of RAP (Speaker F).

At present, all that can be said is that initial /ɹ/ appears to possess an acoustically different character from final and syllabic /ɹ/. A traditional discussion of static formant frequency must be regarded as only the first step in a complete description of this speech sound. Formant frequencies are expected to show physiologically motivated speaker-sex effects, in a way that dynamic aspects of the speech signal (such as fortition) are not, and thus serve the goals of the present study.

5.4.2 *No effect of distal consonant*

A two-factor ANOVA was run over the subset of the database illustrating /ɹɪ/ sequences followed by various final consonants. The identity of the distal consonant varies over three places of articulation and in voicing for a total of six types. No effect for distal consonant, nor any interaction between distal consonant and speaker sex was found, as illustrated in Table 5.3. Significant effects for speaker sex were found in every formant.

Table 5.3. Results of ANOVA on initial /ɹ/. Main effects are speaker sex and distal consonant.

	F1		F2		F3	
Effect	*F-value*	*p-value*	*F-value*	*p-value*	*F-value*	*p-value*
Sex	33.974	<.0001	85.069	<.0001	294.595	<.0001
Distal C	.892	.4869	.931	.4616	.254	.9377
Sex * Distal C	.760	.5793	.298	.9137	.161	.9764

In interpreting these results, it is important to remember that the database was not structured in such a way as to test interactions between distal consonant and adjacent vowel. That is, these data demonstrate no distal consonant effect only with an intervening /ɪ/ vowel, and not for all possible manners of articulation. From these data, it is inferred that distal consonant has no effect on the formants of an initial /ɹ/. However, it is at least conceivable that such an effect would occur over some other vowel category, or effects for distal consonant might be found with some other set of distal consonants.

5.4.3 *Vowel context and distribution of formant frequencies*

A two-factor ANOVA was run over the subset of the database illustrating /ɹ/ with nine adjacent vowels and two distal consonants. The main effects were speaker sex and adjacent vowel. The results are summarized in Table 5.4.

Table 5.4. Results of ANOVA on initial /ɹ/. Main effects are speaker sex and adjacent vowel.

	F1		**F2**		**F3**	
Effect	*F-value*	*p-value*	*F-value*	*p-value*	*F-value*	*p-value*
Sex	40.085	<.0001	280.444	<.0001	870.304	<.0001
Vowel	4.355	<.0001	3.584	.0004	3.075	.0020
Sex * Vowel	1.109	.3543	.355	.9435	.329	.9550

As Table 5.4 indicates a large and significant main effect for speaker sex is found in every formant. Smaller significant effects are found for adjacent vowel. No interaction was found.

To clarify the effects of vowel context, Scheffe's F-tests were run post hoc on the vowel context data. The results are summarized in Table 5.5.

As Table 5.5 indicates, very few of the pairwise vowel-context comparisons show a significant effect. Specifically, F1 and F3 of /ɹ/ before /i/ are different from /ɹ/ before /ɑ/, as is F3 of /ɹ/ before /ɪ/ from /ɹ/ before /ɑ/. Thus, the Scheffe's tests indicate that, while there are some contextual effects on initial /ɹ/, these are very small overall, and only approach significance when considering pairings of the most peripheral vowels. The significant effects found in the ANOVA, particularly in F2, suggest that the effect of adjacent vowel is gradient, or involves classes of vowels, rather than individual vowel pairings. In short, the formants of the initial allophone are much more independent of contextual effects than post-vocalic /ɹ̯/.

The data for the first and second formants, both the men's and women's data show near normal distributions with slight positive skews. The women's formant averages are higher than the men's, and their standard deviations are larger.

Table 5.5. Results of Scheffe's F-tests on vowel context differences in initial /ɹ/.

F1	*i*	*ɪ*	*e*	*ɛ*	*æ*	*u*	*o*	*ɑ*
ɪ	.8766							
e	.6805	>.9999						
ɛ	.9530	>.9999	.9998					
æ	**.0274**	.7436	.9197	.5907				
u	.9999	.9906	.9359	.9987	.1348			
o	.9934	.9998	.9945	>.9999	.3649	>.9999		
ɑ	**.0136**	.6191	.8462	.4580	>.9999	.0795	.2538	
ʌ	.9906	>.9999	.9959	>.9999	.3857	>.9999	>.9999	.2707

F2	*i*	*ɪ*	*e*	*ɛ*	*æ*	*u*	*o*	*ɑ*
ɪ	>.9999							
e	.9868	.9859						
ɛ	.8659	.8585	>.9999					
æ	.3857	.3691	.9598	.9988				
u	>.9999	>.9999	.9985	.9550	.5757			
o	.4717	.4552	.9784	.9996	>.9999	.6631		
ɑ	.1861	.1735	.8415	.9822	>.9999	.3295	>.9999	
ʌ	.2915	.2761	.9224	.9955	>.9999	.4676	>.9999	>.9999

F3	*i*	*ɪ*	*e*	*ɛ*	*æ*	*u*	*o*	*ɑ*
ɪ	>.9999							
e	.9957	.9759						
ɛ	.9967	.9799	>.9999					
æ	.9795	.9259	>.9999	>.9999				
u	>.9999	.9994	>.9999	>.9999	.9991			
o	.8763	.7335	.9996	.9994	>.9999	.9794		
ɑ	**.0260**	**.0083**	.3069	.2878	.4640	.0925	.7577	
ʌ	.7819	.6028	.9974	.9965	.9998	.9466	>.9999	.8504

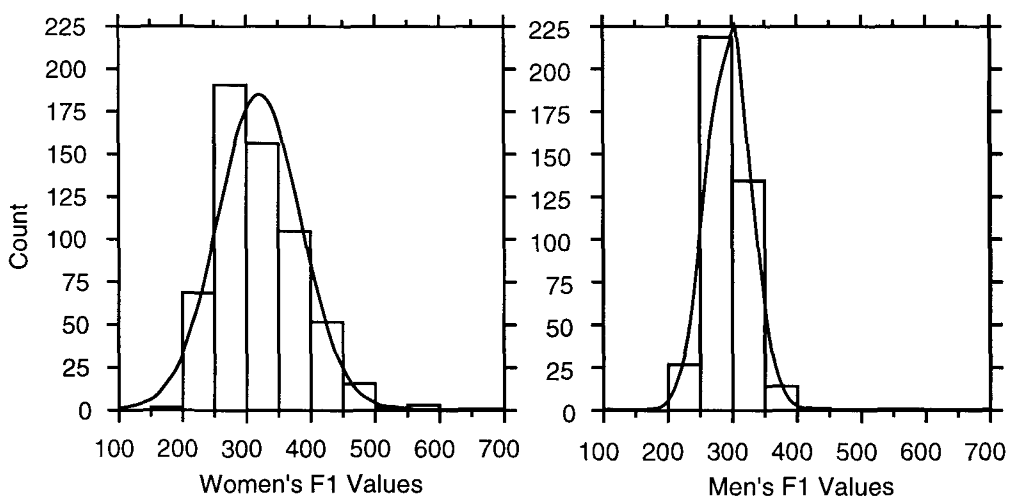


Figure 5.6. Histograms of women's (left) and men's (right) F1 values, in Hz.

Figure 5.6 illustrates the distribution of F1 values. The women's mean was 322 (64) Hz; the men's was 297 (34) Hz. These values are extremely low. This would indicate an extremely narrow constriction in the vocal tract, as with high vowels. In this case, the extremely low measured F1 values are *lower* than those measured for syllabic /ɹ̩/, indicating that the aperture in initial /ɹ/ is narrower than for syllabic /ɹ̩/. The measured F1 frequencies, in fact, appear to be more related to the lowest harmonics of the voicing source, rather than the resonance properties of the vocal tract. Compare the apparent first formant of [ɹ] with the voicing bar in the final [d] in Figure 5.2.

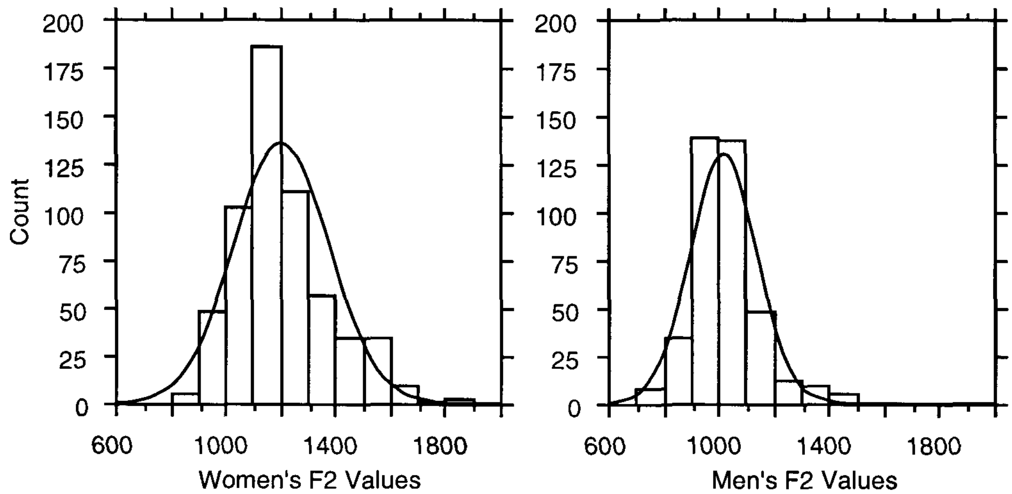


Figure 5.7. Histograms of women's (left) and men's (right) F2 values, in Hz.

The F2 histograms in Figure 5.7 again show nearly normal distributions. In all the data presented in the present studies, this is the only occasion in which the nine women together produce *more* tokens in a their modal range (1100-1200 Hz), than the six men in theirs. The distributions appear nearly normal with a slight positive skew. The women's mean is almost 200 Hz higher than the men's (1201 (171) Hz vs. 1020 (120) Hz).

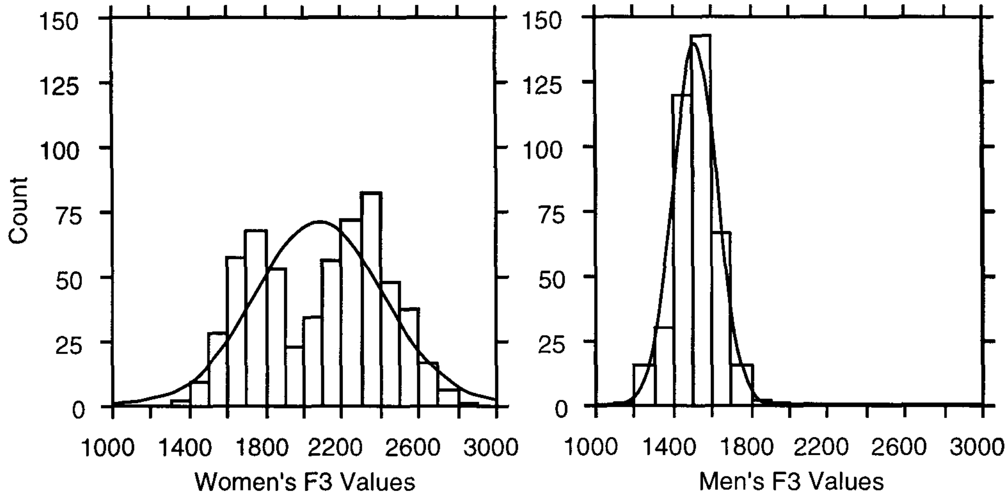


Figure 5.8. Histograms of women's (left) and men's (right) F3 values, in Hz.

As Figure 5.8 illustrates, the women's third formant measurements of initial /ɹ/ clearly show a bimodal distribution. The formant averages presented in Table 5.2 suggest that the women can be divided into three groups: women with a relatively low average F3 (S4, S8, and S9, whose F3 averages 1700-1800 Hz), women with a relatively high F3 (S1, S2, S5, and S6, whose average F3 was above 2200 Hz), and women with averages near the grand mean, but with relatively large standard deviations (S3 and S7). (Recall from the previous chapter that S7 also exhibited a large standard deviation in her F3 of final /ɹ̥/.)

Looking closely at the distribution of measured F3 values in S3 and S7, it is apparent that they may also exhibit a bimodal distribution within their own productions. These are illustrated histographically in Figure 5.9.

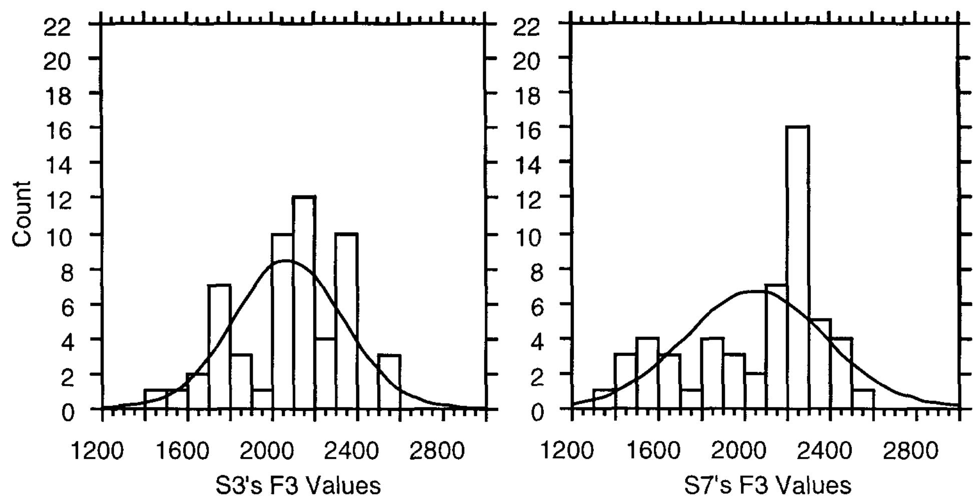


Figure 5.9. Histograms of S3's (left) and S7's (right) F3 values, in Hz.

With this in mind, another ANOVA was run over the F3 data, dividing the women into two groups: those whose means were below the grand mean (S4, S7, S8, S9) and those whose means were above the grand mean (S1, S2, S3, S5, S6). S3 and S7 were assigned to their respective groups based on their individual means, and thus these groups represent at least a partially arbitrary division among female speakers. The group averages are presented in Table 5.6. The results of the ANOVA are summarized in Table 5.7.

Table 5.6. Group F3 averages in Hz, given a three-way distribution of F3 values.

Men(F3)	1516	(107)
Women(HiF3)	2285	(241)
Women(LoF3)	1822	(248)

Table 5.7. Results of ANOVA on F3 data. Hi/Lo category has three values: Women(HiF3), Women(LoF3), and Men.

Effect	*F-value*	*p-value*
Hi/Lo	1147.648	<.0001
Vowel	7.563	<.0001
Hi/Lo * Vowel	.995	.4604

The results of Scheffe's F post hoc tests are summarized in Table 5.8 (Hi/Lo category effects) and in Table 5.9 (vowel context effects. As can be seen in Table 5.8, the men's group, the women's high F3 group, and the women's low F3 group were all significantly different from one another. It is perhaps worth noting that all of the men's individual F3 averages were below 1700 Hz, whereas all of the women's individual averages, including those in the 'low F3' group, were above 1700 Hz.

Table 5.8. Results of Scheffe's F-tests on F3 grouping.

	p-value
Women(HiF3), Women(LoF3)	<.0001
Women(HiF3), Men'sF3	<.0001
Women(LoF3), Men'sF3	<.0001

Table 5.9. Results of Scheffe's F-tests on vowel context differences in initial /ɹ/, given a 3-way grouping of F3 values.

F3	*i*	*ɪ*	*e*	*ɛ*	*æ*	*u*	*o*	*ɑ*
ɪ	>.9999							
e	.9605	.8714						
ɛ	**.9682**	.8893	>.9999					
æ	**.8584**	.6910	>.9999	>.9999				
u	**.9997**	.9955	.9996	.9997	.9921			
o	**.5081**	.3086	.9960	.9944	.9999	.8742		
ɑ	**<.0001**	**<.0001**	**.0258**	**.0219**	.0758	**.0015**	.3204	
ʌ	.3310	.1726	.9783	.9725	.9978	.7376	>.9999	.4780

Comparing Table 5.8 to Table 5.5, the number of significant vowel context effects increases if the three-way grouping of F3 values is taken into account, although they all involve the /ɑ/ vowel.

There is a strong effect for speaker sex on all three formants of initial /ɹ/. Within the women's data, there is a significant bimodal distribution of F3 values, with two of the nine women appearing to mirror, to some extent the bimodal distribution of the group within their own productions. There is a weaker effect of adjacent (following) vowel context on the formants of /ɹ/, although these are clearly significant only for particular vowel pairs, usually representing the extremes of the F1 and F2 continua. That is, if there is a significant effect for any vowel, it will involve at least one, and usually two, vowels in the peripheries of the F1xF2 vowel space.

ANOVAs also showed small but statistically significant differences between the two groups of women in the lower formants (average differences were 19 Hz in F1, 71 Hz in F2). While statistically significant, the relatively small numbers in each group when coupled with the small differences in average formant frequency suggest that these differences should be discounted as random, particularly in the case of F1.

5.4.4 *Speaker sex scaling factors*

As the ANOVAs in the previous sections indicate, there is a strong effect for speaker sex in all three formants of initial /ɹ/. The bimodal distribution of women's F3 values poses clear problems for the notion of formant scaling. That is, one cannot assume, in light of the present data, that the women's formant values bear any trivial relationship to the men's formant values. This is because the women, as a group, do not exhibit data which follows a unitary distribution, but rather represents a distribution into two distinct formant ranges, either of which is acceptable for the third formant of /ɹ/.

Table 5.10. Scaling (K-) factors for initial /ɹ/.

	F1	*F2*	*F3*
Men's formants:	**297**	1020	1516
Women's formants:	322	1201	2079
K	**= 8.4**	**= 17.7**	**= 37.1**
	Women's (HiF3):		2285
	K(Hi)		**= 50.7**
	Women's (LoF3):		1822
	K(Lo)		**= 20.2**

This is demonstrated more concretely in Table 5.10, in which the K-scaling factors are presented for all three formants. In the case of the third formant, the grand mean, the women's high F3 mean (averaged over speakers S1, S2, S3, S5, and S6), and the women's low F3 mean (S4, S7, S8, S9) are presented.

The disparity in K-values between the two subgroups of women indicates that there is little hope in generalizing the notion of formant normalization as a function of speaker sex. Further, it suggests that there are multiple acoustic mechanisms used to produce the 'lowered' formants characteristic of initial /ɹ/. The women in this study appear to utilize at least two; one which produces third formant frequencies below 2000 Hz, and one which produces frequencies above 2000 Hz. The women's "Low F3" group produces third formant values which are about 20% higher than the men's F3. The "High F3" group, in contrast, produce F3 values of initial /ɹ/ which are considerably higher than the men's F3, but still much lower than a neutral F3 for a vocal tract length of 13 cm.

It should be noted at this point that the phenomenon discussed above as 'fortition' is not an adequate explanation of the bimodal distribution of F3 values in the women's data. As discussed earlier, fortition is a process which is variable within as well as between speakers. At least some of the variance in the frequency measurements of initial /ɹ/ is attributable to variable measurement techniques required by attempting to measure segments under varying degrees of fortition. However, fortition occurred to varying degrees in both the male and female data studied here. The men did not show a bimodal distribution of F3 values; appealing to fortition as an explanation of the bimodal distribution in the women's data does not explain the *unimodal* distribution of F3 frequencies among the men.

5.5 Conclusion

The initial allophone of /ɹ/ was more difficult to measure than either the syllabic or final allophones, partially because variable fortition made it difficult to consistently identify a 'target' or steady state F3 associated with an initial /ɹ/ segment. Fortition takes a presumably fully-voiced segment with at least three high-energy formants and makes it appear more 'consonantal' by reducing the acoustic energy in the segment, thus increasing the salience of the segmental 'edge' between the consonantal /ɹ/ and the following vowel. Fortis /ɹ/ can be acoustically silent, and thus the formant frequencies associated with it must be identified by the transitions into the vowel; it can be voiceless, and thus have weak formants supported primarily by aspiration noise; it can be voiced, but have appreciable energy only in a low-frequency first formant.

A significant effect for speaker sex was found in all three formants. Among the men, the F3 average was 1516 (107) Hz. Among the women, a bimodal distribution of F3 values was noted: the lower mode has an average of 1822 (248) Hz; the higher mode has an average of 2285 (241) Hz. The F3 frequencies of the two groups of women were found to be significantly different; both groups were significantly different from the men.

A significant effect for following vowel context was found, but pairwise comparisons of vowel context differences revealed that the relatively extreme formant values if /i/ and /ɑ/ were probably the most significant contributors to this effect on the formants of initial /ɹ/.

The precise reason for the bimodal distribution in the women's data has not been determined. Fortition by itself is not a useful explanation of the bimodal distribution. American /r/ is known to have several articulatory variants, but that these do not lead to significant differences in the frequency of the first three formants (e.g. Uldall 1952, but see Boyce & Espy-Wilson 1994 for a discussion of the higher formants). Whether different articulatory configurations can be used to explain the bimodal distribution of women's F3 values in initial /r/ will be addressed in more detail in the next chapter.

Chapter 6. Probe-contact study of American /r/[1]

6.1 Introduction

When describing American English, writers will sometimes make reference to the use of two distinct tongue shapes associated with American /r/: one *retroflex*, with the tip of the tongue raised; the other *bunched*, with the tip of the tongue retracted and pointed down, commenting that these two articulatory configurations, though very different, both have similar effects on the acoustic speech signal. For instance, Ladefoged (1993:84) writes,

> Some speakers have the tip of the tongue raised, as in a retroflex consonant, but others keep the tip down and produce a high bunched tongue position. These two gestures produce a very similar acoustic effect.

However, Delattre & Freeman (1968) demonstrated that a wide variety of tongue shapes are used by American speakers to produce approximant [ɹ], rather than only two. These they divided into six types, varying chiefly in the location and shape of the oral constriction.

Figure 6.1 is derived from the X-ray tracings published by Delattre & Freeman (1968), and corresponds to Delattre & Freeman's Types 2 through 7. (Delattre & Freeman present examples of a total of eight tongue shapes, Types 1 and 8 being used only by the British English speakers in their study.) Type 7 is the only one of the six tongue shapes in Figure 1 which can properly be regarded as 'retroflex'. Type 3 is perhaps the most 'canonical' example of a bunched tongue shape. Type 2 is probably best regarded as a schwa-like configuration, such as are used for post-vocalic /r/ in some 'non-rhotic' dialects of English.

Delattre & Freeman apparently regarded the six tongue shapes as a continuum. This continuum may be defined as lying between two extremes, the traditionally described bunched (Type 2) and retroflex (Type 7) tongue shapes. However, writers may refer to the two extremes, ignoring or omitting reference to the 'intermediate' tongue shapes described by Delattre & Freeman. Unfortunately, this may leave many readers with an oversimplified view of the articulations of American /r/. This difficulty is compounded by the idea that retroflex and non-retroflex articulations alike produce an acoustic effect which

---

[1]A portion of this chapter is based on Hagiwara (1994a).

has itself been referred to as 'retroflexion', but is more properly labeled 'rhoticity': the characteristic lowering of the third formant.

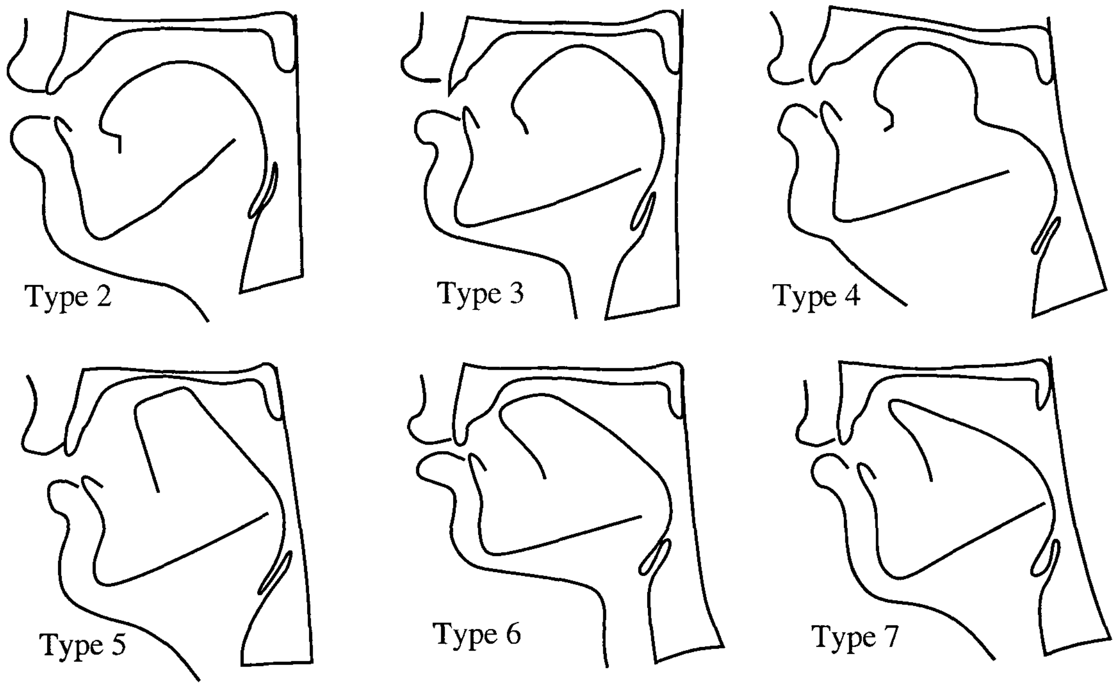


Figure 6.1. Sagittal diagrams of six tongue shapes used for American /r/ (after Delattre & Freeman, 1968).

It should be remembered that any description of the articulation of American /r/ that relies on observations of the anterior mouth will necessarily be incomplete. Delattre & Freeman (1968) show in their X-ray tracings that American /r/ is usually accompanied by a constriction in the pharynx. It can also be seen in Figure 6.1 that precise shape of the tongue in the posterior mouth shows considerable variation. Imaging the pharynx and the posterior mouth is extremely difficult. Traditional X-ray cineradiography is dangerous to the subject; X-ray microbeam and electromagnetic articulometry systems do not allow tracking of movements of the tongue root. Magnetic resonance imaging and other systems are extremely expensive and do not have the time-resolution necessary to analyze real-time speech. Thus, a simplified view of American /r/ as either bunched or retroflex might be useful descriptively, as long as the articulations of American /r/ can be accurately classified by using what can be observed in the anterior mouth — that is, whether the tongue tip points up or down. The position of the tongue tip can be deduced by inserting a probe into the mouth during articulation.

The goals of the study presented here are a) to investigate how probe-contact testing can be used to reveal the characteristics of the oral constriction during the articulation of American /r/, b) reveal whether or not this information can inform the observations made on acoustic data in early chapters, and c) demonstrate how a relatively simple technique can be used to elicit important articulatory data which cannot otherwise be observed.

6.2 Methods

6.2.1 Testing procedure

In this study, a probe was inserted into the mouth while the speaker articulated /r/ in a variety of contexts. Cotton swabs were used as probes. The tip of the swab was soaked in an iodine preparation to ensure sanitary conditions. Under the direction of the investigator, the subject was asked to insert the probe between the upper and lower incisors, in the midline of the occlusal plane, while articulating the target sound. The subject was then asked to hold the probe against the tongue and to show the investigator where the contact is made. This procedure was repeated until the subject and the investigator were satisfied that a consistent pattern was identified, never more than five repetitions per test allophone (initial, final, syllabic). Typically, three trials were ample.

Because the sound must be sustained long enough for the probe to be inserted, the easiest allophone of /r/ to test in this manner is the syllabic [ɹ̩], as in 'bird' or 'fur'. However, with a minimum of training, the speakers in this study were able to isolate the initial ('reap', 'rap') and final ('peer', 'bar') productions. A relatively low jaw position is preferable. Many speakers in the present study produced /i/ (as in 'peer') with a sufficiently open jaw position as to make the test feasible.

As Delattre & Freeman (1968) indicated, a speaker may use different tongue configurations for the various allophones of /r/. For this reason, the probe technique was used to determine the gross tongue shape used by each speaker for these three allophones of /r/: initial, final and syllabic.

6.2.2 Subjects

The results from fifteen subjects (6 men and 9 women) are included in this report. These were the same speakers in the acoustic study of American /r/ allophones reported in previous chapters.

6.3 Results

Three classes of probe contact were noted. The probe sometimes contacted the underside of the tongue, touching the fleshy surface not covered by taste buds. Sometimes, the probe contacted the upper surface of the tongue, usually a centimeter or more (on a protruded tongue) behind the tongue apex. The probe could also contact the tongue tip. The tongue tip can be defined as that part of the tongue blade anterior of a coronal plane defined by the sub-apical border where the fleshy part of the underside of the tongue meets the taste-bud covered surface. In some speakers, this border is on a muscular ridge. The tongue tip, under this definition, may include several millimeters flanking the apex of the tongue.

Table 6.1 describes the results of the probe-contact test. The first column identifies the speaker (Speakers 1-9 are female, Speakers A-F are male), and the following columns indicate the location of the probe contact for each of the three allophones of /r/ under study.

Table 6.1. Location of probe contacts on the tongue for each speaker.

Spkr	*Initial /r/*	*Syllabic /r/*	*Final /r/*
S1	underside	underside	underside
S4	underside	underside	underside
S5	underside	underside	underside
S6	underside	underside	underside
S8	underside	underside	underside
Sa	underside	underside	underside
Sc	underside	underside	underside
Sd	underside	underside	underside
Sf	underside	underside	underside
S2	tip	upper surface	upper surface
S7	tip	upper surface	upper surface
S9	tip	upper surface	upper surface
Sb	tip	upper surface	upper surface
Se	tip	upper surface	upper surface
S3	upper surface	tip	tip

Table 6.1 indicates the contact location used most often by each speaker in each context. In almost all cases, two or three trials produced identical results. The exceptions to this generality were Speaker A and Speaker E. Speaker A showed a consistent subapical contact in all cases, as indicated by the center of the swab. However in the syllable final allophone, the edge of the swab overlapped the sub-apical ridge. Had the center of the swab also overlapped this line, the

contact would have been classified as a tongue-tip contact. Speaker E showed preferred probe contacts as noted in Table 6.1, and indicated these as 'normal' articulations. Upon noting that his initial /r/ was different from his final /r/, however, he prodigiously began to play with various tongue shapes, ultimately producing several in every syllabic position. In addition, Speaker 7 consistently displayed the pattern listed, but her upper surface contacts in syllabic and final /r/ were not as far back as for most speakers, usually occurring only a few millimeters behind the tongue apex.

6.4 Discussion

Probe contact with the underside of the tongue indicates a retroflex tongue shape, since the tongue curls up and exposes the underside of the tongue to the front of the mouth.

Probe contact with the upper surface of the tongue indicates a bunched tongue shape, where the tip is pulled down, out of the way of the probe.

For the probe to contact the tongue tip, the tongue apex can neither be pointed toward the roof of the mouth, as with a retroflex tongue shape, nor can it be pointed down and retracted, as described for the bunched tongue shape. The blade of the tongue is raised, but the primary constriction is not made with the tongue tip, but some other, more posterior, portion of the tongue, such as the posterior tongue blade and/or the anterior tongue body. Two tongue configurations fitting this general description were noted by Delattre & Freeman (1968); these were Types 5 and 6, on the retroflex end of their implied continuum.

Figure 6.2 is a schematic diagram of the presumed mid-sagittal tongue shapes as revealed by the probe-contact technique. To avoid the confusing terminology often used in discussions of either the articulation or the acoustics of American /r/, these three tongue shapes will be referred to as *'tip down'* (bunched, as indicated by probe contact on the upper surface of the tongue), *'tip up'* (apical retroflex, as indicated by probe contact on the underside of the tongue), and *'blade up'*, (previously unnamed, but indicated by probe contact on the tip of the tongue). In Figure 6.2, the arrow indicates the direction of probe insertion. 'Tip down' (bunched) is in black, 'blade up' is in dark gray and 'tip up' (apical retroflex) is in light gray.

Figure 6.2. Sagittal diagram of idealized tongue shapes for American /r/.

The tongue shapes illustrated in Figure 6.2 are inferred from a variety of information, including the probe contact data, Delattre & Freeman's published tracings, and some separate investigations of the musculature of the tongue and pharynx (UCLA Phonetics Laboratory 1990). The three families of tongue shapes reported here (which are modified slightly from Hagiwara 1994a) recently received some independent confirmation from an MRI study conducted by Narayanan (1995) and reported in part by Narayanan, Alwan & Haker (1995).

Table 6.2 translates the probe-contact data from Table 6.1 into the presumed tongue shapes used. Nine of the fifteen speakers in this study show probe-contact on the underside of the tongue for /r/ in all three syllabic positions, indicating an invariably 'tip up' articulation for their productions of /r/. The others used both 'blade up' and 'tip down' tongue shapes, depending on syllabic position. Five used the 'blade up' shape for initial /r/ and 'tip down' for final and syllabic /r/. Speaker 3 used the opposite pattern, reserving 'tip down' for the initial /r/, and using 'blade up' for the other two.

It should be noted immediately that the evidence of the probe contact data does not inform the problem of the bimodal distribution found in the women's initial /ɹ/ data. The grouping of women into those who use the tip up tongue shape as opposed to blade up or tip down do not correlate to either the high-F3 group or the low-F3 group. That is, neither group corresponds either to the 'tip up' group or the 'blade up' group.

Table 6.2. Tongue shapes used for /r/ by each speaker.

Spkr	*Initial /r/*	*Syllabic /r/*	*Final /r/*
S1	tip up	tip up	tip up
S4	tip up	tip up	tip up
S5	tip up	tip up	tip up
S6	tip up	tip up	tip up
S8	tip up	tip up	tip up
Sa	tip up	tip up	tip up
Sc	tip up	tip up	tip up
Sd	tip up	tip up	tip up
Sf	tip up	tip up	tip up
S2	blade up	tip down	tip down
S7	blade up	tip down	tip down
S9	blade up	tip down	tip down
Sb	blade up	tip down	tip down
Se	blade up	tip down	tip down
S3	tip down	blade up	blade up

The number of speakers who preferred the 'tip up' tongue shape for syllabic [ɹ̩], nine of the fifteen, was somewhat unexpected. Lindau (1985) provided X-ray tracings of six speakers of American English, all of whom Lindau describes as using a bunched tongue shape. Lindau's tracings have been re-drawn in Figure 6.3.

Lindau does not discuss the intermediate tongue shapes described by Delattre & Freeman (1968), but examination of the tracings suggests that at least one of her speakers (P4) and as many as three (P1, P4, P6) might have shown tongue-tip contact in the probe contact test described above. That is, it is possible these speakers used the 'blade up' tongue shape for syllabic /r/. Tracing soft tissues such as the tongue is extremely difficult, particularly in the anterior mouth, where the image is confused by the much clearer shadows of the teeth. Unfortunately, the original X-rays are not available for examination, so it is impossible to tell if such an interpretation of these tracings is consistent with the more detailed evidence that would have been available on the X-ray.

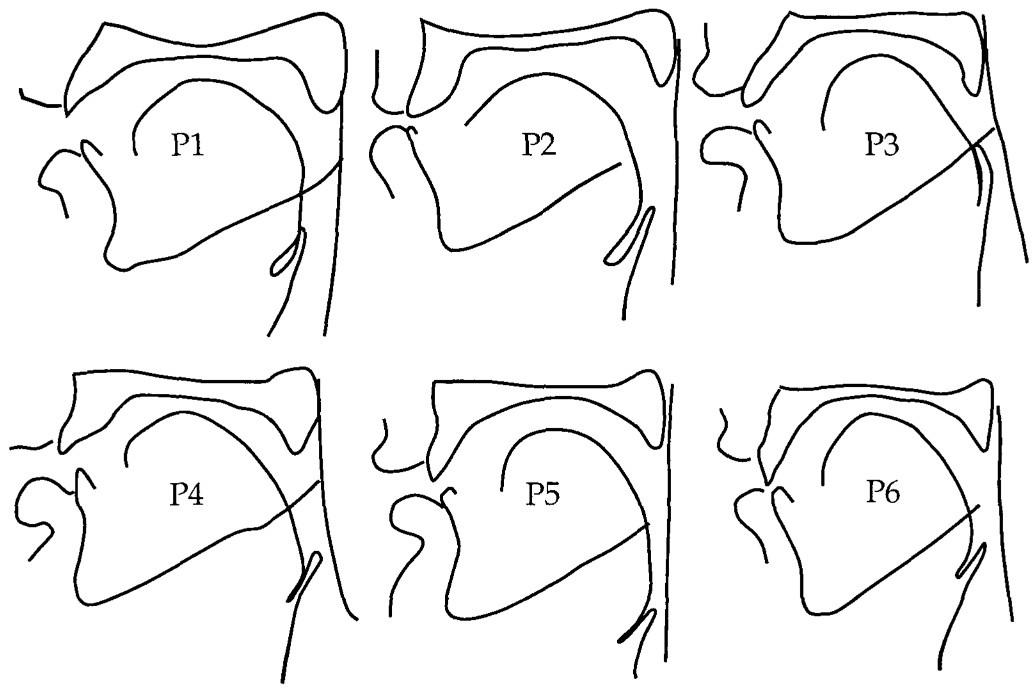


Figure 6.3. X-ray tracings of [ɹ̩] (after Lindau, 1985:164).

Returning to the main point, even without examining the original X-rays, it is clear that none of Lindau's speakers used a 'tip up' articulation for syllabic [ɹ̩], in which highest point of the tongue should be the tongue apex. Even allowing for tracing errors, this is not true of any of Lindau's speakers.

The interpretation of the probe-contact tests given in Table 6.2, however, supports the traditional view of the 'tip up' or retroflex articulation of American /r/ as the more common tongue shape, a view which until now was largely unsupported by any quantifiable evidence and flatly denied by Delattre & Freeman. However, Delattre & Freeman's examples of Types 5 and 6 both have tongue tip locations which are higher than the occlusal plane. These speakers might have produced tongue-underside contacts if they had been subjected to the probe-contact test. Thus, it is obviously premature to accept the interpretation in Table 6.2 without question. In particular, modern imaging methods, such as electromagnetometry, magnetic resonance imaging and ultrasound, should be explored as a source of more conclusive evidence.

As noted above, Narayanan (1995) and Narayanan *et al.* (1995) have described three similar tongue shapes in four speakers of American English using MRI. However, Narayanan (1995) did not investigate all three allophones studied here, and the requirements of MRI did not allow testing of tongue shapes in running speech. Boyce & Espy-Wilson (1994) using electromagnetometry and

Westbury, Hashi & Lindstrom (1995) using X-ray microbeam have analyzed some articulatory data on American /r/, but the number and placement of tracking points in each case did not allow adequate imaging of the tongue tip (and cannot image the tongue root at all). Thus until additional evidence can be brought to bear, the question of the number and the relative distribution of the various tongue shapes in running speech must remain open.

6.5 Is 'blade up' a variant of 'tip up'?

By itself, the probe-contact data does not invalidate the view that there are two primary ways to articulate an American /r/. In Delattre & Freeman (1968), the tongue shapes that correspond to what the present study calls 'blade up' are placed on the retroflex end of the continuum. The 'blade up' articulation may represent merely a variation of the extreme tongue shape commonly called retroflex. Perhaps it should be called 'laminal retroflex' to distinguish it from 'apical retroflex' (in which the constriction is formed by the tongue apex) and 'sub-laminal retroflex' (in which the constriction is formed by the underside of the tongue blade curling back over the tongue) articulations as described by Ladefoged & Maddieson (in press). However, there is little about the 'blade up' tongue shape which is suggestive of what is normally meant by 'retroflexion'. There is some further, indirect evidence that 'blade up' should not be classed with the other truly retroflex articulations, in particular what here is being called 'tip up'.

The distribution of tongue shapes among speakers seems particularly interesting. The nine speakers who used 'tip up', or truly retroflex, articulations appear to do so to the exclusion of other tongue shapes, or at least other tongue shapes are very highly marked. The remaining six speakers who use either the 'blade up' or 'tip down' articulations appear never to use only one or the other, but both, the choice being conditioned by the syllabic positions or other factors not tested in the present study. In this way, the 'blade up' and 'tip down' articulations appear to form a class, distinct from the 'tip up' articulation.

Another piece of more anecdotal evidence also suggests this trend. When subjects were asked to show the investigator where the probe made contact with the tongue, the 'blade up' and 'tip down' configurations allowed the speaker to protrude the tongue easily — speakers often did so spontaneously and without prompting. With the sublaminal contact of the probe, the tongue could not be easily protruded, and so the subjects usually tipped their heads back and lowered their jaw to permit the investigator to see into their mouths. The muscles used to produce the 'tip up' or retroflex configuration appear to prohibit tongue protrusion (which would entail uncurling the tongue) as an obvious option. As this prohibition is not in force when the probe contacts the tongue apex, this suggests that producing the 'blade up' tongue shape has the same or similar kinesiological requirements as the 'tip down' tongue shape, and that these constraints are different from those placed on the truly retroflex, 'tip up', configuration.

The question of how the many tongue shapes used to produce American /r/ should be grouped into some reasonable number of types is best left to future research. However, the present data suggest that reducing the variation into two families, the traditional retroflex and bunched types, is inappropriate. Even the three categories suggested by the probe-contact data may be inadequate (Westbury *et al.* 1995).

6.6 Effect of tongue shape on formant frequency

It was mentioned above that the various tongue shapes used to produce American /r/ are regarded as being interchangeable, in that all adequately produce F3 frequencies below a critical threshold. Even though the tongue-shape groupings did not coincide with the bimodal distribution in the women's F3 of initial /r/, it can still be asked if tongue shape (or, more precisely, *presumed* tongue shape) has any effect on formant frequency. To investigate this question, ANOVAs were run over the acoustic data discussed in previous chapters (excluding distal consonant data), using speaker sex and tongue shape as main effects. In all these ANOVAs Speaker 3's data was excluded, because she was the only speaker who reversed the blade up/tip down pattern of the other non-tip-up speakers, and thus her tongue shape categories could not be cross classified with speaker sex.

Table 6.3. Results of initial /ɹ/ ANOVA, testing for effects of speaker sex and presumed tongue shape.

	F1		*F2*		*F3*	
	F-Value	*P-Value*	*F-Value*	*P-Value*	*F-Value*	*P-Value*
Sex	26.993	<.0001	191.912	<.0001	690.934	<.0001
Tongue Shape	.173	.6775	.064	.8002	.285	.5934
Sex * Tongue Shape	43.649	<.0001	33.222	<.0001	12.061	.0005

Table 6.3 summarizes the results of the initial /ɹ/ ANOVA, comparing the effect of the tip up and blade up tongue shapes. Tongue shape does not

contribute a statistically significant main effect to the data in initial /ɹ/. However, the interaction between sex and tongue shape is significant, suggesting that the use of one shape or the other has a different acoustic effect on the formants in male vs. female speakers. This is possibly due to the different distance of the oral constriction from the glottis. The tip up and blade up tongue shapes (used by all speakers but S3 for initial /ɹ/) both involve an alveolar or post-alveolar constriction. According to Perturbation Theory (as well as other theories), this position does not approximate a region which optimally lowers F3, but is further from such a region in men than women (as discussed in Chapter 1).

The ANOVA for the syllabic /ɹ/ data is summarized in Table 6.4.

Table 6.4. Results of syllabic /ɹ̩/ ANOVA, testing for effects of speaker sex and presumed tongue shape.

	F1		*F2*		*F3*	
	F-Value	*P-Value*	*F-Value*	*P-Value*	*F-Value*	*P-Value*
Sex	9.334	.0028	43.789	<.0001	27.170	<.0001
Tongue Shape	.449	.5041	9.607	.0024	10.152	.0018
Sex * Tongue Shape	2.383	.1253	14.100	.0003	16.442	<.0001

In syllabic /ɹ̩/, there is a main effect for tongue shape as well as an interaction between tongue shape and speaker sex, in F2 and F3. On average, the tip up tongue shape produces second formants that are 83 Hz higher than the tip down tongue shape. Tip up F3s are 170 Hz higher than tip down F3s on average.

The ANOVA for the final /ɹ̭/ is summarized in Table 6.5.

Table 6.5. Results of final /ɹ̭/ ANOVA, testing for effects of speaker sex and presumed tongue shape.

	F1		*F2*		*F3*	
	F-Value	*P-Value*	*F-Value*	*P-Value*	*F-Value*	*P-Value*
Sex	68.633	<.0001	173.883	<.0001	251.449	<.0001
Tongue Shape	1.906	.1682	16.364	<.0001	25.020	<.0001
Sex * Tongue Shape	.127	.7218	10.086	.0016	18.889	<.0001

Similar to the syllabic /ɹ̩/ data, the tip up and tip down tongue shapes have main effects on F2 and F3 in final /ɹ̭/. There are also significant interactions between tongue shape and speaker sex. The mean differences due to tongue shape in were 66 Hz in F2 and 120 Hz in F3.

The statistical significance of the interaction in F3 probably results from the difference in distance from the optimal constriction location for lowering F3 in the oral cavity. As discussed in Chapter 1, the bunched tongue shape which produces a constriction at the posterior palate is much closer to the optimal F3-

lowering position in women than in men. Thus an interaction between speaker sex and tongue shape in the syllabic and final /r/ data is not unexpected, given that one of the tongue shapes tested (tip down) is presumed to produce a posterior palatal constriction, as opposed to the tip up tongue shape which produces a constriction near the alveolar ridge.

To test this hypothesis, the F3 data were split by syllabic position (syllabic vs. final) and speaker sex, and the resulting groups subjected to a series of unpaired t-tests. The results are summarized in Table 6.6.

Table 6.6. Unpaired t-test on F3/tongue shape data.

Syllabic /ɹ̩/ Tongue Shapes	*Mean Difference*	*DF*	*t-Value*	*P-value*
Tip Up – Tip Down (women)	344 Hz	70	4.374	<.0001
Tip Up – Tip Down (men)	-41 Hz	52	-1.593	.1172
Final /ɹ/ Tongue Shapes	*Mean Difference*	*DF*	*t-Value*	*P-value*
Tip Up – Tip Down (women)	227 Hz	238	5.741	<.0001
Tip Up – Tip Down (men)	16 Hz	178	.948	.3445

Table 6.6 confirms the interaction for the female speakers. The tip up tongue shape produces significantly higher F3 values than the tip down tongue shape. That is, the tip down tongue shape, which presumably produces a constriction near the posterior palate, is much more effective at lowering the third formant than the tip up tongue shape, at least in women. As Table 6.6 shows, there is no significant effect for tongue shape among the men.

6.7 Conclusion

The probe test results in three classes of probe contacts: contact with the underside of the tongue, contact with the tip of the tongue, and contact with the upper surface of the tongue. These contacts indicate three different tongue configurations, which have here been characterized as 'tip up', 'blade up', and 'tip down', respectively. Speakers seem to be able to vary between 'blade up' and 'tip down', but speakers in this study do not appear to vary between the truly retroflex 'tip up' configuration and either of the other two. The speaker's ability to protrude the tongue in the 'blade up' configuration (as well as the 'tip down' configuration) suggests strongly that the 'blade up' tongue shape is not best characterized as a modification of 'retroflex', but perhaps represents a separate category or a variant of 'tip down'.

The functional labels for the tongue shapes are preferable to the more traditional terms because they make specific reference to the observable shape of the tongue in the anterior mouth, without the possibly confusing acoustic connotations of words like 'retroflex'.

Among the various tongue shapes associated with American /r/, there are clearly more than the two traditionally described classes (retroflex and bunched), and an attempt must be made at distinguishing a third class of 'blade up' tongue shapes. If anything, the above evidence suggests that 'blade up' is not a variation or modification of 'tip up', but is more closely related to the 'tip down' tongue shape.

The evidence presented here suggests that it is an error to assume that American /r/ is always made with one of the two traditionally described tongue shapes. The present data suggest that at least three categories of tongue shape must be recognized in articulatory investigations of American /r/. As Westbury et al. (1995) conclude, whether and how the many individual tongue shapes used to produce /r/ can be reduced to a manageable set of classes (such as the three suggested here) is not a trivial issue.

Chapter 7. Taking a broader view

This chapter will summarize the results discussed in the previous chapters, bringing together the individual conclusions reached into a more cohesive picture of male-female patterns in formant values of American /r/. Some parallel analyses (i.e. formants measured in a quasi-auditory Bark scale) will be discussed briefly, as well as the implications of the patterns found for general phonetic theory. Finally, the results found in previous chapters will be discussed in terms of the goals set out in Chapter 1, and suggestions for further studies of sex-differences in speech will be made.

7.1 Summary of findings

The studies of American /r/ presented in the preceding chapters have focused on the frequencies of the first three formants and how they pattern as a function of speaker sex. While admitting that the best linguistic characterization of this (or any) sound may not be in these terms, static formant frequency has traditionally been used to describe the quality of vowels (e.g. Peterson & Barney 1952, Hillenbrand *et al.* 1995) and provides an appropriate place to begin this study.

Women's formants tend to be higher than men's formants. Linguistic phonetics, following in the tradition of Fant (1960, 1973), mostly takes this to be a function of women's relatively smaller vocal tracts, which are approximately four-fifths the length of men's vocal tracts. All else being equal, smaller cavities resonate at higher frequencies, and thus women's formant values are expected to be higher than men's.

American /r/ presented an unusual case to test this view, because it is typically characterized as having a low third formant. Further, it has both syllabic (i.e. vocalic) and non-syllabic (i.e. consonantal) allophones, making it possible to bridge the gap between the acoustics of vowel-like sounds and consonant-like ones. Previous studies looking at formant frequency have largely ignored non-vocalic segments, liquids, nasals, etc. The dialect studied is taken to be an unmarked western US dialect of southern California, represented by nine women and six men. In addition to data on /r/, the vowels of the dialect were collected and studied.

7.1.1 The southern California vowels

The southern California vowels (Chapter 2) were studied primarily to gain an insight into the phonetic formant ranges used by the speakers in this study, rather than to investigate the effect of speaker sex on vowel formants. Still, some interesting observations were made.

The women's formants were generally higher than the men's, as predicted by general phonetic theory. However, the women's formant frequency data showed greater variance (as measured by their standard deviations) both individually and as a group. (Analysis of the between-speaker variation was confounded by the greater number of speakers in the women's data set.)

Some variation in the shape of the vowel spaces was observed among the women. In particular, most of the women appear to separate the mid vowels into higher and lower groups. Several speakers, such as Speaker 1, appear to avoid mid-range F1 values altogether, producing mid vowels /e/ and /o/ with extremely low F1 values and /ɛ/ with extremely high F1 values. Speaker 8, in contrast, appeared to distribute vowels evenly throughout the F1 range. To varying degrees, the avoidance of middle-range F1 values among the women was quite striking. In contrast, the men appeared to more consistently distribute vowels evenly across the F1 domain.

Most of the women also seemed to produce /æ/ values with unexpectedly low F2 values, such that /æ/ appeared in the central portion of their vowel spaces. In some, such as S6, this produced nearly complete overlap with the /ʌ/ category in an F1xF2 space. In most speakers, the F1 and F2 spaces of /ɛ/ were correspondingly broadened, perhaps to 'fill the gap' left by the relative backing of /æ/.

The men, in contrast, appear to more consistently produce a front /æ/, well separated in the F2 domain from /ʌ/, and correspondingly 'small' /ɛ/ spaces.

The generally higher formant frequencies found among the women's plain vowel data were in general accord with a model of vowel formant frequencies as a function of vocal tract size. However, such a model alone does not account for the different distribution of vowel categories (as represented by dispersion of measured vowel formant averages within an F1xF2 vowel space) between the male and female populations studied. This variation was argued to represent the kind of apparently arbitrary differences that can be found across languages with superficially similar phonological vowel systems (as discussed in

Disner 1985), and thus represent a dialectal difference between the men and women in this study.

7.1.2 *Syllabic /ɹ̩/*

The syllabic allophone /ɹ̩/ is a vowel in this dialect, with primarily a flat (monophthongal) formant structure. Its first and second formant values place /ɹ̩/ in the higher back region of the vowel space — that is, overlapping to various degrees with /ʊ/, /o/, and the lower tokens of /u/ for most speakers. /ɹ̩/ is distinguished from the other plain vowels primarily by its relatively low third formant. The formants of /ɹ̩/ are summarized in Table 7.1.

Table 7.1. Formant frequencies (and standard deviations) of syllabic /ɹ̩/.

	Women's Formants	*Men's Formants*
F1	477 (82)	429 (40)
F2	1558 (170)	1362 (79)
F3	1995 (347)	1679 (91)

The greater variance among the women's data is apparent from the greater standard deviations in Table 7.1. However, the greater number of women speakers in the study make the straightforward interpretation of the standard deviations difficult. Histographic display of the formant frequency measurements suggested that (unlike the initial /ɹ/ data discussed in Chapter 5 and summarized below) the exceptionally large standard deviation in the women's F3 values were not the result of a bimodal distribution. Rather, the women each seemed to place their F3 at some frequency different from the other women. Some clustering of values below 2000 Hz was seen, but the no apparent agreement on a higher modal frequency was observed in the women's data.

In the conclusion to Chapter 3, a definition of a critical cut-off frequency, below which the F3 of /ɹ̩/ usually drops below was suggested: the mean, plus one standard deviation. Using this definition, the cut-off frequencies for the third formant of syllabic /ɹ̩/ were calculated at 1770 Hz (1679 + 91) for the men and 2340 Hz (rounded from 1995 + 347) for the women.

7.1.3 *Final /ɹ̯/*

The final /ɹ̯/ data were explored in Chapter 4. The formant averages are summarized in Table 7.2.

Table 7.2. Formant frequencies (and standard deviations) of final /ɹ̥/.

	Women's Formants	Men's Formants
F1	532 (128)	437 (47)
F2	1628 (186)	1392 (127)
F3	2181 (298)	1768 (106)

Seven of the nine women in the study produced F3 of final /ɹ̥/ above 2000 Hz on average. The other two were within 50 Hz of 2000 Hz, and these two speakers also had relatively large standard deviations. Thus, it would be inappropriate to describe the F3 of final /ɹ̥/ as usually dropping below 2000 Hz. Using the mean-plus-one-standard-deviation definition used above, the F3 of the women's final /ɹ̥/ data can be said to usually drop below 2479 (2181 + 298) Hz. The traditional 2000 Hz cut-off mark is still too high for the men's data, where the F3 usually drops below 1874 (1768 + 106) Hz.

7.1.4 Initial /ɹ/

Measurement of static formants of the initial /ɹ/ were complicated by *fortition*, which enhances the boundary between the initial consonant and the following vowel (Stevens 1980), presumably by increasing the constriction degree (Keating 1995, Fougeron & Keating 1995). This results in a decrease in acoustic energy in an initial /ɹ/, and therefore a greater difference between the energy in the /ɹ/ and the following vowel. The analysis of formant frequencies was further complicated by a bimodal distribution in the women's data. The group means and standard deviations are presented in Table 7.3.

Table 7.3. Formant frequencies (and standard deviations) of initial /ɹ/.

	Women's Formants	Men's Formants
F1	322 (64)	297 (34)
F2	1201 (171)	1020 (120)
F3	2079 (335)*	1516 (107)

* Composite of bimodal distribution. Subsetted women's means were:
2285 (241) 1822 (248)

As before, there was a small but significant contextual effect for the adjacent vowel in all three formants, but comparisons of individual vowel effects were mostly not significant, except for certain pairwise comparisons involving /i/ or /ɑ/.

The bimodal distribution in the women's data made the proposal of a cut-off frequency (below which F3 of initial /ɹ/ would usually be expected to fall) inappropriate.

7.2 Global patterns in American /r/ data

7.2.1 Allophonic variation in formant frequency

7.2.1.1 Syllabic position

The relationships of the formant frequencies among the three positional allophones of /r/ are illustrated graphically in Figure 7.1

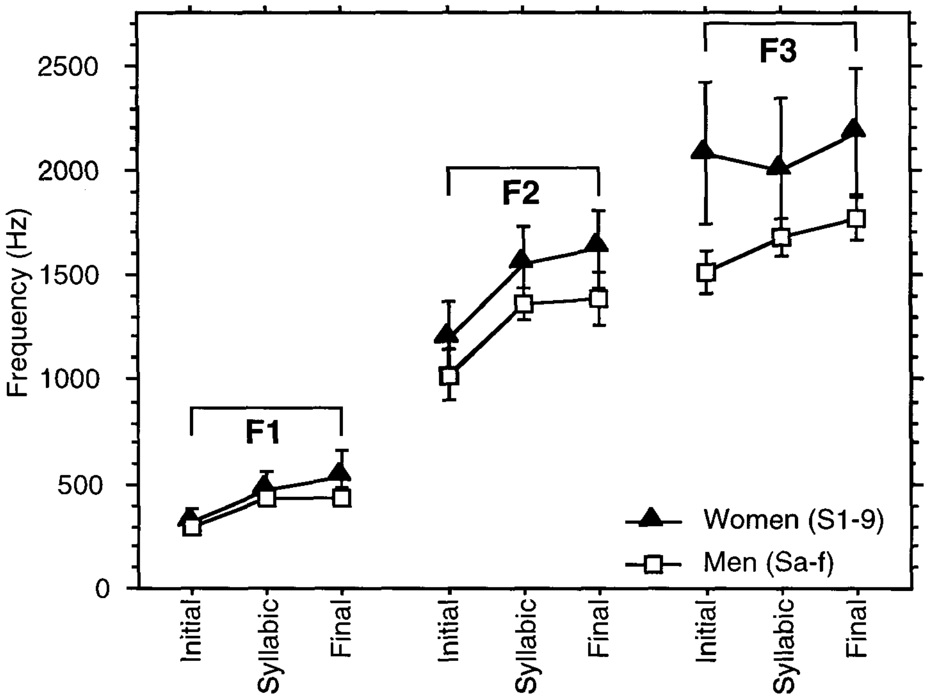


Figure 7.1. Formant frequencies of three allophones of /ɹ/.

As Figure 7.1 suggests, the allophone with the lowest first and second formant frequencies was the initial /ɹ/. Generally, the formants of syllabic /ɹ̩/ were slightly lower than the formants of final /ɹ̯/. Although the men's F1 of syllabic and final /r/ have in absolute terms the opposite relationship, they were virtually identical for all practical purposes. It must be remembered that the F3 of initial /ɹ/ showed a bimodal distribution in the women's data, and thus the global average of F3 values for women's initial /ɹ/ is higher than in syllabic /ɹ/. However, this is actually true only for the higher-mode women.

It was argued in Chapter 4 that it would be inappropriate to exclude the outlying speaker (S5) due to the platykurtic distribution of F3 values in final /ɹ̯/. S5 was taken to represent an extreme end of a continuum along which the women seemed to be distributed unevenly. In Chapter 5, it was argued that a clear bimodal distribution could be treated either bimodally or unimodally, but that analyzing the two modalities separately gave a more accurate reflection of the underlying facts.

From Figure 7.1, it can be inferred that either method would be a reasonable way of approaching the data. The gross variance in F3 values, as indicated by the standard deviations, is extremely large in all three syllabic positions among the women; certainly much larger than the men's variance in F3, and indeed larger than the variance in the lower formants. That is regardless of the underlying distribution, some use is made of the extreme values in the (admittedly broad) 'expected' women's F3 range. In the case of the initial /ɹ/, this took the form of a bimodal distribution, with most women choosing a value at or near one or the other extreme. In the case of final /ɹ̩/, this took the form of one woman in particular representing one relatively extreme value consistently, several women choosing the other (low) value, and several others distributing values in between. Whether this can be seen as representing a trend toward higher F3 values of /ɹ/, or some kind of variance in underlying acoustic mechanism used across speakers, cannot be determined from the present data.

To confirm the positional variation, the initial, syllabic, and final /r/ databases were pooled (excluding the tokens used only to test for consonant context), and a two-factor ANOVA was run over the combined dataset. The main effects tested were speaker sex and syllabic position. The results are summarized in the following tables.

Table 7.4. Results of ANOVA on speaker sex and syllabic position.

	F1		F2		F3	
	F-Value	*P-Value*	*F-Value*	*P-Value*	*F-Value*	*P-Value*
Sex	112.494	<.0001	341.091	<.0001	543.618	<.0001
Position	833.069	<.0001	1013.148	<.0001	64.043	<.0001
Sex * Position	32.036	<.0001	4.082	.0171	19.847	<.0001

Table 7.5. Results of Scheffe's F post-hoc tests on positional data.

	F1	*F2*	*F3*
Initial, Syllabic	<.0001	<.0001	.8299
Initial, Final	<.0001	<.0001	<.0001
Syllabic, Final	<.0001	.0021	<.0001

The ANOVA found significant effects for speaker sex and syllabic position, as well as a significant interaction between the two effects, in all three formants.

Scheffe's F post hoc tests were used to determine the effects of individual syllabic position. The results are summarized in Table 7.5.

As Table 7.5 indicates, significant differences were found between syllabic positions in every formant, with the exception of the F3 comparison between initial /ɹ/ and syllabic /ɹ̩/. Thus, statistically it appears that the three allophones of /r/ described here are statistically different, and that no two allophones appear necessarily more similar than any other pair. If any such similarity were to be argued from the present data, the pair which ought to be regarded as most similar, initial and syllabic /r/, are precisely the pair which independently might be expected to be the most different. Syllabic and final /r/ are related historically, both represent fully-voiced, high-amplitude segments, and speakers who employ different tongue shapes for /r/ use the same tongue shape for these two allophones. Initial and final /r/ might be regarded as similar in that both are in some sense 'consonants', as opposed to syllabic /ɹ̩/ which is best regarded as a vowel. The pairing of initial and syllabic /r/ as most similar should be regarded as accidental in the present data.

7.2.1.2 Contextual effects

In the preceding chapters, the contextual effects, that is the effects of adjacent segmental material, have not been discussed in detail. This was for two reasons. First the principal goal throughout this work has been to illuminate the effect of speaker sex on formant frequencies, rather than the relatively smaller effect of adjacent segments. Second, for the most part these effects are not particularly surprising. They appeared to result from coarticulatory pressure: Adjacent segments with low first formants pulled the first formant of /r/ down, as illustrated in Figure 7.2 for the first formant of final /ɹ̯/.

The trend in Figure 7.2 is for /ɹ̯/ to have a lower F1 when following a higher vowels (that is, vowels with notionally low F1s), and for the opposite to be true with low vowels. That is, the relatively higher F1 of the preceding *a* ([a˞]) appears to pull the F1 of /ɹ̯/ up, where the relatively low F1 of ***i*** and ***u*** ([i˞] and [u˞,ʊ˞]) produce lower F1 values in /ɹ̯/.

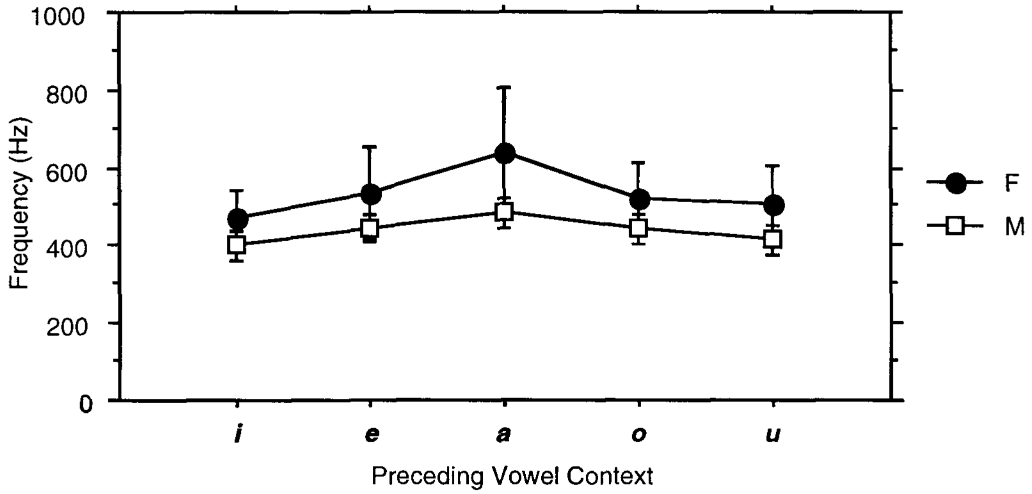


Figure 7.2. First formant of final /ɹ̯/ as a function of preceding vowel.

The second formant of /ɹ̯/ appears to be similarly affected by the frontness of the preceding vowel. That is, relatively front vowels produce relatively higher F2 values in /ɹ̯/, backer vowels produce lower /ɹ̯/ F2s. This is illustrated in Figure 7.3.

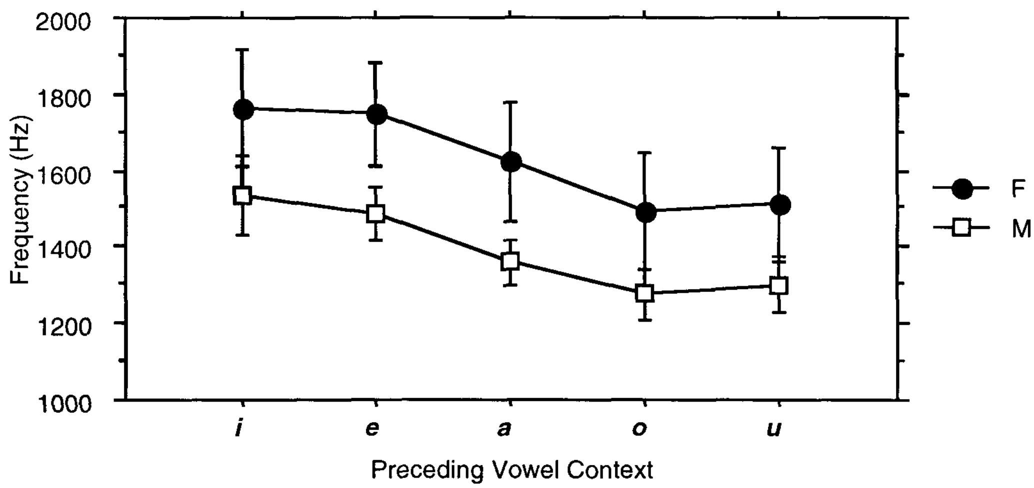


Figure 7.3. Second formant of final /ɹ̯/ as a function of preceding vowel.

A similar trend can be observed in the third formant data (Figure 7.4). It is not immediately apparent whether the effect in F3 represents a relationship between it and the F2 of the preceding vowel, the F3 of the preceding vowel, or the F2 of the /r/. Since the formants of the vowels in this context have not yet been measured, one can only speculate based on the F3 patterns of the plain vowels. which, at least for some speakers, appeared to roughly mirror F2.

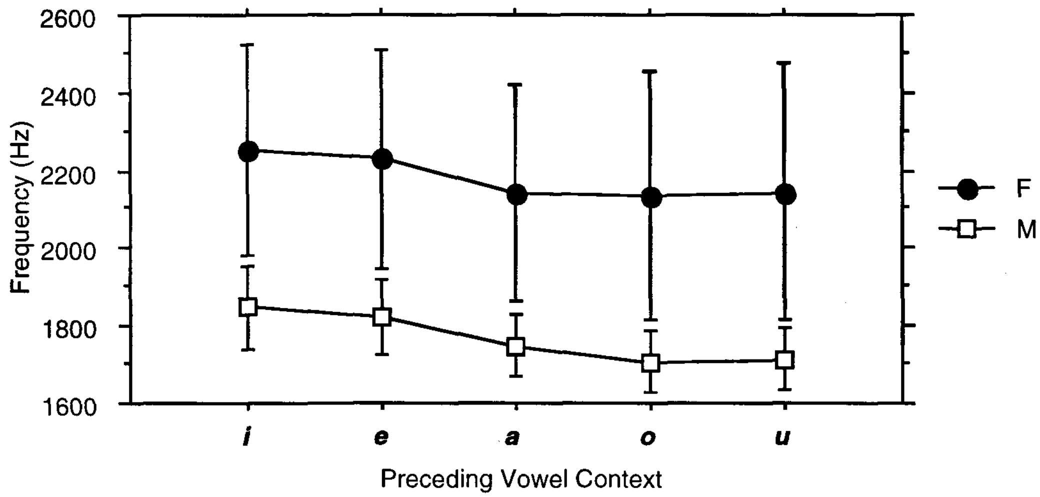


Figure 7.4. First formant of final /ɹ̩/ as a function of preceding vowel.

Similar effects for F1 and F2 of the following vowel were observed in the initial /r/ data. The point here is not to quantify the effect of adjacent vowel, but merely to establish its basically assimilatory nature.

No effect of consonantal context was observed in the syllabic /ɹ̩/ data, although the data set (based on mixed preceding and following contexts) was not particularly designed to reveal any if they existed.

7.2.2 Excursus on Bark-scaled formant analysis

At this point, it would perhaps be useful to explore alternative means of representing the underlying data. Throughout the previous chapters, a linear Hertz scale was assumed. However, the human auditory system is non-linear — 'equivalent' differences in absolute frequency are not heard as equivalent differences in perceived pitch. For example, a difference of 100 Hz represents a difference of one octave between 100 and 200 Hz, but a difference of 100 Hz is only a very small fraction of an octave between 10,000 and 10,100 Hz. Absolute differences in frequency are perceived as less extreme as frequency increases. Thus, it must be considered that relatively small differences in higher formants may be less salient than in lower formants.

To test for this kind of effect, the Hertz-valued measurements in the American /r/ database were converted into Bark units, using the formula

$$\mathbf{B} = 13\arctan(0.76f) + 3.5\arctan(f/7.5)^2$$

after Zwicker & Terhardt (1980), where **B** is a critical band value in Bark, and f is the frequency in kHz.

The Zwicker & Terhardt function is represented in the scatter plot in Figure 7.5. In the figure, Bark values are computed at 100 Hz intervals from 100 to 4400 Hz. Hertz values are represented linearly across the horizontal axis, Bark values linearly on the vertical axis.

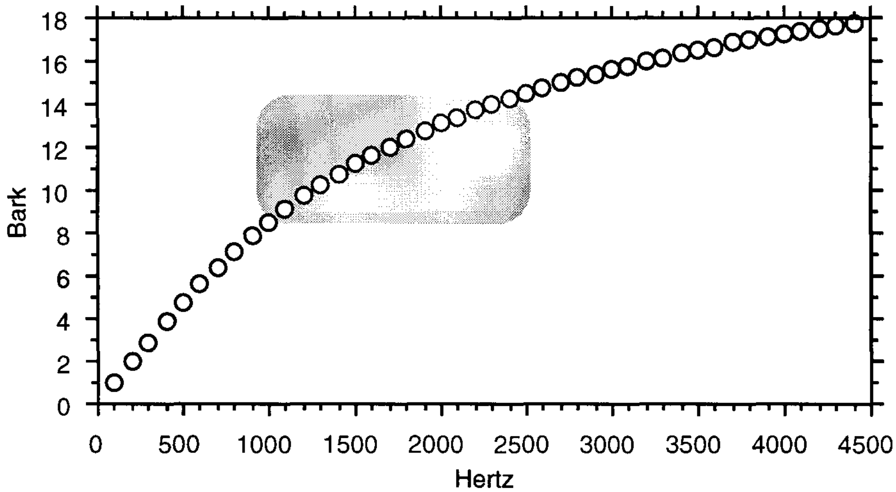


Figure 7.5. The Bark function.

As Figure 7.5 illustrates, there is a considerable change in the slope of the curve between 1000 and 2500 Hz (roughly 8.5 to 14.5 Bk, indicated in Figure 7.2 by the background shading). This encompasses the range into which F3 is presumed to be found in American /r/, and thus analysis of the formant values in Bark might be expected to lead to different results. However, this did not prove to be the case.

Obviously, statistical calculations over values on a different scale are going to result in slight changes in absolute results (F-values, P-values, etc.). However, in only few cases did the Bark-scaled values result in non-significant results when the Hertz-scaled values showed significant results, or vice versa. No changes were noted in the syllabic /ɹ̩/ data. In the initial /ɹ/ data, the Scheffe's post-hoc tests on the vowel effects on F3 showed an additional significant pairwise (/ɑ/-/u/) comparison to the two (/ɑ/-/i/ and /ɑ/-/ɪ/) in the Hertz-scaled test. In the final /ɹ̯/ tests, three additional pairwise comparisons (*a-i*, *e-o*, and *e-u*) were significantly different. Thus, while converting to Bark-scaled formant values resulted in more significant pairwise comparisons of contextual effects, these did not overall change the global significances/non-significances as reported in the ANOVAs.

It is important to note that the Bark scale for the present purposes is taken to represent some approximation of pitch, in the sense that the Hertz scale represents frequency. Classic studies, such as Syrdal & Gopal (1986) have analyzed Bark-scaled formant frequencies in terms of Bark distance between two formants or between F1 and the fundamental frequency, and whether the difference between two Bark-scaled formants is within or exceeds a critical distance measured in critical bands. The present conclusions are not directly comparable with others, and will not be until detailed F0 measurements have been made on the present data.

The Hertz scale and the measurement of formant frequencies has been used in this study primarily because they are traditional measures of phonetic quality. This should not be taken as an argument that they are necessarily superior to Bark-scaled formant measures, formant distance measures, or other possible methods of describing the quality of acoustic phonetic objects.

7.2.3 Normalizing data by speaker sex or phonetic category

One method for describing the mathematical relationships between the formants frequencies of women and those of men is Fant's (1973) K-factors. In describing K, Fant (1973) recognized the limitations a system in which K (or something like it) was used as part of a normalization algorithm — one of the greatest is that the value of K was not constant across formants or across segments. That is, the value of K did not describe a scaling factor which would transform one acoustic phonetic space into another. Rather, K should be regarded as that factor by which a given formant of a given phonetic category (in the narrowest case, a segment; in more extended cases, as Fant argued, a segment class) must be scaled to represent the same formant in the same phonetic category as produced by different groups of speakers.

The evidence of the present studies calls into question the basic assumptions which underlie the calculation of K, and present a very basic problem concerning speaker normalization of formant values. In the vowel formant data discussed in Chapter 2, it was argued that as a group, the women distributed vowel categories in the F1xF2 space differently than the men. The men seemed to distribute the vowels into (at least) four heights (for instance, heights typical of /i,e/, /ɪ/, /ɛ/, and /æ/); in contrast, the women appeared to avoid the middle F1 frequencies, 'crowding' the vowels into two heights at the extremes of the F1 range. The women in this study appeared to be merging the

/æ/ and /ʌ/ categories by maintaining relatively central F2 values of /æ/ and relatively low F1 values of /ʌ/; the men in the study appeared to maintain a separation between these two categories, using relatively front F2 values of /æ/ and relatively higher F1 values of /ʌ/. Obviously the relationship between the men's and women's vowel spaces does not involve *scaling*. That is, it is not merely a matter of multiplying all the formant values in the space by some number (and sliding the vowel space in a Euclidean plane) to produce identity between the two spaces.

However, for normalization to work, the relationships between categories and some internal 'standard' or 'landmark' must be constant. The different distribution of vowel categories in the women's and men's vowel spaces make the identity of such a standard of comparison problematic.

Further, it should be remembered that not all of the women fit exactly the pattern described above. Speaker 8, while utilizing a region of the F1xF2 space similar to the other women, seemed to use a vowel space more similar in shape to the men's vowel space than to the other women. In the face of this evidence, it seems probable that any attempt to 'normalize' the formant data by speaker sex would either fail to correctly predict Speaker 8, or S8 must be excluded from such an attempt and handled separately.

What are the implications of this for speaker normalization? If there must be separate normalization algorithms for different speakers (and by extension, different dialects), is it still feasible to maintain a general normalization algorithm for speaker sex? While it might be that such an algorithm would greatly reduce the variation across speakers, the problem of individual variation must still be considered. Would the power of such 'subsidiary' algorithms be greater than the power of the general algorithm? If so, is there any benefit from maintaining a general normalization algorithm for speaker sex in a phonetic model?

This problem is complicated further by the K-scaling factors found for the allophones of /r/ in Chapters 3, 4, and 5. These are summarized in Table 7.6.

Table 7.6. K-scaling factors for American /r/.

	F1	*F2*	*F3*		*F3 (subset)*	
Initial /ɹ/	8.4	**17.7**	37.1	(all)		
					50.7	Women(HiF3)
					20.2	Women(LoF3)
Syllabic /ɹ̩/	11.2	**14.4**	18.8			
Final /ɹ̯/	21.7	**17.0**	23.4			

The K-factors of F1 range from a low of 8.4 for initial /ɹ/ to a high of 21.7 for final /ɹ̯/. The K-factors of F2 seem to be the most similar across syllabic position. The syllabic, final, and lower-F3 K-factors for F3 are also vaguely similar across syllabic position, but only to the exclusion of the higher-F3 group of women. As can clearly be seen in Table 7.6, there is very little that is constant across formants or across syllabic position. Can even algorithms which make use of formant distance, and distance from the fundamental frequency, be of use to fully account for all the variation observed in the American /ɹ/ data, data which does not show a single, consistent pattern across allophones of what is ostensibly a single phonological unit?

Again, it must be asked whether 'normalization' of such variation is viable. Without detailed pitch measurements, it would obviously be improper to say that no difference between in fundamental frequency exists between the higher-F3 and lower-F3 women's groups in the initial /ɹ/ data. However, it seems extremely unlikely that absolute F0 differences could possibly account for the variation between K-factors across syllabic positions. Individual variation and even token-to-token variation would still be a very real problem.

However, it should not be concluded from these objections that speaker normalization, or more specifically formant scaling, should be abandoned as a part of a linguistic phonetic model. It is still the case that there is some sense in which initial /ɹ/ is the same across contexts and across speakers; that /e/ is still identifiable, whether it is in "bate" uttered by Speaker 4 or in "take" uttered by Speaker B. That is, humans trivially normalize for speaker sex, and other factors, as a part of speech perception. Even infants appear capable of ignoring speaker identity (and therefore speaker sex) in determining changes in vowel category (See Kuhl 1987 for an excellent survey of speech perceptual processes in infants).

There are two main points to be made from this discussion. The first is that variation in phonetics is unavoidable, and averaging across tokens and across speakers disguises the extent of this variation. The second point is related: linguistic phonetic theory has little hope of constructing an adequate model of the phonetic grammar until the extent of the variation in speech is more fully explored. It is well known that speaker sex is a source of variation in the domain of formant frequency. However, merely knowing that women's formants tend to be higher does not predict, either globally or in any specific case, how much higher they are.

If the goal of normalization algorithms is to efficiently reduce the variability across speakers and tokens, the extent and range of the variability in speech must be fully investigated, both to provide an adequate knowledge base for the formulation of normalization algorithms, and to provide a database for testing them. Therefore, the results of this study should not be taken as an indictment of formant normalization. Rather, it should be regarded as an appeal to phoneticians to gather more data, to take much more seriously the variation in that data, and above all to examine closely the assumptions that underlie phonetic hypotheses and thereby shape phonetic investigations.

7.2.4 How much lower is a lowered F3?

In Chapter 3, it was noted that American /r/ is often characterized as having a third formant which drops below some critical frequency, usually described as 2000 Hz. It was suggested that this critical frequency should not be arbitrary, but have some empirical basis. Thus, the definition of the mean plus one standard deviation was suggested as a possible replacement.

However, it was seen in Chapter 5 that the F3 values of initial /ɹ/ among the women had a bimodal distribution, and thus a characterization of the third formant as 'below a particular frequency' was an inappropriate way of describing the underlying facts.

To extend this argument more generally, why should the third formant of American /r/ have ever been described as being below some critical frequency? Vowel formants are rarely described in such terms. Would it make sense to describe the second formant of /ɑ/ as being below 1500 Hz? or the F1 of /i/ being below 450 Hz?

Usually when a given formant of a given vowel is described as being "at" some frequency, what is meant (and what is generally understood) is that the named frequency is at the center of a distribution of formant values. That is, the given frequency is an approximation of an entire population of values. It is never meant that if the formant does not appear at the named frequency then the vowel in question cannot be a member of the class, or even that it is a bad exemplar of that class.

In Table 7.1, where it lists the F3 of the women's syllabic /ɹ̩/ as 1995 Hz, all that was intended was that the measured F3 frequencies have that as their mean. The standard deviation (347 Hz) gives some idea as to the distribution of values about that mean, particularly in comparison to the men's mean and standard deviation, 1679 (91) Hz. Given the large standard deviation, it is perhaps useful to understand that most of the tokens are in fact below 2342 Hz, but that figure does not necessarily permit a more precise approximation to the measured formant values than the mean.

If it is not appropriate to describe the F3 of /r/ as being 'below' some frequency, it is still appropriate to describe it as 'low'. However, if 'low' should not be taken to be 'lower than 2000 Hz', for example, the question "what is meant by low?"can be fairly asked.

It would be useful to express the frequency of F3 as a percentage of a neutral F3 value. A neutral F3 can be approximated by averaging together the F3 values of the plain vowel contexts. This results in a value of 3023 Hz for women and 2543 Hz for men. In both cases, the calculated average F3 is very close to the calculated neutral third formant of a uniform tube. Recall that a 14.5 cm presumed effective vocal tract length in women would produce a neutral third resonance at 3000 Hz, and that a 17.5 cm vocal tract would produce a neutral third resonance at 2500 Hz. Because the average measured F3 values are so close to the predicted neutral frequncies, it can be concluded that the men and women are, as populations, producing F3 values consistent with their vocal tract sizes. It is therefore reasonable to assume that the F3 average of each individual closely approximates the neutral F3 for their vocal tracts. Thus the individual F3 averages represent a useful standard to which the lowered F3 of /r/ can be compared.

The results of such comparisons (both for individual speakers and averaged over speaker sex) is presented in Table 7.7. The first column in Table 7.7 identifies the speaker or speaker group being presented. In the second column, "F3 Vs", the calculated average F3 of the plain vowels is presented in Hz. The remaining three pairs of columns indicate the average F3 of one of the allophones of /r/ in Hz, and the percentage of the neutral F3 value it represents. That is, the value column "% ɹ" is calculated by dividing the value in column "F3 ɹ" by the value of "F3 Vs", and multiplying by 100. The grand averages by population are found in the boldface rows labeled "All women" and "All men".

Table 7.7. F3 of /r/ allophones, expressed as a percentage of a calculated neutral F3.

		Initial /ɹ/		Syllabic /ɹ̩/		Final /ɹ̯/	
Spkr	*F3 Vs*	*F3 ɹ*	*% ɹ*	*F3 ɹ̩*	*% ɹ̩*	*F3 ɹ̯*	*% ɹ̯*
S1	3177	2203	69.3	1925	60.6	2080	65.5
S2	2843	2293	80.7	1733	61.0	2084	73.3
S3	2785	2081	74.7	2141	76.9	2189	78.6
S4	2987	1709	57.2	1680	56.2	1956	65.5
S5	3370	2556	75.8	2725	80.9	2799	83.1
S6	3058	2290	74.9	2343	76.6	2466	80.6
S7	2948	2057	69.8	1670	56.6	1975	67.0
S8	3072	1753	57.1	1856	60.4	2022	65.8
S9	2971	1768	59.5	1882	63.3	2053	69.1
All women:	**3023**	**2079**	**68.8**	**1995**	**66.0**	**2181**	**72.1**
Sa	2498	1489	59.6	1656	66.3	1743	69.8
Sb	2674	1599	59.8	1725	64.5	1795	67.1
Sc	2643	1540	58.3	1656	62.7	1827	69.1
Sd	2438	1488	61.0	1788	73.3	1844	75.6
Se	2537	1543	60.8	1689	66.6	1720	67.8
Sf	2465	1437	58.3	1562	63.4	1679	68.1
All men:	**2543**	**1516**	**59.6**	**1679**	**66.0**	**1768**	**69.5**

The men's and women's initial /ɹ/ percentages are more disparate than for the other two allophones — recall that it was initial /ɹ/ that showed the bimodal distribution of F3 values in the women's data. This is reflected in the individual percentages. For instance S2, a member of the High F3 group, has an F3 of /ɹ/ which is 80.7% of the F3 of all her plain vowel F3s averaged together. However, her average vowel F3 is 2843 Hz, which is somewhat less than the S8's average vowel F3. S8, a member of the Low F3 group, lowers her F3 in /ɹ/ to about 57.1% of its neutral value; this is a much greater lowering, both in absolute terms and as a percentage of her neutral F3. That is, it is not the case that the women producing the higher F3 in initial /ɹ/ necessarily start out with higher average vowel F3s. Rather, whatever their neutral F3s, they lower the F3 of /ɹ/ less (as expressed in percent Hz) than their counterparts in the Low F3 group.

The men, on the other hand, lower F3 more consistently to about 60% of their neutral F3. This is in spite of relatively different neutral F3 values. Compare Sa and Sb, whose initial /ɹ/ F3s are approximately 59.7% of their neutral F3s, but their neutral F3 start out almost 200 Hz different. That is, Sa and Sb appear to be lowering the F3 of /ɹ/ to the same degree from neutral (as expressed in percent Hz), even though this operation begins and ends at different absolute frequencies.

It is striking, particularly in light of the disparity in intial /ɹ/ % ɹ values, that the men and the women, as groups, both have the same % ɹ̩ values, 66.0%, for F3 of syllabic /ɹ̩/. That is, the women and the men, on average, lower the F3 in syllabic /ɹ̩/ to approximately 66% of neutral. The range of individual values is greater in the women, ranging from the most lowering in S4 (56.2%) to the least in S5 (80.9%).

For final /ɹ̯/, the % ɹ̯ values are similar, though not identical for the men's and women's groups.

What can be concluded from Table 7.7 is that if lowering of F3 in American /r/ is regarded as a lowering from a neutral F3 (rather than lowering below some critical frequency), then it can be said that typicall, the F3 in an /r/ allophone can be expected to be roughly 60-70% of neutral, with certain exceptions. Some speakers, such as S5 and S6 do not lower nearly that much; other speakers, particularly the men in their initial /ɹ/ productions, lower more. Lowering to 80% or more (that is, relatively less lowering) may be seen in particular speakers, but those productions are not typical of the population.

This finding suggests that a perception experiment, using tokens with F3 of /r/ at (for instance) 50, 60, 70, 80, and 90% of neutral may result in a useful scale of rhoticity — which tokens are most easily judged as having an /r/, a "good" /r/, a "weak" /r/, etc. Without excluding 'possible' /r/s (because their F3's are above some arbitrary critical frequency), it may nonetheless be possible to quantify the goodness or acceptability of various degrees of rhoticity (F3 lowering). Such a scale for teaching English as a second language, or for measuring 'success' in /r/ productions in child development or in speech-disordered patients, could be quite useful.

7.3 Conclusions

The studies presented in the preceding chapters had two main goals. The first was to develop and extend a program of research into women's speech by extending the existing empirical phonetic database. The other was to make explicit some assumptions about women's speech and test them.

By focusing on American /r/, particularly the non-syllabic allophones of /r/, the first goal met. Previous studies of women's speech seemed to focus on qualities of voice or formants of plain vowels. The principal assumptions tested were that women's formant frequencies are usually higher than men's, that this differences is primarily a function of vocal tract size, and that this difference should be consistent across syllabic position. The women's formant frequencies were in fact found to be higher than men's; but while this was consistent with vocal tract size factors, it was argued that vocal tract size factors alone did not account for the difference. Further, it was found that the differences were not consistent across syllabic position.

Along the way, several other findings were made. By careful examination of the formant frequency data, it was found that the men and women in Southern California appear to have slightly different vowel spaces, and thus have demonstrated that Disner's (1983) finding that phonologically similar vowel systems may differ in phonetic detail holds across closely related dialects of English.

It was also found that the number of speakers who appear to use a retroflex tongue shape for /r/ was larger than might have been expected based on Delattre & Freeman's (1968) and Lindau's (1985) X-ray data, suggesting that retroflexion is undergoing a kind of renaissance in western American English. Also, speakers who use the 'tip up' (retroflex) tongue shape appear to do so to the exclusion of other possible tongue shapes, while speakers who bunch their tongues ('tip down') for /r/ can also use a 'blade up' tongue shape.

Finally, the process of 'fortition', observed in the initial /ɹ/ data (Chapter 5), clearly needs to be explored further. While this process is apparently motivated by 'enhancement' of a consonantal (syllable onset) boundary, it is currently unknown what articulatory mechanism(s) are used to produce this kind of 'fortition'. If fortition can be observed in laterals, nasals, initial glides and so forth, is the mechanism the same in all cases? Does it involve glottal adjustments, the narrowing of constrictions, changing the place of manner of articulation, the tensing or laxing of vocal tract walls, or some combination of these and other effects? Do these adjustments have effects on formant frequency? And does the apparent enhancement of the syllable onset boundary actually enhance the perception of syllable-onset consonants? Further articulatory and acoustic research of this phenomenon, both for /r/ and other segment types, is needed.

As noted earlier, one of the major objectives of the program of research represented by the present work is the expansion of the basic empirical database on women's speech. Any new body of basic research data, such as the formant frequencies of /r/ under discussion in the preceding chapters, obviously will have implications beyond mere description.

Some studies suggest that infants prefer female voices to male voices, or more specifically a special register spoken to infants as produced by female voices when produced by male voices (DeCasper & Fifer 1980; Fernald & Kuhl 1978; and references therein). If this is so, why should this preference exist? What features of the female voice make it particularly useful or interesting to infants?

These data also bear on the question of sex and gender effects in dialectology and language change. However, it is sometimes observed the women appear to excel ahead of men in certain kinds of phonological change. However, the validity of this position is in some dispute, particularly in light of evidence such as Byrd's (1994) observation that women appear to speak more carefully. (See Labov 1994 for a brief review of the issues.) Nonetheless, it must be asked whether the differential vowel systems found in Chapter 2 represent 'random' variation between dialects (as they have been characterized here) or more properly represent differential *degree* of some change-in-progress. This can be studied in real or apparent time. Southern California has not received the kind of attention which has been paid to urban dialects east of the Mississippi River (again, see Labov 1994 for a review); however, the techniques used to study such change in real or apparent time can easily be applied in the West.

Some sociolinguists, notably Eckert (1989), discount the role of speaker sex (as opposed to the more complex notion of speaker gender). It is certainly true that organic sex is unlikely to directly effect innovative or conservative linguistic patterns. However, the role of physiology in constraining and influencing the phonetic form of language should not be so discounted; in discussions of phonetic variation, both physiological and learned factors must be considered. If sex is a factor in this kind of variation (seperate from gender), is sex also a factor in why women appear to lead in some changes and not in others? Are there physiologically based features of men's and women's voices that make changes in progress more or less apparent at certain levels?

Clearly, many questions have been raised and left unanswered by the studies presented in this dissertation. As mentioned above, these studies were not intended to complete the investigation, but to extend the body of existing data and test some assumptions. In this, these studies have been successful. However, it must be recognized that further research remains to be done. Hopefully, the data and conclusions presented here, as well the as the implications of these data for speech development, audition, and other fields concerned with speech, will stimulate other studies and discussions in pursuit of the ultimate goals of phonetic theory.

Appendix A. Speaker survey form

Figure A.1 is a facsimile (reduced) of the form used to survey potential speakers. See Chapter 2 for discussion.

Speaker Survey Form

As part of a phonetic study of /r/ in dialects of American English, I am looking for a group of speakers who are willing to be recorded reading sentences from a written script. Interested speakers should be **monolingual speakers of western American English** who have lived all or most of their lives on the west coast. No other restrictions are placed on candidates. All responses to this survey will be kept strictly confidential, and all survey forms will be destroyed when the study is complete.

If you are selected to participate in this study, you will be asked to come to the Phonetics Laboratory in Campbell Hall and record approximately 200 sentences (such as "Say 'herd' again", "Say 'rock' twice"). Recorded subjects will be compensated **$10** for preparation and recording time. The recording session will probably take less than 20 minutes (usual payment is about $10/hour).

If you would like to be considered as a subject for this study, please fill in the form below, and return it to **Rob Hagiwara** , in the **Department of Linguistics** . My mailbox is in **3128 Campbell Hall** .

<table>
<tr><td colspan="2">Last Name:</td><td colspan="2">First Name:</td><td>Age:</td></tr>
<tr><td>Height:</td><td>Sex:
M F</td><td colspan="3">Phone Number:
( )</td></tr>
<tr><td colspan="5">When is the best time to reach you (for example, weekdays, weekends, weekday evenings)?</td></tr>
<tr><td colspan="5">Please list what high schools(s) and college(s) you attended.</td></tr>
<tr><td colspan="5">Please list the places you have lived for the last 10 years.</td></tr>
<tr><td>Parent or Guardian Occupations</td><td colspan="2">Mother:</td><td colspan="2">Father:</td></tr>
<tr><td>How many siblings do you have?</td><td>Older brothers:</td><td>Older sisters:</td><td>Younger brothers:</td><td>Younger sisters:</td></tr>
</table>

Figure A.1. Speaker survey form.

Appendix B. Raw data

The tables below contain the numerical data used in the study of American English described in Chapters 2 through 5. In every table, the token is identified by the orthographic word followed by a number denoting the numbered set (of three utterances) in the recording script from which the token was extracted.

Table B.1. Vowel data, including syllabic /ɹ̩/. "V" is the vowel category. "Con" is the left and right consontantal contexts. "Hz" (Hertz) and "Bk "(Bark) are the units of the formant columns.

Spkr	*Sex*	*Token*	*V*	*Con*	*F1Hz*	*F2Hz*	*F3Hz*	*F1BK*	*F2Bk*	*F3Bk*
S1	F	bat14	æ	b/t	1083	1882	2978	9.026	12.708	15.559
S1	F	bat39	æ	b/t	1070	1960	3030	8.947	12.973	15.661
S1	F	bat63	æ	b/t	1070	1792	2733	8.947	12.386	15.049
S1	F	bate04	e	b/t	451	2836	3210	4.305	15.270	15.997
S1	F	bate53	e	b/t	477	2669	3262	4.535	14.907	16.090
S1	F	bate56	e	b/t	438	2811	3404	4.189	15.218	16.336
S1	F	beat02	i	b/t	309	3159	4049	3.005	15.904	17.328
S1	F	beat16	i	b/t	309	3159	3365	3.005	15.904	16.270
S1	F	beat23	i	b/t	309	3107	3378	3.005	15.808	16.292
S1	F	bert29	ɹ̩	b/t	502	1547	2037	4.754	11.407	13.222
S1	F	bert31	ɹ̩	b/t	580	1470	1882	5.418	11.063	12.708
S1	F	bert60	ɹ̩	b/t	567	1418	1856	5.309	10.821	12.617
S1	F	bet09	ɛ	b/t	928	2192	3172	8.039	13.691	15.928
S1	F	bet23	ɛ	b/t	851	2076	3185	7.508	13.344	15.952
S1	F	bet51	ɛ	b/t	967	2101	3223	8.297	13.421	16.021
S1	F	bit06	ɪ	b/t	451	2514	3301	4.305	14.544	16.159
S1	F	bit29	ɪ	b/t	490	2501	3365	4.649	14.512	16.270
S1	F	bit55	ɪ	b/t	451	2540	3339	4.305	14.606	16.225
S1	F	boat17	o	b/t	606	1366	3236	5.634	10.570	16.044
S1	F	boat39	o	b/t	606	1328	3288	5.634	10.380	16.136
S1	F	boat66	o	b/t	644	1353	3249	5.943	10.505	16.067
S1	F	boot39	u	b/t	373	1431	3223	3.600	10.882	16.021
S1	F	boot61	u	b/t	348	1353	3223	3.369	10.505	16.021
S1	F	boot68	u	b/t	386	1676	3210	3.719	11.943	15.997
S1	F	bought27	ɑ	b/t	1005	1379	2643	8.542	10.633	14.848
S1	F	bought51	ɑ	b/t	967	1263	2759	8.297	10.043	15.106
S1	F	bought52	ɑ	b/t	1031	1379	2707	8.706	10.633	14.992
S1	F	but01	ʌ	b/t	889	1869	3146	7.774	12.663	15.880
S1	F	but11	ʌ	b/t	902	1934	3107	7.863	12.886	15.808
S1	F	but20	ʌ	b/t	954	1727	2901	8.212	12.142	15.405
S1	F	duke12	u	t/k	399	2140	3069	3.837	13.538	15.736
S1	F	duke28	u	t/k	361	2166	3017	3.489	13.615	15.636
S1	F	duke40	u	t/k	361	2217	3120	3.489	13.762	15.832
S1	F	had06	æ	h/d	1096	1960	3081	9.103	12.973	15.758
S1	F	had12	æ	h/d	1121	1895	2772	9.251	12.753	15.134
S1	F	had58	æ	h/d	1186	1960	2953	9.624	12.973	15.509
S1	F	hate13	e	h/d	438	2927	3275	4.189	15.457	16.113
S1	F	hate35	e	h/d	438	2862	3481	4.189	15.324	16.465
S1	F	hate48	e	h/d	438	2824	3352	4.189	15.245	16.248
S1	F	head04	ɛ	h/d	851	2205	3262	7.508	13.728	16.090
S1	F	head47	ɛ	h/d	735	2308	3275	6.656	14.015	16.113

S1	F	head61	ɛ	h/d	1031	2243	3262	8.706	13.836	16.090
S1	F	heed38	i	h/d	296	3120	3391	2.882	15.832	16.314
S1	F	heed62	i	h/d	296	3081	3584	2.882	15.758	16.632
S1	F	heed67	i	h/d	296	3185	3546	2.882	15.952	16.571
S1	F	herd02	ɹ̩	h/d	618	1521	1960	5.732	11.293	12.973
S1	F	herd34	ɹ̩	h/d	490	1495	1779	4.649	11.177	12.338
S1	F	herd52	ɹ̩	h/d	528	1573	1934	4.978	11.518	12.886
S1	F	hid25	ɪ	h/d	515	2579	3288	4.866	14.699	16.136
S1	F	hid63	ɪ	h/d	490	2527	3391	4.649	14.575	16.314
S1	F	hid65	ɪ	h/d	451	2566	3391	4.305	14.669	16.314
S1	F	hod28	ɑ	h/d	967	1315	2643	8.297	10.314	14.848
S1	F	hod59	ɑ	h/d	954	1250	2707	8.212	9.974	14.992
S1	F	hod67	ɑ	h/d	1044	1276	2604	8.787	10.112	14.758
S1	F	hode14	o	h/d	502	1121	3339	4.754	9.251	16.225
S1	F	hode31	o	h/d	502	1263	3275	4.754	10.043	16.113
S1	F	hode47	o	h/d	477	1108	3288	4.535	9.175	16.136
S1	F	hood02	ʊ	h/d	683	1998	3172	6.253	13.098	15.928
S1	F	hood30	ʊ	h/d	528	2063	3249	4.978	13.304	16.067
S1	F	hood43	ʊ	h/d	477	1753	3185	4.535	12.241	15.952
S1	F	hoot32	u	h/d	412	1353	3249	3.955	10.505	16.067
S1	F	hoot33	u	h/d	309	1444	3262	3.005	10.943	16.090
S1	F	hoot64	u	h/d	335	1250	3146	3.248	9.974	15.880
S1	F	hut17	ʌ	h/d	889	1947	3146	7.774	12.930	15.880
S1	F	hut34	ʌ	h/d	1018	1869	3094	8.625	12.663	15.783
S1	F	hut46	ʌ	h/d	902	2050	3120	7.863	13.263	15.832
S1	F	put09	ʊ	b/t	567	1740	3146	5.309	12.192	15.880
S1	F	put16	ʊ	b/t	618	1470	3172	5.732	11.063	15.928
S1	F	put46	ʊ	b/t	528	1637	3133	4.978	11.785	15.856
S1	F	tack18	æ	t/k	1096	1934	2888	9.103	12.886	15.378
S1	F	tack46	æ	t/k	1186	1960	3120	9.624	12.973	15.832
S1	F	tack48	æ	t/k	1096	1869	2978	9.103	12.663	15.559
S1	F	take07	e	t/k	464	2746	3455	4.421	15.078	16.422
S1	F	take42	e	t/k	515	2656	3443	4.866	14.877	16.402
S1	F	take57	e	t/k	567	2669	3352	5.309	14.907	16.248
S1	F	teak06	i	t/k	335	3056	3314	3.248	15.711	16.182
S1	F	teak25	i	t/k	348	3290	4304	3.369	16.140	17.677
S1	F	teak61	i	t/k	348	2824	3481	3.369	15.245	16.465
S1	F	tech03	ɛ	t/k	941	2101	3107	8.126	13.421	15.808
S1	F	tech37	ɛ	t/k	967	2230	3185	8.297	13.799	15.952
S1	F	tech54	ɛ	t/k	1121	2114	3198	9.251	13.460	15.976
S1	F	tick24	ɪ	t/k	541	2411	3198	5.089	14.286	15.976
S1	F	tick50	ɪ	t/k	528	2475	3210	4.978	14.448	15.997
S1	F	tick68	ɪ	t/k	464	2411	3301	4.421	14.286	16.159
S1	F	tock08	ɑ	t/k	967	1353	2759	8.297	10.505	15.106
S1	F	tock10	ɑ	t/k	1044	1379	2669	8.787	10.633	14.907
S1	F	tock32	ɑ	t/k	1057	1341	2630	8.867	10.445	14.818
S1	F	toke04	o	t/k	696	1482	3223	6.355	11.118	16.021
S1	F	toke27	o	t/k	683	1353	3262	6.253	10.505	16.090
S1	F	toke49	o	t/k	567	1341	3301	5.309	10.445	16.159
S1	F	took41	ʊ	t/k	477	1508	3159	4.535	11.235	15.904
S1	F	took48	ʊ	t/k	528	1882	3198	4.978	12.708	15.976
S1	F	took65	ʊ	t/k	541	1779	3210	5.089	12.338	15.997
S1	F	tuck13	ʌ	t/k	1005	1650	2914	8.542	11.838	15.431
S1	F	tuck17	ʌ	t/k	967	1573	2720	8.297	11.518	15.021

S1	F	tuck50	ʌ	t/k	954	1599	3185	8.212	11.628	15.952
S1	F	turk29	ɹ̩	t/k	490	1599	1998	4.649	11.628	13.098
S1	F	turk45	ɹ̩	t/k	606	1586	1921	5.634	11.574	12.842
S1	F	turk59	ɹ̩	t/k	541	1547	1960	5.089	11.407	12.973
S2	F	bat14	æ	b/t	1044	1573	2682	8.787	11.518	14.936
S2	F	bat39	æ	b/t	1070	1599	2617	8.947	11.628	14.788
S2	F	bat63	æ	b/t	992	1740	2785	8.459	12.192	15.162
S2	F	bate04	e	b/t	464	2566	3081	4.421	14.669	15.758
S2	F	bate53	e	b/t	407	2633	3417	3.910	14.825	16.358
S2	F	bate56	e	b/t	438	2579	2862	4.189	14.699	15.324
S2	F	beat02	i	b/t	348	2918	3469	3.369	15.439	16.445
S2	F	beat16	i	b/t	348	2558	3296	3.369	14.650	16.150
S2	F	beat23	i	b/t	335	2553	3275	3.248	14.638	16.113
S2	F	bert29	ɹ̩	b/t	618	1328	1676	5.732	10.380	11.943
S2	F	bert31	ɹ̩	b/t	554	1250	1599	5.200	9.974	11.628
S2	F	bert60	ɹ̩	b/t	567	1341	1611	5.309	10.445	11.678
S2	F	bet09	ɛ	b/t	825	2166	3081	7.323	13.615	15.758
S2	F	bet23	ɛ	b/t	863	2076	3223	7.593	13.344	16.021
S2	F	bet51	ɛ	b/t	954	2076	3210	8.212	13.344	15.997
S2	F	bit06	ɪ	b/t	657	2321	3094	6.047	14.050	15.783
S2	F	bit29	ɪ	b/t	554	2282	3159	5.200	13.944	15.904
S2	F	bit55	ɪ	b/t	541	2334	3236	5.089	14.085	16.044
S2	F	boat17	o	b/t	593	1263	2475	5.526	10.043	14.448
S2	F	boat39	o	b/t	528	1353	2475	4.978	10.505	14.448
S2	F	boat66	o	b/t	670	1457	2566	6.151	11.004	14.669
S2	F	boot39	u	b/t	361	1353	2501	3.489	10.505	14.512
S2	F	boot61	u	b/t	412	1444	2488	3.955	10.943	14.480
S2	F	boot68	u	b/t	425	1534	2540	4.073	11.350	14.606
S2	F	bought27	ɑ	b/t	941	1225	2720	8.126	9.839	15.021
S2	F	bought51	ɑ	b/t	992	1250	2604	8.459	9.974	14.758
S2	F	bought52	ɑ	b/t	1005	1341	2579	8.542	10.445	14.699
S2	F	but01	ʌ	b/t	825	2024	2953	7.323	13.181	15.509
S2	F	but11	ʌ	b/t	838	2011	2940	7.416	13.139	15.483
S2	F	but20	ʌ	b/t	863	1663	2733	7.593	11.891	15.049
S2	F	duke12	u	t/k	361	2334	2733	3.489	14.085	15.049
S2	F	duke28	u	t/k	348	1972	2424	3.369	13.013	14.320
S2	F	duke40	u	t/k	309	2230	2604	3.005	13.799	14.758
S2	F	had06	æ	h/d	1121	1805	2617	9.251	12.434	14.788
S2	F	had12	æ	h/d	1037	1584	2871	8.744	11.565	15.343
S2	F	had58	æ	h/d	1044	1663	2630	8.787	11.891	14.818
S2	F	hate13	e	h/d	399	2591	3107	3.837	14.727	15.808
S2	F	hate35	e	h/d	412	2785	3455	3.955	15.162	16.422
S2	F	hate48	e	h/d	464	2707	3509	4.421	14.992	16.511
S2	F	head04	ɛ	h/d	786	2166	3107	7.039	13.615	15.808
S2	F	head47	ɛ	h/d	773	2205	3210	6.942	13.728	15.997
S2	F	head61	ɛ	h/d	992	2243	2720	8.459	13.836	15.021
S2	F	heed38	i	h/d	322	2566	3481	3.126	14.669	16.465
S2	F	heed62	i	h/d	373	2811	3623	3.600	15.218	16.694
S2	F	heed67	i	h/d	361	2669	3430	3.489	14.907	16.380
S2	F	herd02	ɹ̩	h/d	425	1560	1934	4.073	11.463	12.886
S2	F	herd34	ɹ̩	h/d	361	1495	1702	3.489	11.177	12.045
S2	F	herd52	ɹ̩	h/d	528	1470	1702	4.978	11.063	12.045
S2	F	hid25	ɪ	h/d	438	2334	3172	4.189	14.085	15.928
S2	F	hid63	ɪ	h/d	438	2359	2914	4.189	14.151	15.431

S2	F	hid65	ɪ	h/d	451	2359	3275	4.305	14.151	16.113
S2	F	hod28	ɑ	h/d	1044	1328	2656	8.787	10.380	14.877
S2	F	hod59	ɑ	h/d	992	1341	2591	8.459	10.445	14.727
S2	F	hod67	ɑ	h/d	954	1341	2475	8.212	10.445	14.448
S2	F	hode14	o	h/d	464	1250	2514	4.421	9.974	14.544
S2	F	hode31	o	h/d	515	1289	2514	4.866	10.180	14.544
S2	F	hode47	o	h/d	554	1302	2591	5.200	10.247	14.727
S2	F	hood02	ʊ	h/d	528	2089	2927	4.978	13.384	15.457
S2	F	hood30	ʊ	h/d	464	1663	2553	4.421	11.891	14.638
S2	F	hood43	ʊ	h/d	490	1998	2579	4.649	13.098	14.699
S2	F	hoot32	u	h/d	322	1392	2501	3.126	10.696	14.512
S2	F	hoot33	u	h/d	348	1482	2527	3.369	11.118	14.575
S2	F	hoot64	u	h/d	386	1534	2424	3.719	11.350	14.320
S2	F	hut17	ʌ	h/d	902	1934	3159	7.863	12.886	15.904
S2	F	hut34	ʌ	h/d	889	1844	2617	7.774	12.575	14.788
S2	F	hut46	ʌ	h/d	863	1663	2591	7.593	11.891	14.727
S2	F	put09	ʊ	b/t	567	1534	2514	5.309	11.350	14.544
S2	F	put16	ʊ	b/t	490	1573	2488	4.649	11.518	14.480
S2	F	put46	ʊ	b/t	554	1405	2630	5.200	10.759	14.818
S2	F	tack18	æ	t/k	1057	1637	2579	8.867	11.785	14.699
S2	F	tack46	æ	t/k	1044	1702	2656	8.787	12.045	14.877
S2	F	tack48	æ	t/k	1044	1547	2617	8.787	11.407	14.788
S2	F	take07	e	t/k	438	2553	3410	4.189	14.638	16.346
S2	F	take42	e	t/k	477	2579	2824	4.535	14.699	15.245
S2	F	take57	e	t/k	502	2643	3275	4.754	14.848	16.113
S2	F	teak06	i	t/k	348	2669	3417	3.369	14.907	16.358
S2	F	teak25	i	t/k	373	2682	3520	3.600	14.936	16.529
S2	F	teak61	i	t/k	425	2798	3520	4.073	15.190	16.529
S2	F	tech03	ɛ	t/k	889	2166	3056	7.774	13.615	15.711
S2	F	tech37	ɛ	t/k	851	2179	2528	7.508	13.653	14.578
S2	F	tech54	ɛ	t/k	1173	2101	2643	9.551	13.421	14.848
S2	F	tick24	ɪ	t/k	412	2334	2772	3.955	14.085	15.134
S2	F	tick50	ɪ	t/k	464	2359	3159	4.421	14.151	15.904
S2	F	tick68	ɪ	t/k	490	2356	3459	4.649	14.143	16.428
S2	F	tock08	ɑ	t/k	1005	1353	2385	8.542	10.505	14.219
S2	F	tock10	ɑ	t/k	1005	1379	2462	8.542	10.633	14.415
S2	F	tock32	ɑ	t/k	1057	1276	2488	8.867	10.112	14.480
S2	F	toke04	o	t/k	541	1431	2540	5.089	10.882	14.606
S2	F	toke27	o	t/k	541	1276	2527	5.089	10.112	14.575
S2	F	toke49	o	t/k	451	1276	2553	4.305	10.112	14.638
S2	F	took41	ʊ	t/k	438	1624	2527	4.189	11.732	14.575
S2	F	took48	ʊ	t/k	554	1521	2579	5.200	11.293	14.699
S2	F	took65	ʊ	t/k	451	1457	2450	4.305	11.004	14.385
S2	F	tuck13	ʌ	t/k	954	1586	2527	8.212	11.574	14.575
S2	F	tuck17	ʌ	t/k	876	1624	2527	7.684	11.732	14.575
S2	F	tuck50	ʌ	t/k	928	1934	3094	8.039	12.886	15.783
S2	F	turk29	ɹ̩	t/k	477	1263	1637	4.535	10.043	11.785
S2	F	turk45	ɹ̩	t/k	618	1534	1740	5.732	11.350	12.192
S2	F	turk59	ɹ̩	t/k	657	1534	1998	6.047	11.350	13.098
S3	F	bat14	æ	b/t	1096	1663	2553	9.103	11.891	14.638
S3	F	bat39	æ	b/t	1044	1637	2527	8.787	11.785	14.575
S3	F	bat63	æ	b/t	1108	1637	2527	9.175	11.785	14.575
S3	F	bate04	e	b/t	464	2656	3468	4.421	14.877	16.443
S3	F	bate53	e	b/t	464	2501	2434	4.421	14.512	14.345

S3	F	bate56	e	b/t	451	2630	2991	4.305	14.818	15.585
S3	F	beat02	i	b/t	348	2488	3185	3.369	14.480	15.952
S3	F	beat16	i	b/t	373	2785	3468	3.600	15.162	16.443
S3	F	beat23	i	b/t	373	2772	3455	3.600	15.134	16.422
S3	F	bert29	ɹ̩	b/t	567	1521	1882	5.309	11.293	12.708
S3	F	bert31	ɹ̩	b/t	477	1624	2166	4.535	11.732	13.615
S3	F	bert60	ɹ̩	b/t	477	1597	2217	4.535	11.620	13.762
S3	F	bet09	ε	b/t	954	2114	2888	8.212	13.460	15.378
S3	F	bet23	ε	b/t	902	2127	2773	7.863	13.499	15.136
S3	F	bet51	ε	b/t	876	2192	2772	7.684	13.691	15.134
S3	F	bit06	ɪ	b/t	502	2334	2836	4.754	14.085	15.270
S3	F	bit29	ɪ	b/t	541	2282	3288	5.089	13.944	16.136
S3	F	bit55	ɪ	b/t	515	2243	2798	4.866	13.836	15.190
S3	F	boat17	o	b/t	967	1599	2566	8.297	11.628	14.669
S3	F	boat39	o	b/t	502	1392	2669	4.754	10.696	14.907
S3	F	boat66	o	b/t	541	1457	2798	5.089	11.004	15.190
S3	F	boot39	u	b/t	464	1611	2566	4.421	11.678	14.669
S3	F	boot61	u	b/t	477	1663	2566	4.535	11.891	14.669
S3	F	boot68	u	b/t	464	1702	2682	4.421	12.045	14.936
S3	F	bought27	ɑ	b/t	992	1341	2514	8.459	10.445	14.544
S3	F	bought51	ɑ	b/t	1005	1379	2450	8.542	10.633	14.385
S3	F	bought52	ɑ	b/t	967	1379	2450	8.297	10.633	14.385
S3	F	but01	ʌ	b/t	863	1895	2940	7.593	12.753	15.483
S3	F	but11	ʌ	b/t	915	1766	2514	7.951	12.290	14.544
S3	F	but20	ʌ	b/t	928	1753	2630	8.039	12.241	14.818
S3	F	duke12	u	t/k	451	2256	2836	4.305	13.872	15.270
S3	F	duke28	u	t/k	438	2243	2901	4.189	13.836	15.405
S3	F	duke40	u	t/k	464	2076	2759	4.421	13.344	15.106
S3	F	had06	æ	h/d	1096	1611	2540	9.103	11.678	14.606
S3	F	had12	æ	h/d	1096	1560	2411	9.103	11.463	14.286
S3	F	had58	æ	h/d	1057	1663	2475	8.867	11.891	14.448
S3	F	hate13	e	h/d	502	2606	3851	4.754	14.763	17.042
S3	F	hate35	e	h/d	451	2604	2965	4.305	14.758	15.533
S3	F	hate48	e	h/d	477	2566	2836	4.535	14.669	15.270
S3	F	head04	ε	h/d	902	2319	3676	7.863	14.045	16.777
S3	F	head47	ε	h/d	941	2256	2785	8.126	13.872	15.162
S3	F	head61	ε	h/d	980	2243	2888	8.382	13.836	15.378
S3	F	heed38	i	h/d	376	2706	3580	3.627	14.990	16.626
S3	F	heed62	i	h/d	425	2657	3703	4.073	14.880	16.819
S3	F	heed67	i	h/d	386	2772	3468	3.719	15.134	16.443
S3	F	herd02	ɹ̩	h/d	490	1650	2127	4.649	11.838	13.499
S3	F	herd34	ɹ̩	h/d	477	1740	2295	4.535	12.192	13.980
S3	F	herd52	ɹ̩	h/d	425	1805	2243	4.073	12.434	13.836
S3	F	hid25	ɪ	h/d	541	2372	3395	5.089	14.185	16.321
S3	F	hid63	ɪ	h/d	515	2346	2785	4.866	14.117	15.162
S3	F	hid65	ɪ	h/d	554	2372	3133	5.200	14.185	15.856
S3	F	hod28	ɑ	h/d	992	1379	2450	8.459	10.633	14.385
S3	F	hod59	ɑ	h/d	980	1379	2462	8.382	10.633	14.415
S3	F	hod67	ɑ	h/d	1121	1431	2656	9.251	10.882	14.877
S3	F	hode14	o	h/d	515	1418	2579	4.866	10.821	14.699
S3	F	hode31	o	h/d	567	1431	2656	5.309	10.882	14.877
S3	F	hode47	o	h/d	696	1457	2643	6.355	11.004	14.848
S3	F	hood02	ʊ	h/d	593	1599	2308	5.526	11.628	14.015
S3	F	hood30	ʊ	h/d	528	1508	2733	4.978	11.235	15.049

S3	F	hood43	ʊ	h/d	567	1663	2617	5.309	11.891	14.788
S3	F	hoot32	u	h/d	490	1689	2720	4.649	11.994	15.021
S3	F	hoot33	u	h/d	490	1663	2656	4.649	11.891	14.877
S3	F	hoot64	u	h/d	464	1289	2591	4.421	10.180	14.727
S3	F	hut17	ʌ	h/d	967	1805	2669	8.297	12.434	14.907
S3	F	hut34	ʌ	h/d	992	1650	2733	8.459	11.838	15.049
S3	F	hut46	ʌ	h/d	954	1624	2720	8.212	11.732	15.021
S3	F	put09	ʊ	b/t	889	1457	2553	7.774	11.004	14.638
S3	F	put16	ʊ	b/t	722	1663	2656	6.557	11.891	14.877
S3	F	put46	ʊ	b/t	657	1586	2579	6.047	11.574	14.699
S3	F	tack18	æ	t/k	1108	1560	2462	9.175	11.463	14.415
S3	F	tack46	æ	t/k	1005	1818	2540	8.542	12.481	14.606
S3	F	tack48	æ	t/k	1070	1715	2604	8.947	12.096	14.758
S3	F	take07	e	t/k	490	2553	2927	4.649	14.638	15.457
S3	F	take42	e	t/k	477	2475	2759	4.535	14.448	15.106
S3	F	take57	e	t/k	477	2514	3546	4.535	14.544	16.571
S3	F	teak06	i	t/k	438	2604	2914	4.189	14.758	15.431
S3	F	teak25	i	t/k	399	2604	3443	3.837	14.758	16.402
S3	F	teak61	i	t/k	361	2591	3312	3.489	14.727	16.178
S3	F	tech03	ε	t/k	928	2024	2553	8.039	13.181	14.638
S3	F	tech37	ε	t/k	902	1733	2591	7.863	12.165	14.727
S3	F	tech54	ε	t/k	954	2205	2604	8.212	13.728	14.758
S3	F	tick24	ɪ	t/k	631	2269	2940	5.838	13.908	15.483
S3	F	tick50	ɪ	t/k	541	2217	2669	5.089	13.762	14.907
S3	F	tick68	ɪ	t/k	554	2243	2798	5.200	13.836	15.190
S3	F	tock08	ɑ	t/k	1005	1379	2475	8.542	10.633	14.448
S3	F	tock10	ɑ	t/k	992	1366	2424	8.459	10.570	14.320
S3	F	tock32	ɑ	t/k	1070	1457	2682	8.947	11.004	14.936
S3	F	toke04	o	t/k	1005	1637	2617	8.542	11.785	14.788
S3	F	toke27	o	t/k	954	1624	2566	8.212	11.732	14.669
S3	F	toke49	o	t/k	760	1586	2591	6.845	11.574	14.727
S3	F	took41	ʊ	t/k	683	1663	2591	6.253	11.891	14.727
S3	F	took48	ʊ	t/k	851	1611	2553	7.508	11.678	14.638
S3	F	took65	ʊ	t/k	696	1663	2488	6.355	11.891	14.480
S3	F	tuck13	ʌ	t/k	954	1637	2591	8.212	11.785	14.727
S3	F	tuck17	ʌ	t/k	967	1650	2566	8.297	11.838	14.669
S3	F	tuck50	ʌ	t/k	941	1624	2540	8.126	11.732	14.606
S3	F	turk29	ɹ̩	t/k	644	1508	2024	5.943	11.235	13.181
S3	F	turk45	ɹ̩	t/k	502	1650	2166	4.754	11.838	13.615
S3	F	turk59	ɹ̩	t/k	502	1689	2153	4.754	11.994	13.577
S4	F	bat14	æ	b/t	1199	1818	3030	9.696	12.481	15.661
S4	F	bat39	æ	b/t	1096	1818	2862	9.103	12.481	15.324
S4	F	bat63	æ	b/t	954	1908	3030	8.212	12.798	15.661
S4	F	bate04	e	b/t	425	2417	3120	4.073	14.302	15.832
S4	F	bate53	e	b/t	425	2372	2914	4.073	14.185	15.431
S4	F	bate56	e	b/t	412	2617	3210	3.955	14.788	15.997
S4	F	beat02	i	b/t	373	2836	3700	3.600	15.270	16.814
S4	F	beat16	i	b/t	322	2798	3636	3.126	15.190	16.714
S4	F	beat23	i	b/t	361	2746	3520	3.489	15.078	16.529
S4	F	bert29	ɹ̩	b/t	451	1444	1779	4.305	10.943	12.338
S4	F	bert31	ɹ̩	b/t	438	1315	1611	4.189	10.314	11.678
S4	F	bert60	ɹ̩	b/t	412	1405	1766	3.955	10.759	12.290
S4	F	bet09	ε	b/t	825	2162	3183	7.323	13.603	15.948
S4	F	bet23	ε	b/t	1023	1948	2784	8.656	12.933	15.160

S4	F	bet51	ɛ	b/t	1169	1808	2764	9.528	12.445	15.117
S4	F	bit06	ɪ	b/t	451	2327	3244	4.305	14.066	16.058
S4	F	bit29	ɪ	b/t	451	2359	3365	4.305	14.151	16.270
S4	F	bit55	ɪ	b/t	438	2372	3236	4.189	14.185	16.044
S4	F	boat17	o	b/t	399	1134	2824	3.837	9.327	15.245
S4	F	boat39	o	b/t	399	1147	2914	3.837	9.402	15.431
S4	F	boat66	o	b/t	477	1225	2901	4.535	9.839	15.405
S4	F	boot39	u	b/t	386	1289	2875	3.719	10.180	15.351
S4	F	boot61	u	b/t	361	1482	2772	3.489	11.118	15.134
S4	F	boot68	u	b/t	348	1276	2862	3.369	10.112	15.324
S4	F	bought27	ɑ	b/t	1147	1637	2759	9.402	11.785	15.106
S4	F	bought51	ɑ	b/t	1031	1328	2836	8.706	10.380	15.270
S4	F	bought52	ɑ	b/t	954	1341	2862	8.212	10.445	15.324
S4	F	but01	ʌ	b/t	845	1631	2914	7.466	11.761	15.431
S4	F	but11	ʌ	b/t	967	1663	2927	8.297	11.891	15.457
S4	F	but20	ʌ	b/t	769	1486	3035	6.912	11.136	15.670
S4	F	duke12	u	t/k	348	1341	2772	3.369	10.445	15.134
S4	F	duke28	u	t/k	399	1779	2836	3.837	12.338	15.270
S4	F	duke40	u	t/k	386	1985	2824	3.719	13.055	15.245
S4	F	had06	æ	h/d	967	1895	2656	8.297	12.753	14.877
S4	F	had12	æ	h/d	1070	1818	2695	8.947	12.481	14.965
S4	F	had58	æ	h/d	1108	1779	2669	9.175	12.338	14.907
S4	F	hate13	e	h/d	412	2824	3133	3.955	15.245	15.856
S4	F	hate35	e	h/d	412	2798	3210	3.955	15.190	15.997
S4	F	hate48	e	h/d	451	2772	3107	4.305	15.134	15.808
S4	F	head04	ɛ	h/d	657	2334	3378	6.047	14.085	16.292
S4	F	head47	ɛ	h/d	915	2398	3210	7.951	14.253	15.997
S4	F	head61	ɛ	h/d	943	1667	2609	8.139	11.907	14.769
S4	F	heed38	i	h/d	373	2824	3636	3.600	15.245	16.714
S4	F	heed62	i	h/d	309	2914	3636	3.005	15.431	16.714
S4	F	heed67	i	h/d	386	2901	3520	3.719	15.405	16.529
S4	F	herd02	ɹ̩	h/d	412	1457	1702	3.955	11.004	12.045
S4	F	herd34	ɹ̩	h/d	399	1418	1637	3.837	10.821	11.785
S4	F	herd52	ɹ̩	h/d	373	1315	1599	3.600	10.314	11.628
S4	F	hid25	ɪ	h/d	451	2450	3352	4.305	14.385	16.248
S4	F	hid63	ɪ	h/d	348	2514	3262	3.369	14.544	16.090
S4	F	hid65	ɪ	h/d	464	2334	3455	4.421	14.085	16.422
S4	F	hod28	ɑ	h/d	967	1418	3056	8.297	10.821	15.711
S4	F	hod59	ɑ	h/d	1031	1328	2940	8.706	10.380	15.483
S4	F	hod67	ɑ	h/d	967	1289	2978	8.297	10.180	15.559
S4	F	hode14	o	h/d	412	1173	2940	3.955	9.551	15.483
S4	F	hode31	o	h/d	412	1237	2785	3.955	9.904	15.162
S4	F	hode47	o	h/d	386	1160	2978	3.719	9.477	15.559
S4	F	hood02	ʊ	h/d	425	1637	2720	4.073	11.785	15.021
S4	F	hood30	ʊ	h/d	438	1715	3288	4.189	12.096	16.136
S4	F	hood43	ʊ	h/d	502	1534	2566	4.754	11.350	14.669
S4	F	hoot32	u	h/d	386	1573	2811	3.719	11.518	15.218
S4	F	hoot33	u	h/d	399	1341	2798	3.837	10.445	15.190
S4	F	hoot64	u	h/d	322	1276	2746	3.126	10.112	15.078
S4	F	hut17	ʌ	h/d	915	1792	2836	7.951	12.386	15.270
S4	F	hut34	ʌ	h/d	863	1818	3120	7.593	12.481	15.832
S4	F	hut46	ʌ	h/d	1083	1683	2958	9.026	11.970	15.519
S4	F	put09	ʊ	b/t	451	1753	3081	4.305	12.241	15.758
S4	F	put16	ʊ	b/t	361	1611	2759	3.489	11.678	15.106

S4	F	put46	ʊ	b/t	386	1702	2707	3.719	12.045	14.992
S4	F	tack18	æ	t/k	1121	1856	2591	9.251	12.617	14.727
S4	F	tack46	æ	t/k	1096	1856	2579	9.103	12.617	14.699
S4	F	tack48	æ	t/k	1096	1972	2786	9.103	13.013	15.164
S4	F	take07	e	t/k	373	2630	3352	3.600	14.818	16.248
S4	F	take42	e	t/k	412	2579	3223	3.955	14.699	16.021
S4	F	take57	e	t/k	386	2566	3404	3.719	14.669	16.336
S4	F	teak06	i	t/k	386	2875	3446	3.719	15.351	16.407
S4	F	teak25	i	t/k	386	2720	3597	3.719	15.021	16.653
S4	F	teak61	i	t/k	361	2798	3430	3.489	15.190	16.380
S4	F	tech03	ɛ	t/k	1083	2063	2695	9.026	13.304	14.965
S4	F	tech37	ɛ	t/k	1007	2415	2919	8.555	14.297	15.441
S4	F	tech54	ɛ	t/k	1045	1933	2858	8.793	12.883	15.316
S4	F	tick24	ɪ	t/k	386	2501	2849	3.719	14.512	15.297
S4	F	tick50	ɪ	t/k	451	2527	2914	4.305	14.575	15.431
S4	F	tick68	ɪ	t/k	412	2514	2978	3.955	14.544	15.559
S4	F	tock08	ɑ	t/k	1018	1328	2604	8.625	10.380	14.758
S4	F	tock10	ɑ	t/k	1018	1353	2720	8.625	10.505	15.021
S4	F	tock32	ɑ	t/k	1044	1353	2669	8.787	10.505	14.907
S4	F	toke04	o	t/k	386	1186	2798	3.719	9.624	15.190
S4	F	toke27	o	t/k	438	1341	2836	4.189	10.445	15.270
S4	F	toke49	o	t/k	395	1359	2816	3.801	10.535	15.228
S4	F	took41	ʊ	t/k	335	1470	2798	3.248	11.063	15.190
S4	F	took48	ʊ	t/k	451	1508	2927	4.305	11.235	15.457
S4	F	took65	ʊ	t/k	425	1366	2836	4.073	10.570	15.270
S4	F	tuck13	ʌ	t/k	980	1663	2733	8.382	11.891	15.049
S4	F	tuck17	ʌ	t/k	980	1624	2656	8.382	11.732	14.877
S4	F	tuck50	ʌ	t/k	1005	1702	2720	8.542	12.045	15.021
S4	F	turk29	ɹ̩	t/k	438	1392	1676	4.189	10.696	11.943
S4	F	turk45	ɹ̩	t/k	348	1418	1663	3.369	10.821	11.891
S4	F	turk59	ɹ̩	t/k	399	1341	1689	3.837	10.445	11.994
S5	F	bat14	æ	b/t	941	1985	3893	8.126	13.055	17.104
S5	F	bat39	æ	b/t	1044	1908	3533	8.787	12.798	16.550
S5	F	bat63	æ	b/t	967	1869	2991	8.297	12.663	15.585
S5	F	bate04	e	b/t	399	2901	3623	3.837	15.405	16.694
S5	F	bate53	e	b/t	425	2901	3971	4.073	15.405	17.217
S5	F	bate56	e	b/t	438	2798	3739	4.189	15.190	16.874
S5	F	beat02	i	b/t	309	3043	3855	3.005	15.686	17.048
S5	F	beat16	i	b/t	348	3017	3778	3.369	15.636	16.933
S5	F	beat23	i	b/t	322	2901	3739	3.126	15.405	16.874
S5	F	bert29	ɹ̩	b/t	464	1882	2669	4.421	12.708	14.907
S5	F	bert31	ɹ̩	b/t	528	1727	2682	4.978	12.142	14.936
S5	F	bert60	ɹ̩	b/t	490	1831	2630	4.649	12.528	14.818
S5	F	bet09	ɛ	b/t	670	2359	3636	6.151	14.151	16.714
S5	F	bet23	ɛ	b/t	696	2424	3584	6.355	14.320	16.632
S5	F	bet51	ɛ	b/t	696	2295	3571	6.355	13.980	16.611
S5	F	bit06	ɪ	b/t	464	2450	3583	4.421	14.385	16.630
S5	F	bit29	ɪ	b/t	451	2553	3662	4.305	14.638	16.755
S5	F	bit55	ɪ	b/t	477	2514	3623	4.535	14.544	16.694
S5	F	boat17	o	b/t	477	2024	3017	4.535	13.181	15.636
S5	F	boat39	o	b/t	541	1869	3314	5.089	12.663	16.182
S5	F	boat66	o	b/t	541	1882	3043	5.089	12.708	15.686
S5	F	boot39	u	b/t	425	2334	3236	4.073	14.085	16.044
S5	F	boot61	u	b/t	451	2424	3249	4.305	14.320	16.067

S5	F	boot68	u	b/t	477	2114	2927	4.535	13.460	15.457
S5	F	bought27	ɑ	b/t	825	1341	2888	7.323	10.445	15.378
S5	F	bought51	ɑ	b/t	863	1418	3094	7.593	10.821	15.783
S5	F	bought52	ɑ	b/t	709	1250	3262	6.456	9.974	16.090
S5	F	but01	ʌ	b/t	580	1998	3481	5.418	13.098	16.465
S5	F	but11	ʌ	b/t	709	1947	3340	6.456	12.930	16.227
S5	F	but20	ʌ	b/t	683	2024	3417	6.253	13.181	16.358
S5	F	duke12	u	t/k	451	2166	3198	4.305	13.615	15.976
S5	F	duke28	u	t/k	412	2579	3107	3.955	14.699	15.808
S5	F	duke40	u	t/k	477	2540	3365	4.535	14.606	16.270
S5	F	had06	æ	h/d	825	2089	2991	7.323	13.384	15.585
S5	F	had12	æ	h/d	902	1985	2824	7.863	13.055	15.245
S5	F	had58	æ	h/d	1057	1934	2836	8.867	12.886	15.270
S5	F	hate13	e	h/d	438	2953	4026	4.189	15.509	17.296
S5	F	hate35	e	h/d	464	2824	3726	4.421	15.245	16.854
S5	F	hate48	e	h/d	464	2824	3172	4.421	15.245	15.928
S5	F	head04	ɛ	h/d	528	2630	3741	4.978	14.818	16.877
S5	F	head47	ɛ	h/d	618	2205	3094	5.732	13.728	15.783
S5	F	head61	ɛ	h/d	670	2630	3970	6.151	14.818	17.216
S5	F	heed38	i	h/d	412	2940	3804	3.955	15.483	16.972
S5	F	heed62	i	h/d	412	3069	4036	3.955	15.736	17.310
S5	F	heed67	i	h/d	425	2978	3778	4.073	15.559	16.933
S5	F	herd02	ɹ̩	h/d	490	1882	2591	4.649	12.708	14.727
S5	F	herd34	ɹ̩	h/d	477	1934	2811	4.535	12.886	15.218
S5	F	herd52	ɹ̩	h/d	618	1908	2811	5.732	12.798	15.218
S5	F	hid25	ɪ	h/d	451	2656	3636	4.305	14.877	16.714
S5	F	hid63	ɪ	h/d	502	2617	3978	4.754	14.788	17.227
S5	F	hid65	ɪ	h/d	490	2656	4142	4.649	14.877	17.458
S5	F	hod28	ɑ	h/d	773	1470	2927	6.942	11.063	15.457
S5	F	hod59	ɑ	h/d	941	1573	3043	8.126	11.518	15.686
S5	F	hod67	ɑ	h/d	992	1599	2836	8.459	11.628	15.270
S5	F	hode14	o	h/d	464	1766	3107	4.421	12.290	15.808
S5	F	hode31	o	h/d	528	1856	3236	4.978	12.617	16.044
S5	F	hode47	o	h/d	593	1766	2901	5.526	12.290	15.405
S5	F	hood02	ʊ	h/d	528	1895	3288	4.978	12.753	16.136
S5	F	hood30	ʊ	h/d	541	1908	3275	5.089	12.798	16.113
S5	F	hood43	ʊ	h/d	477	1702	3378	4.535	12.045	16.292
S5	F	hoot32	u	h/d	386	1611	3236	3.719	11.678	16.044
S5	F	hoot33	u	h/d	399	1856	2927	3.837	12.617	15.457
S5	F	hoot64	u	h/d	361	1844	2940	3.489	12.575	15.483
S5	F	hut17	ʌ	h/d	799	2024	3713	7.134	13.181	16.834
S5	F	hut34	ʌ	h/d	722	2101	3636	6.557	13.421	16.714
S5	F	hut46	ʌ	h/d	876	2011	3301	7.684	13.139	16.159
S5	F	put09	ʊ	b/t	606	1934	3430	5.634	12.886	16.380
S5	F	put16	ʊ	b/t	606	1908	3314	5.634	12.798	16.182
S5	F	put46	ʊ	b/t	593	1831	3301	5.526	12.528	16.159
S5	F	tack18	æ	t/k	915	1895	2836	7.951	12.753	15.270
S5	F	tack46	æ	t/k	941	1856	2746	8.126	12.617	15.078
S5	F	tack48	æ	t/k	1057	1934	2914	8.867	12.886	15.431
S5	F	take07	e	t/k	451	2769	3741	4.305	15.128	16.877
S5	F	take42	e	t/k	502	2785	3868	4.754	15.162	17.068
S5	F	take57	e	t/k	644	2566	3726	5.943	14.669	16.854
S5	F	teak06	i	t/k	361	2811	3713	3.489	15.218	16.834
S5	F	teak25	i	t/k	335	2824	3584	3.248	15.245	16.632

S5	F	teak61	i	t/k	361	2927	3675	3.489	15.457	16.775
S5	F	tech03	ε	t/k	618	2153	3146	5.732	13.577	15.880
S5	F	tech37	ε	t/k	954	2243	3494	8.212	13.836	16.486
S5	F	tech54	ε	t/k	773	2230	3094	6.942	13.799	15.783
S5	F	tick24	ɪ	t/k	528	2462	3468	4.978	14.415	16.443
S5	F	tick50	ɪ	t/k	515	2450	3829	4.866	14.385	17.010
S5	F	tick68	ɪ	t/k	541	2746	3551	5.089	15.078	16.579
S5	F	tock08	ɑ	t/k	1121	1482	2798	9.251	11.118	15.190
S5	F	tock10	ɑ	t/k	967	1573	2759	8.297	11.518	15.106
S5	F	tock32	ɑ	t/k	1070	1379	2772	8.947	10.633	15.134
S5	F	toke04	o	t/k	593	1844	3210	5.526	12.575	15.997
S5	F	toke27	o	t/k	580	1934	3610	5.418	12.886	16.673
S5	F	toke49	o	t/k	593	2011	3030	5.526	13.139	15.661
S5	F	took41	ʊ	t/k	425	1676	3236	4.073	11.943	16.044
S5	F	took48	ʊ	t/k	528	1831	2953	4.978	12.528	15.509
S5	F	took65	ʊ	t/k	580	1611	3430	5.418	11.678	16.380
S5	F	tuck13	ʌ	t/k	722	1805	3360	6.557	12.434	16.261
S5	F	tuck17	ʌ	t/k	709	1856	3559	6.456	12.617	16.592
S5	F	tuck50	ʌ	t/k	799	1869	2940	7.134	12.663	15.483
S5	F	turk29	ɹ̩	t/k	515	1972	2733	4.866	13.013	15.049
S5	F	turk45	ɹ̩	t/k	644	1805	2798	5.943	12.434	15.190
S5	F	turk59	ɹ̩	t/k	670	1895	2798	6.151	12.753	15.190
S6	F	bat14	æ	b/t	963	1999	3063	8.271	13.101	15.724
S6	F	bat39	æ	b/t	1048	1725	3045	8.812	12.134	15.690
S6	F	bat63	æ	b/t	1038	1896	2997	8.750	12.757	15.596
S6	F	bate04	e	b/t	392	2872	3312	3.774	15.345	16.178
S6	F	bate53	e	b/t	388	2747	3158	3.737	15.080	15.902
S6	F	bate56	e	b/t	402	2736	3036	3.865	15.056	15.672
S6	F	beat02	i	b/t	412	2947	3255	3.955	15.497	16.078
S6	F	beat16	i	b/t	406	2834	3102	3.901	15.266	15.798
S6	F	beat23	i	b/t	384	2766	3165	3.701	15.121	15.915
S6	F	bert29	ɹ̩	b/t	395	1587	2274	3.801	11.578	13.922
S6	F	bert31	ɹ̩	b/t	499	1686	2225	4.728	11.982	13.785
S6	F	bert60	ɹ̩	b/t	407	1630	2447	3.910	11.757	14.378
S6	F	bet09	ε	b/t	762	2488	3222	6.860	14.480	16.019
S6	F	bet23	ε	b/t	885	2258	3135	7.746	13.878	15.860
S6	F	bet51	ε	b/t	955	2336	3085	8.219	14.090	15.766
S6	F	bit06	ɪ	b/t	405	2613	3146	3.892	14.779	15.880
S6	F	bit29	ɪ	b/t	414	2465	2975	3.973	14.423	15.553
S6	F	bit55	ɪ	b/t	436	2412	3074	4.171	14.289	15.745
S6	F	boat17	o	b/t	427	1383	3068	4.091	10.653	15.734
S6	F	boat39	o	b/t	535	1300	3013	5.038	10.237	15.628
S6	F	boat66	o	b/t	416	1266	2962	3.992	10.059	15.527
S6	F	boot39	u	b/t	417	1491	2944	4.001	11.159	15.491
S6	F	boot61	u	b/t	403	1615	2949	3.874	11.695	15.501
S6	F	boot68	u	b/t	422	1525	3030	4.046	11.310	15.661
S6	F	bought27	ɑ	b/t	1026	1541	2907	8.675	11.381	15.417
S6	F	bought51	ɑ	b/t	1054	1392	3114	8.849	10.696	15.821
S6	F	bought52	ɑ	b/t	1155	1612	3086	9.448	11.683	15.768
S6	F	but01	ʌ	b/t	1072	1755	3063	8.959	12.248	15.724
S6	F	but11	ʌ	b/t	1057	1735	3141	8.867	12.173	15.871
S6	F	but20	ʌ	b/t	676	1754	3135	6.198	12.245	15.860
S6	F	duke12	u	t/k	413	1633	2691	3.964	11.769	14.956
S6	F	duke28	u	t/k	432	1729	2840	4.136	12.150	15.279

S6	F	duke40	u	t/k	423	1779	2948	4.055	12.338	15.499
S6	F	had06	æ	h/d	1020	1858	3120	8.637	12.624	15.832
S6	F	had12	æ	h/d	1087	1812	3037	9.050	12.460	15.674
S6	F	had58	æ	h/d	1075	1681	2969	8.977	11.962	15.541
S6	F	hate13	e	h/d	420	2730	3197	4.028	15.043	15.974
S6	F	hate35	e	h/d	395	2901	3257	3.801	15.405	16.082
S6	F	hate48	e	h/d	435	2724	3080	4.163	15.030	15.757
S6	F	head04	ɛ	h/d	776	2430	3279	6.965	14.335	16.120
S6	F	head47	ɛ	h/d	733	2171	3146	6.641	13.630	15.880
S6	F	head61	ɛ	h/d	690	2488	3265	6.308	14.480	16.096
S6	F	heed38	i	h/d	388	2817	3287	3.737	15.230	16.135
S6	F	heed62	i	h/d	379	3129	3528	3.655	15.849	16.542
S6	F	heed67	i	h/d	414	2923	3355	3.973	15.449	16.253
S6	F	herd02	ɹ̩	h/d	396	1726	2479	3.810	12.138	14.458
S6	F	herd34	ɹ̩	h/d	499	1765	2401	4.728	12.286	14.261
S6	F	herd52	ɹ̩	h/d	445	1735	2379	4.252	12.173	14.204
S6	F	hid25	ɪ	h/d	414	2700	3156	3.973	14.976	15.899
S6	F	hid63	ɪ	h/d	421	2616	3008	4.037	14.786	15.618
S6	F	hid65	ɪ	h/d	393	2621	3106	3.783	14.797	15.806
S6	F	hod28	ɑ	h/d	1168	1660	3042	9.522	11.879	15.684
S6	F	hod59	ɑ	h/d	1023	1631	3080	8.656	11.761	15.757
S6	F	hod67	ɑ	h/d	1143	1458	2944	9.379	11.008	15.491
S6	F	hode14	o	h/d	385	1256	3114	3.710	10.006	15.821
S6	F	hode31	o	h/d	407	1180	3131	3.910	9.590	15.852
S6	F	hode47	o	h/d	442	1272	2960	4.225	10.091	15.523
S6	F	hood02	ʊ	h/d	350	1725	3095	3.387	12.134	15.785
S6	F	hood30	ʊ	h/d	398	1370	2981	3.828	10.589	15.565
S6	F	hood43	ʊ	h/d	409	1361	2764	3.928	10.545	15.117
S6	F	hoot32	u	h/d	371	1620	2843	3.581	11.716	15.285
S6	F	hoot33	u	h/d	402	1480	3050	3.865	11.109	15.699
S6	F	hoot64	u	h/d	401	1665	2988	3.856	11.899	15.579
S6	F	hut17	ʌ	h/d	977	1712	2998	8.362	12.084	15.598
S6	F	hut34	ʌ	h/d	902	1893	3130	7.863	12.747	15.851
S6	F	hut46	ʌ	h/d	1136	1848	3104	9.339	12.589	15.802
S6	F	put09	ʊ	b/t	401	1803	2985	3.856	12.427	15.573
S6	F	put16	ʊ	b/t	342	1738	2990	3.313	12.184	15.583
S6	F	put46	ʊ	b/t	398	1856	2917	3.828	12.617	15.437
S6	F	tack18	æ	t/k	1022	1787	2732	8.650	12.368	15.047
S6	F	tack46	æ	t/k	1145	1665	2754	9.391	11.899	15.095
S6	F	tack48	æ	t/k	1245	1859	2758	9.947	12.628	15.104
S6	F	take07	e	t/k	443	2790	3251	4.234	15.173	16.071
S6	F	take42	e	t/k	417	2697	3293	4.001	14.970	16.145
S6	F	take57	e	t/k	417	2759	3383	4.001	15.106	16.301
S6	F	teak06	i	t/k	412	2949	3287	3.955	15.501	16.135
S6	F	teak25	i	t/k	407	2858	3198	3.910	15.316	15.976
S6	F	teak61	i	t/k	397	2893	3394	3.819	15.388	16.319
S6	F	tech03	ɛ	t/k	871	2187	3014	7.649	13.676	15.630
S6	F	tech37	ɛ	t/k	989	2590	3171	8.440	14.725	15.926
S6	F	tech54	ɛ	t/k	853	2601	3036	7.522	14.751	15.672
S6	F	tick24	ɪ	t/k	448	2533	2996	4.279	14.590	15.595
S6	F	tick50	ɪ	t/k	385	2528	3095	3.710	14.578	15.785
S6	F	tick68	ɪ	t/k	419	2559	3118	4.019	14.652	15.828
S6	F	tock08	ɑ	t/k	1103	1419	2883	9.145	10.826	15.368
S6	F	tock10	ɑ	t/k	1127	1412	2612	9.286	10.793	14.776

S6	F	tock32	ɑ	t/k	1029	1384	3040	8.694	10.658	15.680
S6	F	toke04	o	t/k	384	1434	3093	3.701	10.897	15.781
S6	F	toke27	o	t/k	392	1222	3134	3.774	9.823	15.858
S6	F	toke49	o	t/k	472	1334	2999	4.491	10.410	15.600
S6	F	took41	ʊ	t/k	407	1633	2844	3.910	11.769	15.287
S6	F	took48	ʊ	t/k	429	1782	2887	4.109	12.349	15.376
S6	F	took65	ʊ	t/k	404	1578	2783	3.883	11.540	15.158
S6	F	tuck13	ʌ	t/k	929	1719	2948	8.046	12.111	15.499
S6	F	tuck17	ʌ	t/k	1013	1711	3029	8.593	12.080	15.659
S6	F	tuck50	ʌ	t/k	1002	1629	2962	8.523	11.753	15.527
S6	F	turk29	ɹ̩	t/k	405	1633	2284	3.892	11.769	13.950
S6	F	turk45	ɹ̩	t/k	391	1704	2293	3.765	12.053	13.974
S6	F	turk59	ɹ̩	t/k	443	1739	2305	4.234	12.188	14.007
S7	F	bat14	æ	b/t	1054	1823	2819	8.849	12.499	15.234
S7	F	bat39	æ	b/t	1119	1654	2790	9.240	11.854	15.173
S7	F	bat63	æ	b/t	1194	1767	2807	9.669	12.294	15.209
S7	F	bate04	e	b/t	366	2487	3000	3.535	14.477	15.602
S7	F	bate53	e	b/t	372	2797	3094	3.590	15.188	15.783
S7	F	bate56	e	b/t	372	2766	3176	3.590	15.121	15.935
S7	F	beat02	i	b/t	326	2880	3715	3.164	15.362	16.837
S7	F	beat16	i	b/t	345	3009	3695	3.341	15.620	16.806
S7	F	beat23	i	b/t	334	2934	3665	3.239	15.471	16.760
S7	F	bert29	ɹ̩	b/t	383	1381	1711	3.691	10.643	12.080
S7	F	bert31	ɹ̩	b/t	365	1309	1545	3.526	10.283	11.398
S7	F	bert60	ɹ̩	b/t	441	1364	1633	4.216	10.560	11.769
S7	F	bet09	ɛ	b/t	743	2253	3002	6.717	13.864	15.606
S7	F	bet23	ɛ	b/t	843	2065	2824	7.452	13.310	15.245
S7	F	bet51	ɛ	b/t	731	2113	2936	6.626	13.457	15.475
S7	F	bit06	ɪ	b/t	432	2292	3085	4.136	13.971	15.766
S7	F	bit29	ɪ	b/t	346	2330	2970	3.350	14.074	15.543
S7	F	bit55	ɪ	b/t	416	2425	3108	3.992	14.322	15.809
S7	F	boat17	o	b/t	434	1268	2915	4.154	10.070	15.433
S7	F	boat39	o	b/t	451	1299	2894	4.305	10.232	15.390
S7	F	boat66	o	b/t	404	1352	2830	3.883	10.500	15.258
S7	F	boot39	u	b/t	396	1609	2836	3.810	11.670	15.270
S7	F	boot61	u	b/t	396	1594	2923	3.810	11.607	15.449
S7	F	boot68	u	b/t	389	1524	2858	3.746	11.306	15.316
S7	F	bought27	ɑ	b/t	1086	1382	2836	9.044	10.648	15.270
S7	F	bought51	ɑ	b/t	1001	1329	2851	8.517	10.385	15.302
S7	F	bought52	ɑ	b/t	1078	1340	2897	8.995	10.440	15.396
S7	F	but01	ʌ	b/t	877	1572	2707	7.691	11.514	14.992
S7	F	but11	ʌ	b/t	747	1611	2948	6.747	11.678	15.499
S7	F	but20	ʌ	b/t	930	1681	2891	8.052	11.962	15.384
S7	F	duke12	u	t/k	370	1887	2686	3.572	12.726	14.945
S7	F	duke28	u	t/k	379	1973	2840	3.655	13.016	15.279
S7	F	duke40?	u	t/k	372	2289	2844	3.590	13.963	15.287
S7	F	had06	æ	h/d	1104	1686	2683	9.151	11.982	14.938
S7	F	had12	æ	h/d	1239	1749	2833	9.915	12.226	15.264
S7	F	had58	æ	h/d	1190	1658	2805	9.646	11.871	15.205
S7	F	hate13	e	h/d	365	2834	3090	3.526	15.266	15.775
S7	F	hate35	e	h/d	365	2783	3054	3.526	15.158	15.707
S7	F	hate48	e	h/d	368	2952	3261	3.554	15.507	16.089
S7	F	head04	ɛ	h/d	790	2139	2965	7.068	13.535	15.533
S7	F	head47	ɛ	h/d	821	2446	3099	7.294	14.375	15.792

S7	F	head61	ɛ	h/d	810	1887	2973	7.214	12.726	15.549
S7	F	heed38	i	h/d	315	2973	3746	3.061	15.549	16.885
S7	F	heed62	i	h/d	378	3087	3333	3.646	15.770	16.215
S7	F	heed67	i	h/d	323	2973	3383	3.136	15.549	16.301
S7	F	herd02	ɹ̩	h/d	398	1376	1677	3.828	10.619	11.946
S7	F	herd34	ɹ̩	h/d	448	1479	1690	4.279	11.105	11.998
S7	F	herd52	ɹ̩	h/d	306	1357	1687	2.976	10.525	11.986
S7	F	hid25	ɪ	h/d	442	2461	3028	4.225	14.413	15.657
S7	F	hid63	ɪ	h/d	408	2487	3086	3.919	14.477	15.768
S7	F	hid65	ɪ	h/d	386	2515	3023	3.719	14.546	15.647
S7	F	hod28	ɑ	h/d	1092	1389	2806	9.080	10.682	15.207
S7	F	hod59	ɑ	h/d	1070	1329	2830	8.947	10.385	15.258
S7	F	hod67	ɑ	h/d	1152	1420	2780	9.431	10.831	15.151
S7	F	hode14	o	h/d	475	1280	2811	4.518	10.133	15.218
S7	F	hode31	o	h/d	315	1220	2862	3.061	9.812	15.324
S7	F	hode47	o	h/d	331	1132	2818	3.211	9.316	15.232
S7	F	hood02	ʊ	h/d	310	1631	2988	3.014	11.761	15.579
S7	F	hood30	ʊ	h/d	242	1640	2929	2.368	11.798	15.461
S7	F	hood43	ʊ	h/d	331	1610	2853	3.211	11.674	15.306
S7	F	hoot32	u	h/d	281	1346	2838	2.740	10.470	15.274
S7	F	hoot33	u	h/d	302	1415	2830	2.939	10.807	15.258
S7	F	hoot64	u	h/d	313	1337	2851	3.042	10.425	15.302
S7	F	hut17	ʌ	h/d	1014	1725	2957	8.600	12.134	15.517
S7	F	hut34	ʌ	h/d	1130	1681	2829	9.304	11.962	15.256
S7	F	hut46	ʌ	h/d	956	1688	2920	8.225	11.990	15.443
S7	F	put09	ʊ	b/t	312	1494	2944	3.033	11.172	15.491
S7	F	put16	ʊ	b/t	304	1689	2952	2.957	11.994	15.507
S7	F	put46	ʊ	b/t	409	1464	2903	3.928	11.036	15.409
S7	F	tack18	æ	t/k	946	1675	2558	8.159	11.939	14.650
S7	F	tack46	æ	t/k	1050	1695	2793	8.824	12.018	15.179
S7	F	tack48	æ	t/k	1242	1694	2729	9.931	12.014	15.041
S7	F	take07	e	t/k	407	2555	3116	3.910	14.642	15.824
S7	F	take42	e	t/k	405	2751	3215	3.892	15.089	16.006
S7	F	take57	e	t/k	321	2767	3066	3.117	15.123	15.730
S7	F	teak06	i	t/k	308	2923	3083	2.995	15.449	15.762
S7	F	teak25	i	t/k	334	2573	3112	3.239	14.685	15.817
S7	F	teak61	i	t/k	387	2958	3277	3.728	15.519	16.117
S7	F	tech03	ɛ	t/k	899	1758	2382	7.842	12.260	14.211
S7	F	tech37	ɛ	t/k	909	1959	2802	7.911	12.970	15.198
S7	F	tech54	ɛ	t/k	798	1965	2929	7.127	12.990	15.461
S7	F	tick24	ɪ	t/k	364	2530	2878	3.517	14.582	15.357
S7	F	tick50	ɪ	t/k	362	2399	2801	3.498	14.255	15.196
S7	F	tick68	ɪ	t/k	389	2588	2981	3.746	14.720	15.565
S7	F	tock08	ɑ	t/k	1011	1318	2856	8.581	10.329	15.312
S7	F	tock10	ɑ	t/k	1052	1335	2884	8.837	10.415	15.370
S7	F	tock32	ɑ	t/k	1073	1263	2882	8.965	10.043	15.366
S7	F	toke04	o	t/k	323	1348	2765	3.136	10.480	15.119
S7	F	toke27	o	t/k	389	1339	2785	3.746	10.435	15.162
S7	F	toke49	o	t/k	396	1344	2882	3.810	10.460	15.366
S7	F	took41	ʊ	t/k	357	1559	2819	3.452	11.459	15.234
S7	F	took48	ʊ	t/k	311	1689	2913	3.023	11.994	15.429
S7	F	took65	ʊ	t/k	373	1452	2857	3.600	10.981	15.314
S7	F	tuck13	ø	t/k	1017	1625	2688	8.618	11.736	14.950
S7	F	tuck17	ʌ	t/k	961	1673	2859	8.258	11.931	15.318

S7	F	tuck50	ʌ	t/k	929	1577	2862	8.046	11.536	15.324
S7	F	turk29	ɹ̩	t/k	263	1344	1688	2.569	10.460	11.990
S7	F	turk45	ɹ̩	t/k	368	1424	1726	3.554	10.849	12.138
S7	F	turk59	ɹ̩	t/k	350	1374	1672	3.387	10.609	11.927
S8	F	bat14	æ	b/t	633	2071	2983	5.854	13.329	15.569
S8	F	bat39	æ	b/t	800	1915	2783	7.141	12.822	15.158
S8	F	bat63	æ	b/t	808	2001	3048	7.200	13.107	15.695
S8	F	bate04	e	b/t	459	2298	3087	4.376	13.988	15.770
S8	F	bate53	e	b/t	477	2157	2974	4.535	13.588	15.551
S8	F	bate56	e	b/t	484	2331	3079	4.597	14.077	15.755
S8	F	beat02	i	b/t	359	2963	3552	3.471	15.529	16.581
S8	F	beat16	i	b/t	318	3049	3423	3.089	15.697	16.368
S8	F	beat23	i	b/t	300	2899	3332	2.920	15.400	16.213
S8	F	bert29	ɹ̩	b/t	483	1469	1861	4.588	11.059	12.635
S8	F	bert31	ɹ̩	b/t	486	1579	1924	4.614	11.544	12.853
S8	F	bert60	ɹ̩	b/t	456	1411	1680	4.350	10.788	11.958
S8	F	bet09	ɛ	b/t	565	1968	2986	5.293	13.000	15.575
S8	F	bet23	ɛ	b/t	619	1958	3124	5.740	12.967	15.839
S8	F	bet51	ɛ	b/t	636	1978	3148	5.878	13.032	15.884
S8	F	bit06	ɪ	b/t	427	2168	3142	4.091	13.621	15.873
S8	F	bit29	ɪ	b/t	478	2107	3056	4.544	13.439	15.711
S8	F	bit55	ɪ	b/t	508	2233	3184	4.806	13.808	15.950
S8	F	boat17	o	b/t	606	1291	2956	5.634	10.190	15.515
S8	F	boat39	o	b/t	613	1393	3007	5.691	10.701	15.616
S8	F	boat66	o	b/t	678	1382	2649	6.214	10.648	14.862
S8	F	boot39	u	b/t	449	1399	2847	4.288	10.730	15.293
S8	F	boot61	u	b/t	456	1346	2928	4.350	10.470	15.459
S8	F	boot68	u	b/t	423	1454	3124	4.055	10.990	15.839
S8	F	bought27	ɑ	b/t	714	1325	2464	6.495	10.365	14.420
S8	F	bought51	ɑ	b/t	807	1310	2628	7.193	10.288	14.813
S8	F	bought52	ɑ	b/t	967	1428	2584	8.297	10.868	14.711
S8	F	but01	ʌ	b/t	587	1729	3037	5.477	12.150	15.674
S8	F	but11	ʌ	b/t	675	1717	3181	6.190	12.103	15.945
S8	F	but20	ʌ	b/t	620	1826	3011	5.748	12.510	15.624
S8	F	duke12	u	t/k	403	2101	2958	3.874	13.421	15.519
S8	F	duke28	u	t/k	391	2177	2986	3.765	13.647	15.575
S8	F	duke40	u	t/k	403	2117	3034	3.874	13.469	15.668
S8	F	had06	æ	h/d	864	1952	3001	7.600	12.947	15.604
S8	F	had12	æ	h/d	881	1833	2805	7.718	12.535	15.205
S8	F	had58	æ	h/d	885	1846	2902	7.746	12.582	15.407
S8	F	hate13	e	h/d	439	2883	3585	4.198	15.368	16.634
S8	F	hate35	e	h/d	441	2350	3202	4.216	14.127	15.983
S8	F	hate48	e	h/d	519	2266	3025	4.901	13.900	15.651
S8	F	head04	ɛ	h/d	603	2019	2907	5.609	13.165	15.417
S8	F	head47	ɛ	h/d	638	2061	3331	5.895	13.298	16.211
S8	F	head61	ɛ	h/d			(misread)			
S8	F	heed38	i	h/d	378	2951	3380	3.646	15.505	16.296
S8	F	heed62	i	h/d	326	3038	4061	3.164	15.676	17.345
S8	F	heed67	i	h/d	328	3268	3862	3.183	16.101	17.059
S8	F	herd02	ɹ̩	h/d	516	1682	1960	4.875	11.966	12.973
S8	F	herd34	ɹ̩	h/d	472	1461	1707	4.491	11.022	12.064
S8	F	herd52	ɹ̩	h/d	483	1612	1803	4.588	11.683	12.427
S8	F	hid25	ɪ	h/d	510	1999	3119	4.823	13.101	15.830
S8	F	hid63	ɪ	h/d	552	2218	3100	5.183	13.765	15.794

S8	F	hid65	ɪ	h/d	513	2161	3251	4.849	13.600	16.071
S8	F	hod28	ɑ	h/d	852	1515	2846	7.515	11.266	15.291
S8	F	hod59	ɑ	h/d	817	1282	2850	7.265	10.143	15.299
S8	F	hod67	ɑ	h/d	711	1402	2722	6.472	10.745	15.025
S8	F	hode14	o	h/d	452	1250	3044	4.314	9.974	15.688
S8	F	hode31	o	h/d	473	1404	3279	4.500	10.754	16.120
S8	F	hode47	o	h/d	472	1186	3279	4.491	9.624	16.120
S8	F	hood02	ʊ	h/d	491	1733	3037	4.658	12.165	15.674
S8	F	hood30	ʊ	h/d	493	1709	3011	4.675	12.072	15.624
S8	F	hood43	ʊ	h/d	492	1681	3132	4.667	11.962	15.854
S8	F	hoot32	u	h/d	365	1432	2950	3.526	10.887	15.503
S8	F	hoot33	u	h/d	305	1221	2787	2.967	9.817	15.166
S8	F	hoot64	u	h/d	292	1053	3014	2.844	8.843	15.630
S8	F	hut17	ʌ	h/d	651	1802	3341	5.999	12.423	16.229
S8	F	hut34	ʌ	h/d	685	1835	3172	6.269	12.543	15.928
S8	F	hut46	ʌ	h/d	706	1679	3350	6.433	11.954	16.244
S8	F	put09	ʊ	b/t	549	1717	2926	5.157	12.103	15.455
S8	F	put16	ʊ	b/t	484	1485	3138	4.597	11.132	15.865
S8	F	put46	ʊ	b/t	548	1594	3359	5.149	11.607	16.260
S8	F	tack18	æ	t/k	1053	1970	2771	8.843	13.006	15.132
S8	F	tack46	æ	t/k	1001	1969	3146	8.517	13.003	15.880
S8	F	tack48	æ	t/k	742	1918	2959	6.709	12.832	15.521
S8	F	take07	e	t/k	485	2241	3183	4.606	13.830	15.948
S8	F	take42	e	t/k	489	2227	3204	4.641	13.791	15.986
S8	F	take57	e	t/k	481	2609	3428	4.570	14.769	16.377
S8	F	teak06	i	t/k	369	3004	3597	3.563	15.610	16.653
S8	F	teak25	i	t/k	381	3038	3399	3.673	15.676	16.328
S8	F	teak61	i	t/k	376	3052	3591	3.627	15.703	16.643
S8	F	tech03	ɛ	t/k	634	2119	3013	5.862	13.475	15.628
S8	F	tech37	ɛ	t/k	645	1959	2944	5.951	12.970	15.491
S8	F	tech54	ɛ	t/k	765	2000	2913	6.883	13.104	15.429
S8	F	tick24	ɪ	t/k	562	2093	3249	5.267	13.396	16.067
S8	F	tick50	ɪ	t/k	532	2158	3240	5.013	13.591	16.051
S8	F	tick68	ɪ	t/k	499	2229	3045	4.728	13.796	15.690
S8	F	tock08	ɑ	t/k	1078	1513	2553	8.995	11.257	14.638
S8	F	tock10	ɑ	t/k	947	1471	2499	8.166	11.068	14.507
S8	F	tock32	ɑ	t/k	856	1466	2589	7.544	11.045	14.723
S8	F	toke04	o	t/k	449	1296	2911	4.288	10.216	15.425
S8	F	toke27	o	t/k	493	1472	3132	4.675	11.073	15.854
S8	F	toke49	o	t/k	460	1222	3068	4.385	9.823	15.734
S8	F	took41	ʊ	t/k	548	1372	3116	5.149	10.599	15.824
S8	F	took48	ʊ	t/k	531	1886	3056	5.004	12.722	15.711
S8	F	took65	ʊ	t/k	541	1642	3019	5.089	11.806	15.639
S8	F	tuck13	ʌ	t/k	663	1699	2818	6.095	12.033	15.232
S8	F	tuck17	ʌ	t/k	642	1675	2699	5.927	11.939	14.974
S8	F	tuck50	ʌ	t/k	761	1633	3237	6.853	11.769	16.046
S8	F	turk29	ɹ̩	t/k	492	1750	2029	4.667	12.230	13.197
S8	F	turk45	ɹ̩	t/k	487	1544	1847	4.623	11.394	12.585
S8	F	turk59	ɹ̩	t/k	553	1624	1894	5.191	11.732	12.750
S9	F	bat14	æ	b/t	762	1884	2991	6.860	12.715	15.585
S9	F	bat39	æ	b/t	834	1841	2776	7.387	12.564	15.143
S9	F	bat63	æ	b/t	690	1884	2891	6.308	12.715	15.384
S9	F	bate04	e	b/t	421	2534	3191	4.037	14.592	15.963
S9	F	bate53	e	b/t	441	2471	3078	4.216	14.438	15.753

S9	F	bate56	e	b/t	426	2495	3073	4.082	14.497	15.743
S9	F	beat02	i	b/t	372	3038	3424	3.590	15.676	16.370
S9	F	beat16	i	b/t	367	2861	3128	3.544	15.322	15.847
S9	F	beat23	i	b/t	382	2760	3409	3.682	15.108	16.345
S9	F	bert29	ɹ̩	b/t	484	1646	1947	4.597	11.822	12.930
S9	F	bert31	ɹ̩	b/t	506	1520	1800	4.789	11.288	12.416
S9	F	bert60	ɹ̩	b/t	445	1508	1803	4.252	11.235	12.427
S9	F	bet09	ɛ	b/t	548	2093	3153	5.149	13.396	15.893
S9	F	bet23	ɛ	b/t	530	2169	3063	4.995	13.624	15.724
S9	F	bet51	ɛ	b/t	526	2124	3266	4.961	13.490	16.098
S9	F	bit06	ɪ	b/t	410	2329	3166	3.937	14.071	15.917
S9	F	bit29	ɪ	b/t	400	2351	3175	3.847	14.130	15.934
S9	F	bit55	ɪ	b/t	449	2296	3168	4.288	13.982	15.921
S9	F	boat17	o	b/t	592	1246	2847	5.518	9.953	15.293
S9	F	boat39	o	b/t	520	1388	2525	4.910	10.677	14.570
S9	F	boat66	o	b/t	532	1317	2973	5.013	10.324	15.549
S9	F	boot39	u	b/t	407	1519	3148	3.910	11.284	15.884
S9	F	boot61	u	b/t	435	1413	2709	4.163	10.797	14.996
S9	F	boot68	u	b/t	418	1519	2657	4.010	11.284	14.880
S9	F	bought27	ɑ	b/t	610	1326	2687	5.667	10.370	14.947
S9	F	bought51	ɑ	b/t	525	1353	2804	4.953	10.505	15.203
S9	F	bought52	ɑ	b/t	662	1315	2710	6.087	10.314	14.999
S9	F	but01	ʌ	b/t	661	1713	3159	6.079	12.088	15.904
S9	F	but11	ʌ	b/t	540	1711	3142	5.081	12.080	15.873
S9	F	but20	ʌ	b/t	653	1756	2999	6.015	12.252	15.600
S9	F	duke12	u	t/k	425	1858	2493	4.073	12.624	14.492
S9	F	duke28	u	t/k	414	2098	2508	3.973	13.412	14.529
S9	F	duke40	u	t/k	388	2118	2933	3.737	13.472	15.469
S9	F	had06	æ	h/d	776	1769	2790	6.965	12.301	15.173
S9	F	had12	æ	h/d	834	1740	2862	7.387	12.192	15.324
S9	F	had58?	æ	h/d	1193	1927	3049	9.663	12.863	15.697
S9	F	hate13	e	h/d	423	2834	3326	4.055	15.266	16.203
S9	F	hate35	e	h/d	392	2883	3164	3.774	15.368	15.913
S9	F	hate48	e	h/d	492	2856	3160	4.667	15.312	15.906
S9	F	head04	ɛ	h/d	544	2104	3064	5.115	13.430	15.726
S9	F	head47	ɛ	h/d	549	2032	3185	5.157	13.206	15.952
S9	F	head61	ɛ	h/d	555	2197	3266	5.208	13.705	16.098
S9	F	heed38	i	h/d	406	3095	3425	3.901	15.785	16.372
S9	F	heed62	i	h/d	396	3106	3497	3.810	15.806	16.491
S9	F	heed67	i	h/d	355	3120	3469	3.434	15.832	16.445
S9	F	herd02	ɹ̩	h/d	491	1519	1795	4.658	11.284	12.397
S9	F	herd34	ɹ̩	h/d	500	1442	1816	4.736	10.934	12.474
S9	F	herd52	ɹ̩	h/d	481	1440	1775	4.570	10.925	12.323
S9	F	hid25	ɪ	h/d	441	2290	3188	4.216	13.966	15.957
S9	F	hid63	ɪ	h/d	473	2210	3219	4.500	13.742	16.014
S9	F	hid65	ɪ	h/d	432	2151	3140	4.136	13.571	15.869
S9	F	hod28	ɑ	h/d	689	1399	2607	6.300	10.730	14.765
S9	F	hod59	ɑ	h/d	401	1411	2427	3.856	10.788	14.327
S9	F	hod67	ɑ	h/d	502	1371	2489	4.754	10.594	14.482
S9	F	hode14	o	h/d	461	1252	2904	4.394	9.985	15.411
S9	F	hode31	o	h/d	400	1282	2751	3.847	10.143	15.089
S9	F	hode47	o	h/d	428	1300	2444	4.100	10.237	14.370
S9	F	hood02	ʊ	h/d	443	1873	3084	4.234	12.677	15.764
S9	F	hood30	ʊ	h/d	418	1921	2987	4.010	12.842	15.577

S9	F	hood43	ʊ	h/d	454	1880	3006	4.332	12.702	15.614
S9	F	hoot32	u	h/d	417	1394	2730	4.001	10.706	15.043
S9	F	hoot33	u	h/d	397	1476	2641	3.819	11.091	14.843
S9	F	hoot64	u	h/d	394	1168	2890	3.792	9.522	15.382
S9	F	hut17	ʌ	h/d	564	1891	3119	5.284	12.740	15.830
S9	F	hut34	ʌ	h/d	579	1748	3300	5.410	12.222	16.157
S9	F	hut46	ʌ	h/d	539	1564	3011	5.072	11.480	15.624
S9	F	put09	ʊ	b/t	425	1650	3001	4.073	11.838	15.604
S9	F	put16	ʊ	b/t	415	1550	2947	3.983	11.420	15.497
S9	F	put46	ʊ	b/t	419	1525	2903	4.019	11.310	15.409
S9	F	tack18	æ	t/k	791	1783	2517	7.075	12.353	14.551
S9	F	tack46	æ	t/k	791	1754	2919	7.075	12.245	15.441
S9	F	tack48	æ	t/k	791	1769	2704	7.075	12.301	14.985
S9	F	take07	e	t/k	431	2301	2984	4.127	13.996	15.571
S9	F	take42	e	t/k	461	2526	3182	4.394	14.573	15.946
S9	F	take57	e	t/k	442	2530	3197	4.225	14.582	15.974
S9	F	teak06	i	t/k	400	2873	3206	3.847	15.347	15.990
S9	F	teak25	i	t/k	392	3024	3287	3.774	15.649	16.135
S9	F	teak61	i	t/k	400	3006	3452	3.847	15.614	16.417
S9	F	tech03	ɛ	t/k	533	2156	2909	5.021	13.586	15.421
S9	F	tech37	ɛ	t/k	509	1839	2942	4.815	12.557	15.487
S9	F	tech54	ɛ	t/k	630	2088	2802	5.830	13.381	15.198
S9	F	tick24	ɪ	t/k	524	2355	3070	4.944	14.141	15.738
S9	F	tick50	ɪ	t/k	435	2359	2982	4.163	14.151	15.567
S9	F	tick68	ɪ	t/k	392	2369	3244	3.774	14.177	16.058
S9	F	tock08	ɑ	t/k	485	1462	2453	4.606	11.027	14.393
S9	F	tock10	ɑ	t/k	562	1444	2351	5.267	10.943	14.130
S9	F	tock32	ɑ	t/k	524	1441	2690	4.944	10.929	14.954
S9	F	toke04	o	t/k	498	1575	2862	4.719	11.527	15.324
S9	F	toke27	o	t/k	517	1611	2829	4.884	11.678	15.256
S9	F	toke49	o	t/k	514	1484	2533	4.858	11.127	14.590
S9	F	took41	ʊ	t/k	433	1590	2962	4.145	11.591	15.527
S9	F	took48	ʊ	t/k	452	1608	2702	4.314	11.666	14.981
S9	F	took65	ʊ	t/k	455	1677	2993	4.341	11.946	15.589
S9	F	tuck13	ʌ	t/k	552	1503	3026	5.183	11.213	15.653
S9	F	tuck17	ʌ	t/k	628	1713	3161	5.814	12.088	15.908
S9	F	tuck50	ʌ	t/k	664	1603	3120	6.103	11.645	15.832
S9	F	turk29	ɹ̩	t/k	433	1464	1755	4.145	11.036	12.248
S9	F	turk45	ɹ̩	t/k	388	1582	2085	3.737	11.557	13.372
S9	F	turk59	ɹ̩	t/k	453	1646	2163	4.323	11.822	13.606
Sa	M	bat14	æ	b/t	747	1650	2501	6.747	11.838	14.512
Sa	M	bat39	æ	b/t	722	1573	2398	6.557	11.518	14.253
Sa	M	bat63	æ	b/t	799	1586	2437	7.134	11.574	14.353
Sa	M	bate04	e	b/t	335	2179	2604	3.248	13.653	14.758
Sa	M	bate53	e	b/t	373	2205	2579	3.600	13.728	14.699
Sa	M	bate56	e	b/t	335	2114	2540	3.248	13.460	14.606
Sa	M	beat02	i	b/t	270	2450	3030	2.636	14.385	15.661
Sa	M	beat16	i	b/t	245	2424	2991	2.397	14.320	15.585
Sa	M	beat23	i	b/t	245	2450	2920	2.397	14.385	15.443
Sa	M	bert29	ɹ̩	b/t	438	1328	1689	4.189	10.380	11.994
Sa	M	bert31	ɹ̩	b/t	399	1289	1599	3.837	10.180	11.628
Sa	M	bert60	ɹ̩	b/t	412	1263	1624	3.955	10.043	11.732
Sa	M	bet09	ɛ	b/t	631	1624	2501	5.838	11.732	14.512
Sa	M	bet23	ɛ	b/t	606	1599	2501	5.634	11.628	14.512

Sa	M	bet51	ɛ	b/t	515	1637	2398	4.866	11.785	14.253
Sa	M	bit06	ɪ	b/t	412	1818	2540	3.955	12.481	14.606
Sa	M	bit29	ɪ	b/t	399	1831	2462	3.837	12.528	14.415
Sa	M	bit55	ɪ	b/t	373	1831	2540	3.600	12.528	14.606
Sa	M	boat17	o	b/t	399	1108	2450	3.837	9.175	14.385
Sa	M	boat39	o	b/t	425	1005	2488	4.073	8.542	14.480
Sa	M	boat66	o	b/t	399	1108	2488	3.837	9.175	14.480
Sa	M	boot39	u	b/t	296	1250	2334	2.882	9.974	14.085
Sa	M	boot61	u	b/t	335	1315	2385	3.248	10.314	14.219
Sa	M	boot68	u	b/t	270	1302	2437	2.636	10.247	14.353
Sa	M	bought27	ɑ	b/t	812	1160	2475	7.229	9.477	14.448
Sa	M	bought51	ɑ	b/t	735	1160	2450	6.656	9.477	14.385
Sa	M	bought52	ɑ	b/t	735	1199	2372	6.656	9.696	14.185
Sa	M	but01	ʌ	b/t	593	1328	2424	5.526	10.380	14.320
Sa	M	but11	ʌ	b/t	580	1379	2424	5.418	10.633	14.320
Sa	M	but20	ʌ	b/t	541	1289	2372	5.089	10.180	14.185
Sa	M	duke12	u	t/k	270	1611	2424	2.636	11.678	14.320
Sa	M	duke28	u	t/k	257	1727	2450	2.512	12.142	14.385
Sa	M	duke40	u	t/k	296	1611	2437	2.882	11.678	14.353
Sa	M	had06	æ	h/d	696	1624	2527	6.355	11.732	14.575
Sa	M	had12	æ	h/d	644	1689	2553	5.943	11.994	14.638
Sa	M	had58	æ	h/d	825	1663	2553	7.323	11.891	14.638
Sa	M	hate13	e	h/d	361	2282	2604	3.489	13.944	14.758
Sa	M	hate35	e	h/d	373	2346	2901	3.600	14.117	15.405
Sa	M	hate48	e	h/d	309	2488	2836	3.005	14.480	15.270
Sa	M	head04	ɛ	h/d	541	1779	2579	5.089	12.338	14.699
Sa	M	head47	ɛ	h/d	464	1740	2579	4.421	12.192	14.699
Sa	M	head61	ɛ	h/d	464	1740	2475	4.421	12.192	14.448
Sa	M	heed38	i	h/d	257	2385	3133	2.512	14.219	15.856
Sa	M	heed62	i	h/d	232	2437	3249	2.272	14.353	16.067
Sa	M	heed67	i	h/d	232	2475	3172	2.272	14.448	15.928
Sa	M	herd02	ɹ̩	h/d	438	1405	1650	4.189	10.759	11.838
Sa	M	herd34	ɹ̩	h/d	386	1379	1676	3.719	10.633	11.943
Sa	M	herd52	ɹ̩	h/d	386	1328	1663	3.719	10.380	11.891
Sa	M	hid25	ɪ	h/d	361	1921	2566	3.489	12.842	14.669
Sa	M	hid63	ɪ	h/d	361	1934	2617	3.489	12.886	14.788
Sa	M	hid65	ɪ	h/d	361	1831	2591	3.489	12.528	14.727
Sa	M	hod28	ɑ	h/d	760	1225	2359	6.845	9.839	14.151
Sa	M	hod59	ɑ	h/d	812	1212	2462	7.229	9.768	14.415
Sa	M	hod67	ɑ	h/d	722	1250	2437	6.557	9.974	14.353
Sa	M	hode14	o	h/d	399	1018	2475	3.837	8.625	14.448
Sa	M	hode31	o	h/d	399	1031	2475	3.837	8.706	14.448
Sa	M	hode47	o	h/d	399	1070	2411	3.837	8.947	14.286
Sa	M	hood02	ʊ	h/d	386	1444	2398	3.719	10.943	14.253
Sa	M	hood30	ʊ	h/d	373	1302	2372	3.600	10.247	14.185
Sa	M	hood43	ʊ	h/d	399	1379	2359	3.837	10.633	14.151
Sa	M	hoot32	u	h/d	270	1225	2308	2.636	9.839	14.015
Sa	M	hoot33	u	h/d	283	1173	2334	2.759	9.551	14.085
Sa	M	hoot64	u	h/d	296	1199	2334	2.882	9.696	14.085
Sa	M	hut17	ʌ	h/d	477	1573	2488	4.535	11.518	14.480
Sa	M	hut34	ʌ	h/d	631	1547	2398	5.838	11.407	14.253
Sa	M	hut46	ʌ	h/d	722	1405	2398	6.557	10.759	14.253
Sa	M	put09	ʊ	b/t	412	1341	2450	3.955	10.445	14.385
Sa	M	put16	ʊ	b/t	412	1237	2462	3.955	9.904	14.415

Sa	M	put46	ʊ	b/t	425	1353	2346	4.073	10.505	14.117
Sa	M	tack18	æ	t/k	838	1637	2269	7.416	11.785	13.908
Sa	M	tack46	æ	t/k	965	1731	2385	8.284	12.157	14.219
Sa	M	tack48	æ	t/k	799	1573	2308	7.134	11.518	14.015
Sa	M	take07	e	t/k	386	2101	2617	3.719	13.421	14.788
Sa	M	take42	e	t/k	373	2076	2540	3.600	13.344	14.606
Sa	M	take57	e	t/k	386	2140	2566	3.719	13.538	14.669
Sa	M	teak06	i	t/k	296	2385	2746	2.882	14.219	15.078
Sa	M	teak25	i	t/k	270	2359	2772	2.636	14.151	15.134
Sa	M	teak61	i	t/k	309	2437	3017	3.005	14.353	15.636
Sa	M	tech03	ɛ	t/k	670	1715	2321	6.151	12.096	14.050
Sa	M	tech37	ɛ	t/k	631	1676	2295	5.838	11.943	13.980
Sa	M	tech54	ɛ	t/k	631	1715	2308	5.838	12.096	14.015
Sa	M	tick24	ɪ	t/k	399	1792	2398	3.837	12.386	14.253
Sa	M	tick50	ɪ	t/k	399	1766	2359	3.837	12.290	14.151
Sa	M	tick68	ɪ	t/k	399	1753	2450	3.837	12.241	14.385
Sa	M	tock08	ɑ	t/k	851	1302	2346	7.508	10.247	14.117
Sa	M	tock10	ɑ	t/k	799	1237	2359	7.134	9.904	14.151
Sa	M	tock32	ɑ	t/k	812	1212	2243	7.229	9.768	13.836
Sa	M	toke04	o	t/k	412	1083	2437	3.955	9.026	14.353
Sa	M	toke27	o	t/k	386	1108	2424	3.719	9.175	14.320
Sa	M	toke49	o	t/k	399	1186	2398	3.837	9.624	14.253
Sa	M	took41	ʊ	t/k	412	1186	2321	3.955	9.624	14.050
Sa	M	took48	ʊ	t/k	386	1263	2217	3.719	10.043	13.762
Sa	M	took65	ʊ	t/k	399	1250	2346	3.837	9.974	14.117
Sa	M	tuck13	ʌ	t/k	657	1392	2282	6.047	10.696	13.944
Sa	M	tuck17	ʌ	t/k	670	1444	2243	6.151	10.943	13.836
Sa	M	tuck50	ʌ	t/k	631	1366	2321	5.838	10.570	14.050
Sa	M	turk29	ɹ̩	t/k	451	1379	1676	4.305	10.633	11.943
Sa	M	turk45	ɹ̩	t/k	438	1225	1676	4.189	9.839	11.943
Sa	M	turk59	ɹ̩	t/k	399	1289	1650	3.837	10.180	11.838
Sb	M	bat14	æ	b/t	528	1586	2475	4.978	11.574	14.448
Sb	M	bat39	æ	b/t	541	1676	3326	5.089	11.943	16.203
Sb	M	bat63	æ	b/t	554	1560	2720	5.200	11.463	15.021
Sb	M	bate04	e	b/t	373	1972	2630	3.600	13.013	14.818
Sb	M	bate53	e	b/t	425	1972	2669	4.073	13.013	14.907
Sb	M	bate56	e	b/t	399	1895	2424	3.837	12.753	14.320
Sb	M	beat02	i	b/t	270	2669	3172	2.636	14.907	15.928
Sb	M	beat16	i	b/t	257	2669	3301	2.512	14.907	16.159
Sb	M	beat23	i	b/t	283	2707	3185	2.759	14.992	15.952
Sb	M	bert29	ɹ̩	b/t	386	1392	1715	3.719	10.696	12.096
Sb	M	bert31	ɹ̩	b/t	386	1353	1676	3.719	10.505	11.943
Sb	M	bert60	ɹ̩	b/t	386	1444	1715	3.719	10.943	12.096
Sb	M	bet09	ɛ	b/t	528	1715	2630	4.978	12.096	14.818
Sb	M	bet23	ɛ	b/t	477	1689	2540	4.535	11.994	14.606
Sb	M	bet51	ɛ	b/t	528	1727	2656	4.978	12.142	14.877
Sb	M	bit06	ɪ	b/t	386	1869	2682	3.719	12.663	14.936
Sb	M	bit29	ɪ	b/t	399	1908	2695	3.837	12.798	14.965
Sb	M	bit55	ɪ	b/t	425	1895	2579	4.073	12.753	14.699
Sb	M	boat17	o	b/t	412	1263	2230	3.955	10.043	13.799
Sb	M	boat39	o	b/t	425	1212	2166	4.073	9.768	13.615
Sb	M	boat66	o	b/t	425	1173	2050	4.073	9.551	13.263
Sb	M	boot39	u	b/t	348	1573	3210	3.369	11.518	15.997
Sb	M	boot61	u	b/t	322	1328	2063	3.126	10.380	13.304

Sb	M	boot68	u	b/t	322	1392	2836	3.126	10.696	15.270
Sb	M	bought27	ɑ	b/t	529	1134	2552	4.987	9.327	14.635
Sb	M	bought51	ɑ	b/t	554	1212	2643	5.200	9.768	14.848
Sb	M	bought52	ɑ	b/t	541	1160	2720	5.089	9.477	15.021
Sb	M	but01	ʌ	b/t	554	1624	2579	5.200	11.732	14.699
Sb	M	but11	ʌ	b/t	541	1482	2527	5.089	11.118	14.575
Sb	M	but20	ʌ	b/t	541	1431	2630	5.089	10.882	14.818
Sb	M	duke12	u	t/k	270	1740	2707	2.636	12.192	14.992
Sb	M	duke28	u	t/k	348	1779	2359	3.369	12.338	14.151
Sb	M	duke40	u	t/k	309	1882	2639	3.005	12.708	14.839
Sb	M	had06	æ	h/d	515	1702	2940	4.866	12.045	15.483
Sb	M	had12	æ	h/d	528	1637	2566	4.978	11.785	14.669
Sb	M	had58	æ	h/d	528	1663	2914	4.978	11.891	15.431
Sb	M	hate13	e	h/d	335	1998	2630	3.248	13.098	14.818
Sb	M	hate35	e	h/d	361	2063	2669	3.489	13.304	14.907
Sb	M	hate48	e	h/d	361	2037	2617	3.489	13.222	14.788
Sb	M	head04	ɛ	h/d	515	1766	2682	4.866	12.290	14.936
Sb	M	head47	ɛ	h/d	451	1727	2682	4.305	12.142	14.936
Sb	M	head61	ɛ	h/d	541	1740	2604	5.089	12.192	14.758
Sb	M	heed38	i	h/d	309	2849	3236	3.005	15.297	16.044
Sb	M	heed62	i	h/d	322	2746	3443	3.126	15.078	16.402
Sb	M	heed67	i	h/d	309	2720	3159	3.005	15.021	15.904
Sb	M	herd02	ɹ̩	h/d	386	1508	1766	3.719	11.235	12.290
Sb	M	herd34	ɹ̩	h/d	412	1457	1689	3.955	11.004	11.994
Sb	M	herd52	ɹ̩	h/d	399	1379	1650	3.837	10.633	11.838
Sb	M	hid25	ɪ	h/d	373	1856	2604	3.600	12.617	14.758
Sb	M	hid63	ɪ	h/d	399	1831	2707	3.837	12.528	14.992
Sb	M	hid65	ɪ	h/d	386	1831	2656	3.719	12.528	14.877
Sb	M	hod28	ɑ	h/d	554	1212	2361	5.200	9.768	14.156
Sb	M	hod59	ɑ	h/d	528	1263	2604	4.978	10.043	14.758
Sb	M	hod67	ɑ	h/d	490	1328	2733	4.649	10.380	15.049
Sb	M	hode14	o	h/d	425	1199	2579	4.073	9.696	14.699
Sb	M	hode31	o	h/d	425	1418	2597	4.073	10.821	14.742
Sb	M	hode47	o	h/d	399	1470	2862	3.837	11.063	15.324
Sb	M	hood02	ʊ	h/d	425	1457	2566	4.073	11.004	14.669
Sb	M	hood30	ʊ	h/d	425	1573	2501	4.073	11.518	14.512
Sb	M	hood43	ʊ	h/d	438	1611	2540	4.189	11.678	14.606
Sb	M	hoot32	u	h/d	296	1418	2496	2.882	10.821	14.500
Sb	M	hoot33	u	h/d	335	1263	2579	3.248	10.043	14.699
Sb	M	hoot64	u	h/d	361	1534	3094	3.489	11.350	15.783
Sb	M	hut17	ʌ	h/d	477	1599	2591	4.535	11.628	14.727
Sb	M	hut34	ʌ	h/d	464	1586	2656	4.421	11.574	14.877
Sb	M	hut46	ʌ	h/d	438	1573	2591	4.189	11.518	14.727
Sb	M	put09	ʊ	b/t	412	1482	2617	3.955	11.118	14.788
Sb	M	put16	ʊ	b/t	438	1495	2604	4.189	11.177	14.758
Sb	M	put46	ʊ	b/t	451	1405	2630	4.305	10.759	14.818
Sb	M	tack18	æ	t/k	541	1637	2334	5.089	11.785	14.085
Sb	M	tack46	æ	t/k	515	1650	2540	4.866	11.838	14.606
Sb	M	tack48	æ	t/k	541	1650	2849	5.089	11.838	15.297
Sb	M	take07	e	t/k	386	1960	2759	3.719	12.973	15.106
Sb	M	take42	e	t/k	412	1947	2656	3.955	12.930	14.877
Sb	M	take57	e	t/k	425	1856	2604	4.073	12.617	14.758
Sb	M	teak06	i	t/k	296	2630	3133	2.882	14.818	15.856
Sb	M	teak25	i	t/k	283	2707	3326	2.759	14.992	16.203

Sb	M	teak61	i	t/k	309	2695	3301	3.005	14.965	16.159
Sb	M	tech03	ɛ	t/k	464	1766	2553	4.421	12.290	14.638
Sb	M	tech37	ɛ	t/k	528	1715	2591	4.978	12.096	14.727
Sb	M	tech54	ɛ	t/k	451	1702	2643	4.305	12.045	14.848
Sb	M	tick24	ɪ	t/k	361	1908	2614	3.489	12.798	14.781
Sb	M	tick50	ɪ	t/k	451	1895	2682	4.305	12.753	14.936
Sb	M	tick68	ɪ	t/k	399	1805	2643	3.837	12.434	14.848
Sb	M	tock08	ɑ	t/k	490	1276	2385	4.649	10.112	14.219
Sb	M	tock10	ɑ	t/k	657	1225	2372	6.047	9.839	14.185
Sb	M	tock32	ɑ	t/k	593	1225	2707	5.526	9.839	14.992
Sb	M	toke04	o	t/k	399	1457	2467	3.837	11.004	14.428
Sb	M	toke27	o	t/k	412	1495	2450	3.955	11.177	14.385
Sb	M	toke49	o	t/k	438	1353	2579	4.189	10.505	14.699
Sb	M	took41	ʊ	t/k	425	1534	2488	4.073	11.350	14.480
Sb	M	took48	ʊ	t/k	425	1482	2566	4.073	11.118	14.669
Sb	M	took65	ʊ	t/k	412	1457	2940	3.955	11.004	15.483
Sb	M	tuck13	ʌ	t/k	515	1521	2501	4.866	11.293	14.512
Sb	M	tuck17	ʌ	t/k	545	1560	2514	5.123	11.463	14.544
Sb	M	tuck50	ʌ	t/k	502	1482	2540	4.754	11.118	14.606
Sb	M	turk29	ɹ̩	t/k	412	1508	1831	3.955	11.235	12.528
Sb	M	turk45	ɹ̩	t/k	386	1457	1715	3.719	11.004	12.096
Sb	M	turk59	ɹ̩	t/k	412	1457	1766	3.955	11.004	12.290
Sc	M	bat14	æ	b/t	657	1611	3404	6.047	11.678	16.336
Sc	M	bat39	æ	b/t	773	1650	2540	6.942	11.838	14.606
Sc	M	bat63	æ	b/t	657	1702	2707	6.047	12.045	14.992
Sc	M	bate04	e	b/t	386	2050	3481	3.719	13.263	16.465
Sc	M	bate53	e	b/t	386	2076	2707	3.719	13.344	14.992
Sc	M	bate56	e	b/t	425	2011	2813	4.073	13.139	15.222
Sc	M	beat02	i	b/t	270	2217	2811	2.636	13.762	15.218
Sc	M	beat16	i	b/t	283	2243	2836	2.759	13.836	15.270
Sc	M	beat23	i	b/t	296	2166	2785	2.882	13.615	15.162
Sc	M	bert29	ɹ̩	b/t	399	1276	1650	3.837	10.112	11.838
Sc	M	bert31	ɹ̩	b/t	425	1289	1650	4.073	10.180	11.838
Sc	M	bert60	ɹ̩	b/t	425	1289	1624	4.073	10.180	11.732
Sc	M	bet09	ɛ	b/t	554	1663	2759	5.200	11.891	15.106
Sc	M	bet23	ɛ	b/t	554	1663	2695	5.200	11.891	14.965
Sc	M	bet51	ɛ	b/t	541	1702	2643	5.089	12.045	14.848
Sc	M	bit06	ɪ	b/t	399	1727	2720	3.837	12.142	15.021
Sc	M	bit29	ɪ	b/t	386	1792	2656	3.719	12.386	14.877
Sc	M	bit55	ɪ	b/t	412	1792	2746	3.955	12.386	15.078
Sc	M	boat17	o	b/t	425	1147	2359	4.073	9.402	14.151
Sc	M	boat39	o	b/t	438	1108	2553	4.189	9.175	14.638
Sc	M	boat66	o	b/t	477	1147	2488	4.535	9.402	14.480
Sc	M	boot39	u	b/t	361	1250	2411	3.489	9.974	14.286
Sc	M	boot61	u	b/t	335	1302	2295	3.248	10.247	13.980
Sc	M	boot68	u	b/t	361	1328	2424	3.489	10.380	14.320
Sc	M	bought27	ɑ	b/t	722	1160	2295	6.557	9.477	13.980
Sc	M	bought51	ɑ	b/t	722	1225	2256	6.557	9.839	13.872
Sc	M	bought52	ɑ	b/t	670	1250	2282	6.151	9.974	13.944
Sc	M	but01	ʌ	b/t	593	1418	3288	5.526	10.821	16.136
Sc	M	but11	ʌ	b/t	515	1328	3262	4.866	10.380	16.090
Sc	M	but20	ʌ	b/t	490	1392	2682	4.649	10.696	14.936
Sc	M	duke12	u	t/k	322	1740	2321	3.126	12.192	14.050
Sc	M	duke28	u	t/k	309	1753	2682	3.005	12.241	14.936

Sc	M	duke40	u	t/k	309	1702	2372	3.005	12.045	14.185
Sc	M	had06	æ	h/d	593	1676	3457	5.526	11.943	16.425
Sc	M	had12	æ	h/d	554	1702	2940	5.200	12.045	15.483
Sc	M	had58	æ	h/d	631	1715	2579	5.838	12.096	14.699
Sc	M	hate13	e	h/d	361	2076	2798	3.489	13.344	15.190
Sc	M	hate35	e	h/d	373	2089	2811	3.600	13.384	15.218
Sc	M	hate48	e	h/d	425	2089	2914	4.073	13.384	15.431
Sc	M	head04	ɛ	h/d	451	1702	2707	4.305	12.045	14.992
Sc	M	head47	ɛ	h/d	451	1702	2695	4.305	12.045	14.965
Sc	M	head61	ɛ	h/d	528	1779	2669	4.978	12.338	14.907
Sc	M	heed38	i	h/d	283	2295	3030	2.759	13.980	15.661
Sc	M	heed62	i	h/d	245	2230	2836	2.397	13.799	15.270
Sc	M	heed67	i	h/d	309	2243	2927	3.005	13.836	15.457
Sc	M	herd02	ɹ̩	h/d	386	1379	1650	3.719	10.633	11.838
Sc	M	herd34	ɹ̩	h/d	399	1366	1637	3.837	10.570	11.785
Sc	M	herd52	ɹ̩	h/d	399	1431	1702	3.837	10.882	12.045
Sc	M	hid25	ɪ	h/d	386	1805	2720	3.719	12.434	15.021
Sc	M	hid63	ɪ	h/d	386	1947	2695	3.719	12.930	14.965
Sc	M	hid65	ɪ	h/d	412	1985	2720	3.955	13.055	15.021
Sc	M	hod28	ɑ	h/d	722	1366	3185	6.557	10.570	15.952
Sc	M	hod59	ɑ	h/d	722	1263	2398	6.557	10.043	14.253
Sc	M	hod67	ɑ	h/d	747	1225	2269	6.747	9.839	13.908
Sc	M	hode14	o	h/d	399	1147	3004	3.837	9.402	15.610
Sc	M	hode31	o	h/d	399	1083	3004	3.837	9.026	15.610
Sc	M	hode47	o	h/d	438	1173	2282	4.189	9.551	13.944
Sc	M	hood02	ʊ	h/d	399	1547	2604	3.837	11.407	14.758
Sc	M	hood30	ʊ	h/d	412	1470	2682	3.955	11.063	14.936
Sc	M	hood43	ʊ	h/d	425	1534	2540	4.073	11.350	14.606
Sc	M	hoot32	u	h/d	335	1212	2669	3.248	9.768	14.907
Sc	M	hoot33	u	h/d	361	1225	2253	3.489	9.839	13.864
Sc	M	hoot64	u	h/d	335	1199	2256	3.248	9.696	13.872
Sc	M	hut17	ʌ	h/d	541	1431	2759	5.089	10.882	15.106
Sc	M	hut34	ʌ	h/d	528	1431	2746	4.978	10.882	15.078
Sc	M	hut46	ʌ	h/d	490	1495	2553	4.649	11.177	14.638
Sc	M	put09	ʊ	b/t	438	1212	3063	4.189	9.768	15.724
Sc	M	put16	ʊ	b/t	451	1212	2385	4.305	9.768	14.219
Sc	M	put46	ʊ	b/t	438	1379	2295	4.189	10.633	13.980
Sc	M	tack18	æ	t/k	696	1534	2269	6.355	11.350	13.908
Sc	M	tack46	æ	t/k	618	1573	2669	5.732	11.518	14.907
Sc	M	tack48	æ	t/k	618	1586	2282	5.732	11.574	13.944
Sc	M	take07	e	t/k	438	1908	2901	4.189	12.798	15.405
Sc	M	take42	e	t/k	451	1869	2824	4.305	12.663	15.245
Sc	M	take57	e	t/k	464	1895	2707	4.421	12.753	14.992
Sc	M	teak06	i	t/k	335	2192	2862	3.248	13.691	15.324
Sc	M	teak25	i	t/k	309	2166	2824	3.005	13.615	15.245
Sc	M	teak61	i	t/k	335	2192	2811	3.248	13.691	15.218
Sc	M	tech03	ɛ	t/k	593	1624	2682	5.526	11.732	14.936
Sc	M	tech37	ɛ	t/k	541	1624	2553	5.089	11.732	14.638
Sc	M	tech54	ɛ	t/k	554	1624	2282	5.200	11.732	13.944
Sc	M	tick24	ɪ	t/k	425	1805	2772	4.073	12.434	15.134
Sc	M	tick50	ɪ	t/k	412	1805	2540	3.955	12.434	14.606
Sc	M	tick68	ɪ	t/k	438	1805	2462	4.189	12.434	14.415
Sc	M	tock08	ɑ	t/k	670	1160	2153	6.151	9.477	13.577
Sc	M	tock10	ɑ	t/k	735	1212	2205	6.656	9.768	13.728

Sc	M	tock32	ɑ	t/k	760	1250	2276	6.845	9.974	13.928
Sc	M	toke04	o	t/k	451	1018	2450	4.305	8.625	14.385
Sc	M	toke27	o	t/k	438	1160	3236	4.189	9.477	16.044
Sc	M	toke49	o	t/k	451	1173	2282	4.305	9.551	13.944
Sc	M	took41	ʊ	t/k	464	1315	2540	4.421	10.314	14.606
Sc	M	took48	ʊ	t/k	464	1302	2424	4.421	10.247	14.320
Sc	M	took65	ʊ	t/k	438	1495	2398	4.189	11.177	14.253
Sc	M	tuck13	ʌ	t/k	683	1353	2217	6.253	10.505	13.762
Sc	M	tuck17	ʌ	t/k	554	1366	2282	5.200	10.570	13.944
Sc	M	tuck50	ʌ	t/k	567	1379	2269	5.309	10.633	13.908
Sc	M	turk29	ɹ̩	t/k	438	1353	1663	4.189	10.505	11.891
Sc	M	turk45	ɹ̩	t/k	490	1250	1663	4.649	9.974	11.891
Sc	M	turk59	ɹ̩	t/k	502	1379	1663	4.754	10.633	11.891
Sd	M	bat14	æ	b/t	631	1560	2450	5.838	11.463	14.385
Sd	M	bat39	æ	b/t	722	1508	2398	6.557	11.235	14.253
Sd	M	bat63	æ	b/t	606	1599	2450	5.634	11.628	14.385
Sd	M	bate04	e	b/t	399	2089	2617	3.837	13.384	14.788
Sd	M	bate53	e	b/t	477	1985	2540	4.535	13.055	14.606
Sd	M	bate56	e	b/t	451	1856	2501	4.305	12.617	14.512
Sd	M	beat02	i	b/t	283	2153	2772	2.759	13.577	15.134
Sd	M	beat16	i	b/t	270	2205	2682	2.636	13.728	14.936
Sd	M	beat23	i	b/t	270	2179	2682	2.636	13.653	14.936
Sd	M	bert29	ɹ̩	b/t	464	1431	1715	4.421	10.882	12.096
Sd	M	bert31	ɹ̩	b/t	438	1315	1702	4.189	10.314	12.045
Sd	M	bert60	ɹ̩	b/t	451	1444	1727	4.305	10.943	12.142
Sd	M	bet09	ɛ	b/t	502	1611	2450	4.754	11.678	14.385
Sd	M	bet23	ɛ	b/t	606	1586	2437	5.634	11.574	14.353
Sd	M	bet51	ɛ	b/t	606	1599	2462	5.634	11.628	14.415
Sd	M	bit06	ɪ	b/t	464	1689	2566	4.421	11.994	14.669
Sd	M	bit29	ɪ	b/t	451	1727	2527	4.305	12.142	14.575
Sd	M	bit55	ɪ	b/t	464	1650	2514	4.421	11.838	14.544
Sd	M	boat17	o	b/t	451	1134	2411	4.305	9.327	14.286
Sd	M	boat39	o	b/t	464	1147	2321	4.421	9.402	14.050
Sd	M	boat66	o	b/t	477	1121	2308	4.535	9.251	14.015
Sd	M	boot39	u	b/t	322	1302	2243	3.126	10.247	13.836
Sd	M	boot61	u	b/t	348	1263	2256	3.369	10.043	13.872
Sd	M	boot68	u	b/t	335	1250	2243	3.248	9.974	13.836
Sd	M	bought27	ɑ	b/t	773	1212	2450	6.942	9.768	14.385
Sd	M	bought51	ɑ	b/t	747	1302	2282	6.747	10.247	13.944
Sd	M	bought52	ɑ	b/t	696	1276	2372	6.355	10.112	14.185
Sd	M	but01	ʌ	b/t	580	1405	2424	5.418	10.759	14.320
Sd	M	but11	ʌ	b/t	593	1444	2437	5.526	10.943	14.353
Sd	M	but20	ʌ	b/t	541	1418	2475	5.089	10.821	14.448
Sd	M	duke12	u	t/k	296	1547	2205	2.882	11.407	13.728
Sd	M	duke28	u	t/k	309	1650	2282	3.005	11.838	13.944
Sd	M	duke40	u	t/k	322	1715	2385	3.126	12.096	14.219
Sd	M	had06	æ	h/d	735	1624	2514	6.656	11.732	14.544
Sd	M	had12	æ	h/d	747	1599	2475	6.747	11.628	14.448
Sd	M	had58	æ	h/d	670	1586	2475	6.151	11.574	14.448
Sd	M	hate13	e	h/d	425	2076	2604	4.073	13.344	14.758
Sd	M	hate35	e	h/d	373	1998	2437	3.600	13.098	14.353
Sd	M	hate48	e	h/d	438	1972	2527	4.189	13.013	14.575
Sd	M	head04	ɛ	h/d	425	1715	2527	4.073	12.096	14.575
Sd	M	head47	ɛ	h/d	490	1676	2475	4.649	11.943	14.448

Sd	M	head61	ɛ	h/d	528	1689	2553	4.978	11.994	14.638
Sd	M	heed38	i	h/d	257	2166	2656	2.512	13.615	14.877
Sd	M	heed62	i	h/d	270	2179	2759	2.636	13.653	15.106
Sd	M	heed67	i	h/d	270	2179	2991	2.636	13.653	15.585
Sd	M	herd02	ɹ̩	h/d	464	1534	1818	4.421	11.350	12.481
Sd	M	herd34	ɹ̩	h/d	412	1508	1740	3.955	11.235	12.192
Sd	M	herd52	ɹ̩	h/d	451	1482	1831	4.305	11.118	12.528
Sd	M	hid25	ɪ	h/d	464	1869	2617	4.421	12.663	14.788
Sd	M	hid63	ɪ	h/d	412	1766	2566	3.955	12.290	14.669
Sd	M	hid65	ɪ	h/d	451	1805	2514	4.305	12.434	14.544
Sd	M	hod28	ɑ	h/d	735	1315	2475	6.656	10.314	14.448
Sd	M	hod59	ɑ	h/d	747	1263	2462	6.747	10.043	14.415
Sd	M	hod67	ɑ	h/d	747	1302	2269	6.747	10.247	13.908
Sd	M	hode14	o	h/d	451	1096	2334	4.305	9.103	14.085
Sd	M	hode31	o	h/d	464	1199	2295	4.421	9.696	13.980
Sd	M	hode47	o	h/d	373	1134	2321	3.600	9.327	14.050
Sd	M	hood02	ʊ	h/d	451	1482	2488	4.305	11.118	14.480
Sd	M	hood30	ʊ	h/d	438	1457	2359	4.189	11.004	14.151
Sd	M	hood43	ʊ	h/d	438	1470	2398	4.189	11.063	14.253
Sd	M	hoot32	u	h/d	309	1225	2282	3.005	9.839	13.944
Sd	M	hoot33	u	h/d	283	1173	2230	2.759	9.551	13.799
Sd	M	hoot64	u	h/d	335	1173	2179	3.248	9.551	13.653
Sd	M	hut17	ʌ	h/d	644	1431	2475	5.943	10.882	14.448
Sd	M	hut34	ʌ	h/d	657	1508	2475	6.047	11.235	14.448
Sd	M	hut46	ʌ	h/d	567	1495	2450	5.309	11.177	14.385
Sd	M	put09	ʊ	b/t	451	1444	2334	4.305	10.943	14.085
Sd	M	put16	ʊ	b/t	451	1315	2346	4.305	10.314	14.117
Sd	M	put46	ʊ	b/t	451	1366	2295	4.305	10.570	13.980
Sd	M	tack18	æ	t/k	722	1508	2346	6.557	11.235	14.117
Sd	M	tack46	æ	t/k	747	1534	2398	6.747	11.350	14.253
Sd	M	tack48	æ	t/k	760	1547	2346	6.845	11.407	14.117
Sd	M	take07	e	t/k	438	2050	2630	4.189	13.263	14.818
Sd	M	take42	e	t/k	425	1740	2643	4.073	12.192	14.848
Sd	M	take57	e	t/k	464	1985	2643	4.421	13.055	14.848
Sd	M	teak06	i	t/k	283	2101	2746	2.759	13.421	15.078
Sd	M	teak25	i	t/k	270	2140	2682	2.636	13.538	14.936
Sd	M	teak61	i	t/k	283	2140	2656	2.759	13.538	14.877
Sd	M	tech03	ɛ	t/k	541	1611	2514	5.089	11.678	14.544
Sd	M	tech37	ɛ	t/k	502	1573	2321	4.754	11.518	14.050
Sd	M	tech54	ɛ	t/k	502	1637	2372	4.754	11.785	14.185
Sd	M	tick24	ɪ	t/k	438	1856	2514	4.189	12.617	14.544
Sd	M	tick50	ɪ	t/k	438	1856	2424	4.189	12.617	14.320
Sd	M	tick68	ɪ	t/k	464	1663	2424	4.421	11.891	14.320
Sd	M	tock08	ɑ	t/k	760	1276	2282	6.845	10.112	13.944
Sd	M	tock10	ɑ	t/k	825	1237	2308	7.323	9.904	14.015
Sd	M	tock32	ɑ	t/k	760	1237	2359	6.845	9.904	14.151
Sd	M	toke04	o	t/k	438	1212	2295	4.189	9.768	13.980
Sd	M	toke27	o	t/k	515	1276	2308	4.866	10.112	14.015
Sd	M	toke49	o	t/k	464	1212	2230	4.421	9.768	13.799
Sd	M	took41	ʊ	t/k	438	1392	2269	4.189	10.696	13.908
Sd	M	took48	ʊ	t/k	451	1302	2179	4.305	10.247	13.653
Sd	M	took65	ʊ	t/k	451	1379	2385	4.305	10.633	14.219
Sd	M	tuck13	ʌ	t/k	554	1392	2256	5.200	10.696	13.872
Sd	M	tuck17	ʌ	t/k	631	1431	2372	5.838	10.882	14.185

Sd	M	tuck50	ʌ	t/k	644	1482	2243	5.943	11.118	13.836
Sd	M	turk29	ɹ̩	t/k	477	1405	1715	4.535	10.759	12.096
Sd	M	turk45	ɹ̩	t/k	477	1457	1921	4.535	11.004	12.842
Sd	M	turk59	ɹ̩	t/k	477	1457	1921	4.535	11.004	12.842
Se	M	bat14	æ	b/t	799	1611	2527	7.134	11.678	14.575
Se	M	bat39	æ	b/t	747	1521	2411	6.747	11.293	14.286
Se	M	bat63	æ	b/t	760	1534	2437	6.845	11.350	14.353
Se	M	bate04	e	b/t	438	2024	2682	4.189	13.181	14.936
Se	M	bate53	e	b/t	451	2243	2682	4.305	13.836	14.936
Se	M	bate56	e	b/t	412	1985	2604	3.955	13.055	14.758
Se	M	beat02	i	b/t	335	2385	2811	3.248	14.219	15.218
Se	M	beat16	i	b/t	322	2346	2746	3.126	14.117	15.078
Se	M	beat23	i	b/t	322	2282	2888	3.126	13.944	15.378
Se	M	bert29	ɹ̩	b/t	464	1302	1663	4.421	10.247	11.891
Se	M	bert31	ɹ̩	b/t	554	1315	1753	5.200	10.314	12.241
Se	M	bert60	ɹ̩	b/t	412	1392	1727	3.955	10.696	12.142
Se	M	bet09	ɛ	b/t	631	1599	2553	5.838	11.628	14.638
Se	M	bet23	ɛ	b/t	567	1599	2579	5.309	11.628	14.699
Se	M	bet51	ɛ	b/t	644	1560	2527	5.943	11.463	14.575
Se	M	bit06	ɪ	b/t	490	1792	2759	4.649	12.386	15.106
Se	M	bit29	ɪ	b/t	477	1637	2656	4.535	11.785	14.877
Se	M	bit55	ɪ	b/t	490	1611	2527	4.649	11.678	14.575
Se	M	boat17	o	b/t	451	1289	2527	4.305	10.180	14.575
Se	M	boat39	o	b/t	464	1237	2437	4.421	9.904	14.353
Se	M	boat66	o	b/t	528	1199	2514	4.978	9.696	14.544
Se	M	boot39	u	b/t	361	1289	2527	3.489	10.180	14.575
Se	M	boot61	u	b/t	361	1444	2398	3.489	10.943	14.253
Se	M	boot68	u	b/t	373	1418	2501	3.600	10.821	14.512
Se	M	bought27	ɑ	b/t	580	992	2514	5.418	8.459	14.544
Se	M	bought51	ɑ	b/t	554	1044	2372	5.200	8.787	14.185
Se	M	bought52	ɑ	b/t	618	1147	2411	5.732	9.402	14.286
Se	M	but01	ʌ	b/t	709	1302	2501	6.456	10.247	14.512
Se	M	but11	ʌ	b/t	644	1353	2527	5.943	10.505	14.575
Se	M	but20	ʌ	b/t	618	1289	2475	5.732	10.180	14.448
Se	M	duke12	u	t/k	348	1521	2488	3.369	11.293	14.480
Se	M	duke28	u	t/k	348	1547	2488	3.369	11.407	14.480
Se	M	duke40	u	t/k	361	1560	2462	3.489	11.463	14.415
Se	M	had06	æ	h/d	773	1573	2424	6.942	11.518	14.320
Se	M	had12	æ	h/d	760	1624	2475	6.845	11.732	14.448
Se	M	had58	æ	h/d	773	1573	2501	6.942	11.518	14.512
Se	M	hate13	e	h/d	373	2256	2759	3.600	13.872	15.106
Se	M	hate35	e	h/d	386	2166	2707	3.719	13.615	14.992
Se	M	hate48	e	h/d	438	2205	2720	4.189	13.728	15.021
Se	M	head04	ɛ	h/d	528	1702	2669	4.978	12.045	14.907
Se	M	head47	ɛ	h/d	528	1663	2695	4.978	11.891	14.965
Se	M	head61	ɛ	h/d	528	1624	2579	4.978	11.732	14.699
Se	M	heed38	i	h/d	309	2359	2746	3.005	14.151	15.078
Se	M	heed62	i	h/d	335	2566	3546	3.248	14.669	16.571
Se	M	heed67	i	h/d	309	2462	2746	3.005	14.415	15.078
Se	M	herd02	ɹ̩	h/d	464	1263	1624	4.421	10.043	11.732
Se	M	herd34	ɹ̩	h/d	451	1328	1727	4.305	10.380	12.142
Se	M	herd52	ɹ̩	h/d	464	1315	1689	4.421	10.314	11.994
Se	M	hid25	ɪ	h/d	438	1727	2695	4.189	12.142	14.965
Se	M	hid63	ɪ	h/d	464	1740	2720	4.421	12.192	15.021

Se	M	hid65	ɪ	h/d	477	1676	2630	4.535	11.943	14.818
Se	M	hod28	ɑ	h/d	735	1263	2475	6.656	10.043	14.448
Se	M	hod59	ɑ	h/d	773	1276	2424	6.942	10.112	14.320
Se	M	hod67	ɑ	h/d	954	1225	2475	8.212	9.839	14.448
Se	M	hode14	o	h/d	451	1083	2540	4.305	9.026	14.606
Se	M	hode31	o	h/d	490	1147	2630	4.649	9.402	14.818
Se	M	hode47	o	h/d	477	1160	2553	4.535	9.477	14.638
Se	M	hood02	ʊ	h/d	528	1199	2682	4.978	9.696	14.936
Se	M	hood30	ʊ	h/d	515	1379	2579	4.866	10.633	14.699
Se	M	hood43	ʊ	h/d	515	1353	2643	4.866	10.505	14.848
Se	M	hoot32	u	h/d	348	1173	2501	3.369	9.551	14.512
Se	M	hoot33	u	h/d	348	1186	2566	3.369	9.624	14.669
Se	M	hoot64	u	h/d	361	1134	2566	3.489	9.327	14.669
Se	M	hut17	ʌ	h/d	631	1470	2385	5.838	11.063	14.219
Se	M	hut34	ʌ	h/d	618	1405	2488	5.732	10.759	14.480
Se	M	hut46	ʌ	h/d	670	1392	2488	6.151	10.696	14.480
Se	M	put09	ʊ	b/t	541	1315	2488	5.089	10.314	14.480
Se	M	put16	ʊ	b/t	502	1353	2540	4.754	10.505	14.606
Se	M	put46	ʊ	b/t	515	1418	2475	4.866	10.821	14.448
Se	M	tack18	æ	t/k	799	1508	2321	7.134	11.235	14.050
Se	M	tack46	æ	t/k	799	1534	2398	7.134	11.350	14.253
Se	M	tack48	æ	t/k	825	1534	2334	7.323	11.350	14.085
Se	M	take07	e	t/k	464	2076	2695	4.421	13.344	14.965
Se	M	take42	e	t/k	515	1856	2643	4.866	12.617	14.848
Se	M	take57	e	t/k	502	1882	2591	4.754	12.708	14.727
Se	M	teak06	i	t/k	335	2321	2720	3.248	14.050	15.021
Se	M	teak25	i	t/k	373	2205	2707	3.600	13.728	14.992
Se	M	teak61	i	t/k	361	2192	2707	3.489	13.691	14.992
Se	M	tech03	ɛ	t/k	644	1547	2205	5.943	11.407	13.728
Se	M	tech37	ɛ	t/k	657	1586	2398	6.047	11.574	14.253
Se	M	tech54	ɛ	t/k	618	1534	2372	5.732	11.350	14.185
Se	M	tick24	ɪ	t/k	438	1689	2295	4.189	11.994	13.980
Se	M	tick50	ɪ	t/k	438	1792	2359	4.189	12.386	14.151
Se	M	tick68	ɪ	t/k	502	1715	2501	4.754	12.096	14.512
Se	M	tock08	ɑ	t/k	747	1263	2334	6.747	10.043	14.085
Se	M	tock10	ɑ	t/k	799	1276	2450	7.134	10.112	14.385
Se	M	tock32	ɑ	t/k	786	1328	2411	7.039	10.380	14.286
Se	M	toke04	o	t/k	515	1173	2385	4.866	9.551	14.219
Se	M	toke27	o	t/k	502	1263	2424	4.754	10.043	14.320
Se	M	toke49	o	t/k	502	1199	2450	4.754	9.696	14.385
Se	M	took41	ʊ	t/k	386	1225	2346	3.719	9.839	14.117
Se	M	took48	ʊ	t/k	502	1186	2334	4.754	9.624	14.085
Se	M	took65	ʊ	t/k	515	1250	2346	4.866	9.974	14.117
Se	M	tuck13	ʌ	t/k	696	1315	2282	6.355	10.314	13.944
Se	M	tuck17	ʌ	t/k	735	1379	2321	6.656	10.633	14.050
Se	M	tuck50	ʌ	t/k	709	1289	2385	6.456	10.180	14.219
Se	M	turk29	ɹ̩	t/k	464	1250	1611	4.421	9.974	11.678
Se	M	turk45	ɹ̩	t/k	502	1302	1689	4.754	10.247	11.994
Se	M	turk59	ɹ̩	t/k	515	1289	1715	4.866	10.180	12.096
Sf	M	bat14	æ	b/t	577	1578	2400	5.393	11.540	14.258
Sf	M	bat39	æ	b/t	690	1539	2459	6.308	11.372	14.408
Sf	M	bat63	æ	b/t	542	1574	2357	5.098	11.523	14.146
Sf	M	bate04	e	b/t	364	2047	2649	3.517	13.254	14.862
Sf	M	bate53	e	b/t	369	2085	2865	3.563	13.372	15.331

Sf	M	bate56	e	b/t	394	2138	2524	3.792	13.532	14.568
Sf	M	beat02	i	b/t	286	1974	2820	2.787	13.019	15.237
Sf	M	beat16	i	b/t	265	2243	2844	2.588	13.836	15.287
Sf	M	beat23	i	b/t	290	2217	2736	2.825	13.762	15.056
Sf	M	bert29	ɹ̩	b/t	385	1367	1530	3.710	10.575	11.332
Sf	M	bert31	ɹ̩	b/t	394	1349	1505	3.792	10.485	11.222
Sf	M	bert60	ɹ̩	b/t	372	1272	1489	3.590	10.091	11.150
Sf	M	bet09	ε	b/t	466	1699	2631	4.438	12.033	14.820
Sf	M	bet23	ε	b/t	433	1729	2673	4.145	12.150	14.916
Sf	M	bet51	ε	b/t	449	1653	2641	4.288	11.850	14.843
Sf	M	bit06	ɪ	b/t	400	1741	2620	3.847	12.195	14.795
Sf	M	bit29	ɪ	b/t	404	1783	2662	3.883	12.353	14.891
Sf	M	bit55	ɪ	b/t	430	1790	2830	4.118	12.379	15.258
Sf	M	boat17	o	b/t	416	1102	2288	3.992	9.139	13.960
Sf	M	boat39	o	b/t	414	1503	2268	3.973	11.213	13.905
Sf	M	boat66	o	b/t	401	1107	2278	3.856	9.169	13.933
Sf	M	boot61	u	b/t	330	1307	2234	3.201	10.273	13.810
Sf	M	boot68	u	b/t	309	1492	2303	3.005	11.163	14.001
Sf	M	bought27	ɑ	b/t	647	1265	2402	5.967	10.054	14.263
Sf	M	bought51	ɑ	b/t	707	1159	2377	6.441	9.471	14.198
Sf	M	bought52	ɑ	b/t	690	1165	2502	6.308	9.505	14.514
Sf	M	but01	ʌ	b/t	401	1295	2584	3.856	10.211	14.711
Sf	M	but11	ʌ	b/t	451	1321	2594	4.305	10.344	14.735
Sf	M	but20	ʌ	b/t	488	1352	2859	4.632	10.500	15.318
Sf	M	duke12	u	t/k	301	1559	2131	2.929	11.459	13.511
Sf	M	duke28	u	t/k	318	1694	2188	3.089	12.014	13.679
Sf	M	duke40	u	t/k	316	1890	2613	3.070	12.736	14.779
Sf	M	had06	æ	h/d	661	1596	2358	6.079	11.616	14.149
Sf	M	had12	æ	h/d	642	1586	2370	5.927	11.574	14.180
Sf	M	had58	æ	h/d	791	1625	2387	7.075	11.736	14.224
Sf	M	hate13	e	h/d	373	2143	2589	3.600	13.547	14.723
Sf	M	hate35	e	h/d	393	2160	2649	3.783	13.597	14.862
Sf	M	hate48	e	h/d	364	2306	2908	3.517	14.010	15.419
Sf	M	head04	ε	h/d	440	1759	2590	4.207	12.264	14.725
Sf	M	head47	ε	h/d	434	1769	2482	4.154	12.301	14.465
Sf	M	head61	ε	h/d	410	1739	2655	3.937	12.188	14.875
Sf	M	heed38	i	h/d	294	2075	2845	2.863	13.341	15.289
Sf	M	heed62	i	h/d	297	2312	2854	2.891	14.026	15.308
Sf	M	heed67	i	h/d	265	2225	2861	2.588	13.785	15.322
Sf	M	herd02	ɹ̩	h/d	399	1338	1545	3.837	10.430	11.398
Sf	M	herd34	ɹ̩	h/d	414	1234	1505	3.973	9.888	11.222
Sf	M	herd52	ɹ̩	h/d	389	1259	1462	3.746	10.022	11.027
Sf	M	hid25	ɪ	h/d	390	1904	2621	3.755	12.784	14.797
Sf	M	hid63	ɪ	h/d	388	1939	2540	3.737	12.903	14.606
Sf	M	hid65	ɪ	h/d	382	1917	2686	3.682	12.829	14.945
Sf	M	hod28	ɑ	h/d	733	1208	2502	6.641	9.746	14.514
Sf	M	hod59	ɑ	h/d	778	1097	2337	6.979	9.109	14.093
Sf	M	hod67	ɑ	h/d	779	1152	2334	6.987	9.431	14.085
Sf	M	hode14	o	h/d	401	1067	2216	3.856	8.929	13.759
Sf	M	hode31	o	h/d	449	1194	2340	4.288	9.669	14.101
Sf	M	hode47	o	h/d	425	1178	2366	4.073	9.579	14.170
Sf	M	hood02	ʊ	h/d	370	1358	2424	3.572	10.530	14.320
Sf	M	hood30	ʊ	h/d	457	1366	2510	4.359	10.570	14.534
Sf	M	hood43	ʊ	h/d	403	1410	2515	3.874	10.783	14.546

Sf	M	hoot32	u	h/d	295	1242	2183	2.873	9.931	13.665
Sf	M	hoot33	u	h/d	317	1263	2140	3.080	10.043	13.538
Sf	M	hoot64	u	h/d	304	1214	2288	2.957	9.779	13.960
Sf	M	hut17	ʌ	h/d	618	1365	2552	5.732	10.565	14.635
Sf	M	hut34	ʌ	h/d	533	1372	2472	5.021	10.599	14.440
Sf	M	hut46	ʌ	h/d	474	1352	2696	4.509	10.500	14.968
Sf	M	put09	ʊ	b/t	427	1101	2237	4.091	9.133	13.819
Sf	M	put16	ʊ	b/t	444	1051	2182	4.243	8.831	13.662
Sf	M	put46	ʊ	b/t	416	1161	2333	3.992	9.483	14.082
Sf	M	tack18	æ	t/k	630	1555	2283	5.830	11.441	13.947
Sf	M	tack46	æ	t/k	691	1525	2139	6.316	11.310	13.535
Sf	M	tack48	æ	t/k	785	1538	2407	7.031	11.367	14.276
Sf	M	take07	e	t/k	415	2135	2909	3.983	13.523	15.421
Sf	M	take42	e	t/k	410	2013	2931	3.937	13.146	15.465
Sf	M	take57	e	t/k	396	2002	2626	3.810	13.111	14.809
Sf	M	teak06	i	t/k	311	2118	2848	3.023	13.472	15.295
Sf	M	teak25	i	t/k	282	2178	2816	2.750	13.650	15.228
Sf	M	teak61	i	t/k	317	2221	2806	3.080	13.774	15.207
Sf	M	tech03	ɛ	t/k	511	1568	2458	4.832	11.497	14.405
Sf	M	tech37	ɛ	t/k	511	1740	2330	4.832	12.192	14.074
Sf	M	tech54	ɛ	t/k	480	1584	2140	4.562	11.565	13.538
Sf	M	tick24	ɪ	t/k	421	1845	2577	4.037	12.578	14.695
Sf	M	tick50	ɪ	t/k	393	1871	2620	3.783	12.670	14.795
Sf	M	tick68	ɪ	t/k	405	1813	2402	3.892	12.463	14.263
Sf	M	tock08	ɑ	t/k	719	1179	2200	6.534	9.585	13.714
Sf	M	tock10	ɑ	t/k	759	1209	2118	6.838	9.752	13.472
Sf	M	tock32	ɑ	t/k	767	1173	2070	6.898	9.551	13.326
Sf	M	toke04	o	t/k	429	1243	2059	4.109	9.937	13.291
Sf	M	toke27	o	t/k	409	1253	2248	3.928	9.990	13.850
Sf	M	toke49	o	t/k	477	1333	2209	4.535	10.405	13.739
Sf	M	took41	ʊ	t/k	455	1410	2296	4.341	10.783	13.982
Sf	M	took48	ʊ	t/k	472	1430	2130	4.491	10.878	13.508
Sf	M	took65	ʊ	t/k	428	1463	2314	4.100	11.031	14.031
Sf	M	tuck13	ʌ	t/k	522	1358	2292	4.927	10.530	13.971
Sf	M	tuck17	ʌ	t/k	520	1299	2435	4.910	10.232	14.348
Sf	M	tuck50	ʌ	t/k	514	1332	2287	4.858	10.400	13.958
Sf	M	turk29	ɹ̩	t/k	416	1365	1698	3.992	10.565	12.029
Sf	M	turk45	ɹ̩	t/k	404	1370	1623	3.883	10.589	11.728
Sf	M	turk59	ɹ̩	t/k	411	1363	1704	3.946	10.555	12.053

Table B.2. Final /ɹ/ data. "AV" stands for "adjacent vowel", "DC" stands for "distal consonant". "Hz" (Hertz) and "Bk" (Bark) are the units used in the formant columns.

Spkr	*Sex*	*Token*	*AV*	*DC*	*F1Hz*	*F2Hz*	*F3Hz*	*F1Bk*	*F2Bk*	*F3Bk*
S1	F	bar23	*ɑ*	—	812	1547	1998	7.229	11.407	13.098
S1	F	bar38	*ɑ*	—	799	1431	1934	7.134	10.882	12.886
S1	F	bar64	*ɑ*	—	786	1599	2050	7.039	11.628	13.263
S1	F	tar21	*ɑ*	—	786	1457	1972	7.039	11.004	13.013
S1	F	tar30	*ɑ*	—	915	1611	2089	7.951	11.678	13.384
S1	F	tar41	*ɑ*	—	799	1534	1947	7.134	11.350	12.930
S2	F	bar23	*ɑ*	—	593	1611	2101	5.526	11.678	13.421
S2	F	bar38	*ɑ*	—	735	1457	1947	6.656	11.004	12.930
S2	F	bar64	*ɑ*	—	825	1457	1960	7.323	11.004	12.973
S2	F	tar21	*ɑ*	—	657	1637	2166	6.047	11.785	13.615

S2	F	tar30	*a*	—	760	1457	2114	6.845	11.004	13.460
S2	F	tar41	*a*	—	709	1521	2153	6.456	11.293	13.577
S3	F	bar23	*a*	—	889	1573	2230	7.774	11.518	13.799
S3	F	bar38	*a*	—	825	1637	2243	7.323	11.785	13.836
S3	F	bar64	*a*	—	928	1573	2076	8.039	11.518	13.344
S3	F	tar21	*a*	—	825	1676	2269	7.323	11.943	13.908
S3	F	tar30	*a*	—	593	1599	2179	5.526	11.628	13.653
S3	F	tar41	*a*	—	760	1753	2295	6.845	12.241	13.980
S4	F	bar23	*a*	—	386	1508	1831	3.719	11.235	12.528
S4	F	bar38	*a*	—	425	1444	1740	4.073	10.943	12.192
S4	F	bar64	*a*	—	400	1431	1779	3.847	10.882	12.338
S4	F	tar21	*a*	—	361	1508	1779	3.489	11.235	12.338
S4	F	tar30	*a*	—	309	1328	1740	3.005	10.380	12.192
S4	F	tar41	*a*	—	335	1521	1831	3.248	11.293	12.528
S5	F	bar23	*a*	—	606	2024	2695	5.634	13.181	14.965
S5	F	bar38	*a*	—	618	1753	2682	5.732	12.241	14.936
S5	F	bar64	*a*	—	580	1792	2695	5.418	12.386	14.965
S5	F	tar21	*a*	—	606	1856	2759	5.634	12.617	15.106
S5	F	tar30	*a*	—	515	2166	2759	4.866	13.615	15.106
S5	F	tar41	*a*	—	657	1844	2643	6.047	12.575	14.848
S6	F	bar23	*a*	—	838	1720	2230	7.416	12.115	13.799
S6	F	bar38	*a*	—	438	1862	2659	4.189	12.638	14.884
S6	F	bar64	*a*	—	727	1734	2304	6.595	12.169	14.004
S6	F	tar21	*a*	—	305	1682	2392	2.967	11.966	14.237
S6	F	tar30	*a*	—	513	1498	2416	4.849	11.190	14.299
S6	F	tar41	*a*	—	556	1807	2600	5.217	12.441	14.749
S7	F	bar23	*a*	—	805	1726	2143	7.178	12.138	13.547
S7	F	bar38	*a*	—	904	1443	1812	7.877	10.939	12.460
S7	F	bar64	*a*	—	810	1462	1780	7.214	11.027	12.342
S7	F	tar21	*a*	—	604	1682	2100	5.617	11.966	13.418
S7	F	tar30	*a*	—	843	1537	1947	7.452	11.363	12.930
S7	F	tar41	*a*	—	512	1718	2144	4.841	12.107	13.550
S8	F	bar23	*a*	—	616	1582	2056	5.716	11.557	13.282
S8	F	bar38	*a*	—	670	1599	2013	6.151	11.628	13.146
S8	F	bar64	*a*	—	562	1599	1913	5.267	11.628	12.815
S8	F	tar21	*a*	—	624	1534	1971	5.781	11.350	13.009
S8	F	tar30	*a*	—	621	1658	1927	5.757	11.871	12.863
S8	F	tar41	*a*	—	584	1616	2021	5.452	11.699	13.172
S9	F	bar23	*a*	—	505	1654	2163	4.780	11.854	13.606
S9	F	bar38	*a*	—	521	1656	2083	4.918	11.862	13.366
S9	F	bar64	*a*	—	478	1613	2099	4.544	11.687	13.415
S9	F	tar21	*a*	—	570	1621	2039	5.335	11.720	13.229
S9	F	tar30	*a*	—	444	1749	2106	4.243	12.226	13.436
S9	F	tar41	*a*	—	484	1521	2011	4.597	11.293	13.139
Sa	M	bar23	*a*	—	567	1276	1727	5.309	10.112	12.142
Sa	M	bar38	*a*	—	477	1289	1740	4.535	10.180	12.192
Sa	M	bar64	*a*	—	451	1289	1702	4.305	10.180	12.045
Sa	M	tar21	*a*	—	528	1302	1727	4.978	10.247	12.142
Sa	M	tar30	*a*	—	528	1353	1792	4.978	10.505	12.386
Sa	M	tar41	*a*	—	477	1289	1740	4.535	10.180	12.192
Sb	M	bar23	*a*	—	515	1418	1766	4.866	10.821	12.290
Sb	M	bar38	*a*	—	528	1353	1753	4.978	10.505	12.241
Sb	M	bar64	*a*	—	464	1431	1831	4.421	10.882	12.528
Sb	M	tar21	*a*	—	490	1547	1831	4.649	11.407	12.528

Sb	M	tar30	*a*	—	477	1392	1908	4.535	10.696	12.798
Sb	M	tar41	*a*	—	541	1457	1844	5.089	11.004	12.575
Sc	M	bar23	*a*	—	464	1341	1766	4.421	10.445	12.290
Sc	M	bar38	*a*	—	451	1379	1779	4.305	10.633	12.338
Sc	M	bar64	*a*	—	451	1418	1908	4.305	10.821	12.798
Sc	M	tar21	*a*	—	477	1315	1702	4.535	10.314	12.045
Sc	M	tar30	*a*	—	451	1341	1715	4.305	10.445	12.096
Sc	M	tar41	*a*	—	464	1315	1805	4.421	10.314	12.434
Sd	M	bar23	*a*	—	477	1379	1689	4.535	10.633	11.994
Sd	M	bar38	*a*	—	490	1392	1702	4.649	10.696	12.045
Sd	M	bar64	*a*	—	515	1418	1895	4.866	10.821	12.753
Sd	M	tar21	*a*	—	490	1379	1676	4.649	10.633	11.943
Sd	M	tar30	*a*	—	451	1457	1844	4.305	11.004	12.575
Sd	M	tar41	*a*	—	528	1366	1779	4.978	10.570	12.338
Se	M	bar23	*a*	—	477	1341	1676	4.535	10.445	11.943
Se	M	bar38	*a*	—	451	1328	1766	4.305	10.380	12.290
Se	M	bar64	*a*	—	515	1392	1727	4.866	10.696	12.142
Se	M	tar21	*a*	—	425	1341	1753	4.073	10.445	12.241
Se	M	tar30	*a*	—	425	1341	1715	4.073	10.445	12.096
Se	M	tar41	*a*	—	464	1392	1766	4.421	10.696	12.290
Sf	M	bar23	*a*	—	569	1300	1698	5.326	10.237	12.029
Sf	M	bar38	*a*	—	531	1327	1665	5.004	10.375	11.899
Sf	M	bar64	*a*	—	460	1342	1732	4.385	10.450	12.161
Sf	M	tar21	*a*	—	445	1286	1550	4.252	10.164	11.420
Sf	M	tar30	*a*	—	449	1311	1629	4.288	10.293	11.753
Sf	M	tar41	*a*	—	465	1352	1630	4.430	10.500	11.757
S1	F	bear03	*e*	—	722	1934	2179	6.557	12.886	13.653
S1	F	bear21	*e*	—	438	1818	2166	4.189	12.481	13.615
S1	F	bear65	*e*	—	490	1908	2256	4.649	12.798	13.872
S1	F	tare10	*e*	—	618	1869	2140	5.732	12.663	13.538
S1	F	tare50	*e*	—	644	1985	2385	5.943	13.055	14.219
S1	F	tare54	*e*	—	670	1792	2089	6.151	12.386	13.384
S2	F	bear03	*e*	—	631	1663	2101	5.838	11.891	13.421
S2	F	bear21	*e*	—	606	1663	2217	5.634	11.891	13.762
S2	F	bear65	*e*	—	670	1573	2166	6.151	11.518	13.615
S2	F	tare10	*e*	—	567	1805	2153	5.309	12.434	13.577
S2	F	tare50	*e*	—	838	1960	2153	7.416	12.973	13.577
S2	F	tare54	*e*	—	606	1637	2217	5.634	11.785	13.762
S3	F	bear03	*e*	—	851	1663	2166	7.508	11.891	13.615
S3	F	bear21	*e*	—	825	1676	2217	7.323	11.943	13.762
S3	F	bear65	*e*	—	722	1624	2166	6.557	11.732	13.615
S3	F	tare10	*e*	—	477	1818	2217	4.535	12.481	13.762
S3	F	tare50	*e*	—	541	1676	2127	5.089	11.943	13.499
S3	F	tare54	*e*	—	554	1779	2243	5.200	12.338	13.836
S4	F	bear03	*e*	—	399	1715	2282	3.837	12.096	13.944
S4	F	bear21	*e*	—	361	1740	1934	3.489	12.192	12.886
S4	F	bear65	*e*	—	438	1573	2273	4.189	11.518	13.919
S4	F	tare10	*e*	—	425	1779	2295	4.073	12.338	13.980
S4	F	tare50	*e*	—	412	1689	2205	3.955	11.994	13.728
S4	F	tare54	*e*	—	361	1560	1831	3.489	11.463	12.528
S5	F	bear03	*e*	—	580	1882	2630	5.418	12.708	14.818
S5	F	bear21	*e*	—	631	1998	2746	5.838	13.098	15.078
S5	F	bear65	*e*	—	541	1908	2695	5.089	12.798	14.965
S5	F	tare10	*e*	—	567	1947	2862	5.309	12.930	15.324

S5	F	tare50	*e*	—	593	1947	2978	5.526	12.930	15.559
S5	F	tare54	*e*	—	631	1856	2849	5.838	12.617	15.297
S6	F	bear03	*e*	—	403	2015	2704	3.874	13.152	14.985
S6	F	bear21	*e*	—	422	1877	2476	4.046	12.691	14.450
S6	F	bear65	*e*	—	478	1787	2569	4.544	12.368	14.676
S6	F	tare10	*e*	—	549	1812	2446	5.157	12.460	14.375
S6	F	tare50	*e*	—	350	1665	2359	3.387	11.899	14.151
S6	F	tare54	*e*	—	442	1828	2545	4.225	12.517	14.618
S7	F	bear03	*e*	—	509	1664	2184	4.815	11.895	13.667
S7	F	bear21	*e*	—	474	1706	2344	4.509	12.061	14.112
S7	F	bear65	*e*	—	396	1552	1807	3.810	11.428	12.441
S7	F	tare10	*e*	—	468	1402	1748	4.456	10.745	12.222
S7	F	tare50	*e*	—	390	1634	2133	3.755	11.773	13.517
S7	F	tare54	*e*	—	446	1532	1736	4.261	11.341	12.176
S8	F	bear03	*e*	—	493	1778	2026	4.675	12.335	13.187
S8	F	bear21	*e*	—	509	1897	2250	4.815	12.760	13.855
S8	F	bear65	*e*	—	541	1694	1937	5.089	12.014	12.896
S8	F	tare10	*e*	—	553	1734	1986	5.191	12.169	13.059
S8	F	tare50	*e*	—	468	1648	1941	4.456	11.830	12.910
S8	F	tare54	*e*	—	546	1744	2014	5.132	12.207	13.149
S9	F	bear03	*e*	—	457	1672	2129	4.359	11.927	13.505
S9	F	bear21	*e*	—	443	1650	2043	4.234	11.838	13.241
S9	F	bear65	*e*	—	405	1638	2055	3.892	11.789	13.279
S9	F	tare10	*e*	—	523	1630	1864	4.935	11.757	12.646
S9	F	tare50	*e*	—	609	1706	2133	5.658	12.061	13.517
S9	F	tare54	*e*	—	490	1683	2029	4.649	11.970	13.197
Sa	M	bear03	*e*	—	399	1508	1805	3.837	11.235	12.434
Sa	M	bear21	*e*	—	399	1457	1792	3.837	11.004	12.386
Sa	M	bear65	*e*	—	412	1457	1805	3.955	11.004	12.434
Sa	M	tare10	*e*	—	399	1521	1831	3.837	11.293	12.528
Sa	M	tare50	*e*	—	399	1457	1779	3.837	11.004	12.338
Sa	M	tare54	*e*	—	361	1508	1869	3.489	11.235	12.663
Sb	M	bear03	*e*	—	451	1521	1844	4.305	11.293	12.575
Sb	M	bear21	*e*	—	425	1502	1892	4.073	11.208	12.743
Sb	M	bear65	*e*	—	438	1560	1844	4.189	11.463	12.575
Sb	M	tare10	*e*	—	477	1599	1844	4.535	11.628	12.575
Sb	M	tare50	*e*	—	412	1482	1792	3.955	11.118	12.386
Sb	M	tare54	*e*	—	464	1405	1715	4.421	10.759	12.096
Sc	M	bear03	*e*	—	515	1482	1844	4.866	11.118	12.575
Sc	M	bear21	*e*	—	451	1431	1715	4.305	10.882	12.096
Sc	M	bear65	*e*	—	451	1482	1882	4.305	11.118	12.708
Sc	M	tare10	*e*	—	451	1521	1921	4.305	11.293	12.842
Sc	M	tare50	*e*	—	425	1521	2089	4.073	11.293	13.384
Sc	M	tare54	*e*	—	451	1495	1882	4.305	11.177	12.708
Sd	M	bear03	*e*	—	464	1586	1934	4.421	11.574	12.886
Sd	M	bear21	*e*	—	451	1573	1895	4.305	11.518	12.753
Sd	M	bear65	*e*	—	464	1573	1947	4.421	11.518	12.930
Sd	M	tare10	*e*	—	477	1573	2011	4.535	11.518	13.139
Sd	M	tare50	*e*	—	464	1534	1934	4.421	11.350	12.886
Sd	M	tare54	*e*	—	464	1508	1921	4.421	11.235	12.842
Se	M	bear03	*e*	—	502	1302	1637	4.754	10.247	11.785
Se	M	bear21	*e*	—	464	1366	1753	4.421	10.570	12.241
Se	M	bear65	*e*	—	490	1444	1831	4.649	10.943	12.528
Se	M	tare10	*e*	—	477	1341	1676	4.535	10.445	11.943

Se	M	tare50	*e*	—	464	1405	1740	4.421	10.759	12.192
Se	M	tare54	*e*	—	490	1444	1663	4.649	10.943	11.891
Sf	M	bear03	*e*	—	389	1496	1709	3.746	11.181	12.072
Sf	M	bear21	*e*	—	415	1474	1742	3.983	11.082	12.199
Sf	M	bear65	*e*	—	452	1587	1817	4.314	11.578	12.478
Sf	M	tare10	*e*	—	424	1512	1780	4.064	11.253	12.342
Sf	M	tare50	*e*	—	432	1397	1688	4.136	10.721	11.990
Sf	M	tare54	*e*	—	459	1531	1815	4.376	11.337	12.470
S1	F	beer01	*i*	—	554	1869	2089	5.200	12.663	13.384
S1	F	beer25	*i*	—	451	1934	2243	4.305	12.886	13.836
S1	F	beer36	*i*	—	580	1844	2282	5.418	12.575	13.944
S1	F	tier05	*i*	—	515	1818	2205	4.866	12.481	13.728
S1	F	tier11	*i*	—	515	1947	2230	4.866	12.930	13.799
S1	F	tier67	*i*	—	477	1831	2217	4.535	12.528	13.762
S2	F	beer01	*i*	—	741	1640	2129	6.702	11.798	13.505
S2	F	beer25	*i*	—	309	1560	2101	3.005	11.463	13.421
S2	F	beer36	*i*	—	554	1573	2076	5.200	11.518	13.344
S2	F	tier05	*i*	—	438	1663	2114	4.189	11.891	13.460
S2	F	tier11	*i*	—	477	1573	2063	4.535	11.518	13.304
S2	F	tier67	*i*	—	528	1599	2140	4.978	11.628	13.538
S3	F	beer01	*i*	—	438	1985	2115	4.189	13.055	13.463
S3	F	beer25	*i*	—	490	1521	2127	4.649	11.293	13.499
S3	F	beer36	*i*	—	477	1972	2205	4.535	13.013	13.728
S3	F	tier05	*i*	—	477	1689	2192	4.535	11.994	13.691
S3	F	tier11	*i*	—	502	1547	2166	4.754	11.407	13.615
S3	F	tier67	*i*	—	515	1624	2011	4.866	11.732	13.139
S4	F	beer01	*i*	—	451	1663	2192	4.305	11.891	13.691
S4	F	beer25	*i*	—	425	1805	2282	4.073	12.434	13.944
S4	F	beer36	*i*	—	361	1727	2669	3.489	12.142	14.907
S4	F	tier05	*i*	—	425	1637	2308	4.073	11.785	14.015
S4	F	tier11	*i*	—	412	1818	2385	3.955	12.481	14.219
S4	F	tier67	*i*	—	399	1413	1827	3.837	10.797	12.514
S5	F	beer01	*i*	—	477	1972	2656	4.535	13.013	14.877
S5	F	beer25	*i*	—	606	1908	2785	5.634	12.798	15.162
S5	F	beer36	*i*	—	502	2050	2720	4.754	13.263	15.021
S5	F	tier05	*i*	—	425	1934	2811	4.073	12.886	15.218
S5	F	tier11	*i*	—	464	2050	2875	4.421	13.263	15.351
S5	F	tier67	*i*	—	593	1895	2965	5.526	12.753	15.533
S6	F	beer01	*i*	—	391	1856	2518	3.765	12.617	14.553
S6	F	beer25	*i*	—	428	1822	2486	4.100	12.496	14.475
S6	F	beer36	*i*	—	396	1660	2496	3.810	11.879	14.500
S6	F	tier05	*i*	—	421	2141	2580	4.037	13.541	14.702
S6	F	tier11	*i*	—	343	1755	2582	3.322	12.248	14.706
S6	F	tier67	*i*	—	427	1831	2392	4.091	12.528	14.237
S7	F	beer01	*i*	—	439	1829	2236	4.198	12.521	13.816
S7	F	beer25	*i*	—	438	1770	2311	4.189	12.305	14.023
S7	F	beer36	*i*	—	398	1682	2100	3.828	11.966	13.418
S7	F	tier05	*i*	—	382	1735	2226	3.682	12.173	13.788
S7	F	tier11	*i*	—	362	1750	2180	3.498	12.230	13.656
S7	F	tier67	*i*	—	416	1675	2101	3.992	11.939	13.421
S8	F	beer01	*i*	—	554	1686	1973	5.200	11.982	13.016
S8	F	beer25	*i*	—	559	1798	2086	5.242	12.408	13.375
S8	F	beer36	*i*	—	494	1828	2121	4.684	12.517	13.481
S8	F	tier05	*i*	—	470	1811	2028	4.474	12.456	13.194

S8	F	tier11	*i*	—	511	1797	2011	4.832	12.405	13.139
S8	F	tier67	*i*	—	471	1665	1921	4.483	11.899	12.842
S9	F	beer01	*i*	—	539	1828	2106	5.072	12.517	13.436
S9	F	beer25	*i*	—	424	1492	1835	4.064	11.163	12.543
S9	F	beer36	*i*	—	516	1666	1871	4.875	11.903	12.670
S9	F	tier05	*i*	—	552	1770	2042	5.183	12.305	13.238
S9	F	tier11	*i*	—	444	1721	2377	4.243	12.119	14.198
S9	F	tier67	*i*	—	416	1540	1852	3.992	11.376	12.603
Sa	M	beer01	*i*	—	361	1560	1805	3.489	11.463	12.434
Sa	M	beer25	*i*	—	322	1470	1792	3.126	11.063	12.386
Sa	M	beer36	*i*	—	361	1534	1740	3.489	11.350	12.192
Sa	M	tier05	*i*	—	348	1534	1792	3.369	11.350	12.386
Sa	M	tier11	*i*	—	335	1508	1766	3.248	11.235	12.290
Sa	M	tier67	*i*	—	373	1508	1753	3.600	11.235	12.241
Sb	M	beer01	*i*	—	399	1560	1792	3.837	11.463	12.386
Sb	M	beer25	*i*	—	399	1650	1934	3.837	11.838	12.886
Sb	M	beer36	*i*	—	399	1611	1869	3.837	11.678	12.663
Sb	M	tier05	*i*	—	348	1702	2011	3.369	12.045	13.139
Sb	M	tier11	*i*	—	412	1650	1960	3.955	11.838	12.973
Sb	M	tier67	*i*	—	373	1573	1895	3.600	11.518	12.753
Sc	M	beer01	*i*	—	412	1495	1792	3.955	11.177	12.386
Sc	M	beer25	*i*	—	399	1457	1792	3.837	11.004	12.386
Sc	M	beer36	*i*	—	399	1534	1831	3.837	11.350	12.528
Sc	M	tier05	*i*	—	386	1534	1960	3.719	11.350	12.973
Sc	M	tier11	*i*	—	386	1599	1947	3.719	11.628	12.930
Sc	M	tier67	*i*	—	438	1637	2063	4.189	11.785	13.304
Sd	M	beer01	*i*	—	412	1650	1998	3.955	11.838	13.098
Sd	M	beer25	*i*	—	438	1624	1960	4.189	11.732	12.973
Sd	M	beer36	*i*	—	438	1779	2050	4.189	12.338	13.263
Sd	M	tier05	*i*	—	412	1624	2024	3.955	11.732	13.181
Sd	M	tier11	*i*	—	425	1521	1818	4.073	11.293	12.481
Sd	M	tier67	*i*	—	438	1599	1998	4.189	11.628	13.098
Se	M	beer01	*i*	—	477	1353	1702	4.535	10.505	12.045
Se	M	beer25	*i*	—	425	1392	1766	4.073	10.696	12.290
Se	M	beer36	*i*	—	464	1328	1676	4.421	10.380	11.943
Se	M	tier05	*i*	—	438	1341	1676	4.189	10.445	11.943
Se	M	tier11	*i*	—	425	1379	1753	4.073	10.633	12.241
Se	M	tier67	*i*	—	451	1431	1753	4.305	10.882	12.241
Sf	M	beer01	*i*	—	396	1546	1868	3.810	11.402	12.660
Sf	M	beer25	*i*	—	353	1545	1801	3.415	11.398	12.419
Sf	M	beer36	*i*	—	385	1545	1823	3.710	11.398	12.499
Sf	M	tier05	*i*	—	414	1434	1724	3.973	10.897	12.130
Sf	M	tier11	*i*	—	371	1505	1775	3.581	11.222	12.323
Sf	M	tier67	*i*	—	394	1622	1843	3.792	11.724	12.571
S1	F	bore05	*o*	b	631	1418	1960	5.838	10.821	12.973
S1	F	bore14	*o*	b	580	1534	2050	5.418	11.350	13.263
S1	F	bore57	*o*	b	554	1366	1831	5.200	10.570	12.528
S1	F	tore40	*o*	t	773	1470	2011	6.942	11.063	13.139
S1	F	tore54	*o*	t	618	1482	2076	5.732	11.118	13.344
S1	F	tore56	*o*	t	554	1431	1727	5.200	10.882	12.142
S2	F	bore05	*o*	b	515	1379	1934	4.866	10.633	12.886
S2	F	bore14	*o*	b	580	1379	2127	5.418	10.633	13.499
S2	F	bore57	*o*	b	644	1431	1895	5.943	10.882	12.753
S2	F	tore40	*o*	t	386	1560	2089	3.719	11.463	13.384

S2	F	tore54	*o*	t	541	1457	2101	5.089	11.004	13.421
S2	F	tore56	*o*	t	644	1457	2024	5.943	11.004	13.181
S3	F	bore05	*o*	b	696	1650	2269	6.355	11.838	13.908
S3	F	bore14	*o*	b	683	1431	2153	6.253	10.882	13.577
S3	F	bore57	*o*	b	541	1586	2127	5.089	11.574	13.499
S3	F	tore40	*o*	t	593	1637	2334	5.526	11.785	14.085
S3	F	tore54	*o*	t	593	1470	2101	5.526	11.063	13.421
S3	F	tore56	*o*	t	631	1560	2243	5.838	11.463	13.836
S4	F	bore05	*o*	b	477	1353	1779	4.535	10.505	12.338
S4	F	bore14	*o*	b	361	1405	1818	3.489	10.759	12.481
S4	F	bore57	*o*	b	399	1405	1702	3.837	10.759	12.045
S4	F	tore40	*o*	t	348	1418	1805	3.369	10.821	12.434
S4	F	tore54	*o*	t	438	1457	1805	4.189	11.004	12.434
S4	F	tore56	*o*	t	386	1328	1779	3.719	10.380	12.338
S5	F	bore05	*o*	b	618	1818	2695	5.732	12.481	14.965
S5	F	bore14	*o*	b	618	1921	2862	5.732	12.842	15.324
S5	F	bore57	*o*	b	477	1689	2759	4.535	11.994	15.106
S5	F	tore40	*o*	t	580	1882	2798	5.418	12.708	15.190
S5	F	tore54	*o*	t	606	1844	2862	5.634	12.575	15.324
S5	F	tore56	*o*	t	502	1702	2772	4.754	12.045	15.134
S6	F	bore05	*o*	b	446	1499	2468	4.261	11.195	14.430
S6	F	bore14	*o*	b	492	1655	2538	4.667	11.858	14.602
S6	F	bore57	*o*	b	497	1618	2492	4.710	11.707	14.490
S6	F	tore40	*o*	t	499	1529	2495	4.728	11.328	14.497
S6	F	tore54	*o*	t	444	1543	2499	4.243	11.389	14.507
S6	F	tore56	*o*	t	554	1412	2416	5.200	10.793	14.299
S7	F	bore05	*o*	b	417	1371	2195	4.001	10.594	13.699
S7	F	bore14	*o*	b	453	1300	1704	4.323	10.237	12.053
S7	F	bore57	*o*	b	436	1328	1671	4.171	10.380	11.923
S7	F	tore40	*o*	t	453	1301	1709	4.323	10.242	12.072
S7	F	tore54	*o*	t	438	1324	1847	4.189	10.360	12.585
S7	F	tore56	*o*	t	446	1236	1898	4.261	9.899	12.764
S8	F	bore05	*o*	b	449	1594	2032	4.288	11.607	13.206
S8	F	bore14	*o*	b	554	1493	2045	5.200	11.168	13.248
S8	F	bore57	*o*	b	532	1420	1908	5.013	10.831	12.798
S8	F	tore40	*o*	t	479	1429	2109	4.553	10.873	13.445
S8	F	tore54	*o*	t	570	1582	2063	5.335	11.557	13.304
S8	F	tore56	*o*	t	439	1378	2069	4.198	10.628	13.323
S9	F	bore05	*o*	b	494	1520	2166	4.684	11.288	13.615
S9	F	bore14	*o*	b	465	1520	2238	4.430	11.288	13.822
S9	F	bore57	*o*	b	535	1430	2108	5.038	10.878	13.442
S9	F	tore40	*o*	t	470	1487	2145	4.474	11.141	13.553
S9	F	tore54	*o*	t	531	1378	2036	5.004	10.628	13.219
S9	F	tore56	*o*	t	507	1346	1992	4.797	10.470	13.078
Sa	M	bore05	*o*	b	386	1212	1740	3.719	9.768	12.192
Sa	M	bore14	*o*	b	425	1250	1727	4.073	9.974	12.142
Sa	M	bore57	*o*	b	399	1302	1715	3.837	10.247	12.096
Sa	M	tore40	*o*	t	425	1250	1676	4.073	9.974	11.943
Sa	M	tore54	*o*	t	399	1212	1676	3.837	9.768	11.943
Sa	M	tore56	*o*	t	412	1212	1637	3.955	9.768	11.785
Sb	M	bore05	*o*	b	477	1225	1740	4.535	9.839	12.192
Sb	M	bore14	*o*	b	425	1250	1753	4.073	9.974	12.241
Sb	M	bore57	*o*	b	451	1289	1805	4.305	10.180	12.434
Sb	M	tore40	*o*	t	361	1379	1715	3.489	10.633	12.096

Sb	M	tore54	*o*	t	412	1173	1624	3.955	9.551	11.732
Sb	M	tore56	*o*	t	399	1186	1702	3.837	9.624	12.045
Sc	M	bore05	*o*	b	425	1379	1792	4.073	10.633	12.386
Sc	M	bore14	*o*	b	425	1366	1766	4.073	10.570	12.290
Sc	M	bore57	*o*	b	438	1302	1818	4.189	10.247	12.481
Sc	M	tore40	*o*	t	438	1379	1805	4.189	10.633	12.434
Sc	M	tore54	*o*	t	425	1315	1766	4.073	10.314	12.290
Sc	M	tore56	*o*	t	438	1341	1753	4.189	10.445	12.241
Sd	M	bore05	*o*	b	464	1315	1663	4.421	10.314	11.891
Sd	M	bore14	*o*	b	438	1302	1689	4.189	10.247	11.994
Sd	M	bore57	*o*	b	477	1276	1779	4.535	10.112	12.338
Sd	M	tore40	*o*	t	464	1353	1805	4.421	10.505	12.434
Sd	M	tore54	*o*	t	477	1250	1818	4.535	9.974	12.481
Sd	M	tore56	*o*	t	464	1315	1715	4.421	10.314	12.096
Se	M	bore05	*o*	b	541	1315	1727	5.089	10.314	12.142
Se	M	bore14	*o*	b	451	1250	1637	4.305	9.974	11.785
Se	M	bore57	*o*	b	490	1250	1676	4.649	9.974	11.943
Se	M	tore40	*o*	t	515	1328	1715	4.866	10.380	12.096
Se	M	tore54	*o*	t	477	1341	1792	4.535	10.445	12.386
Se	M	tore56	*o*	t	464	1315	1727	4.421	10.314	12.142
Sf	M	bore05	*o*	b	392	1269	1550	3.774	10.075	11.420
Sf	M	bore14	*o*	b	435	1182	1558	4.163	9.601	11.454
Sf	M	bore57	*o*	b	429	1156	1663	4.109	9.454	11.891
Sf	M	tore40	*o*	t	457	1237	1609	4.359	9.904	11.670
Sf	M	tore54	*o*	t	443	1192	1554	4.234	9.657	11.437
Sf	M	tore56	*o*	t	458	1211	1560	4.368	9.763	11.463
S1	F	boor11	*u*	—	528	1379	1998	4.978	10.633	13.098
S1	F	boor21	*u*	—	425	1444	2127	4.073	10.943	13.499
S1	F	boor33	*u*	—	593	1482	1998	5.526	11.118	13.098
S1	F	tour31	*u*	—	502	1418	2063	4.754	10.821	13.304
S1	F	tour44	*u*	—	438	1470	2050	4.189	11.063	13.263
S1	F	tour62	*u*	—	399	1418	2024	3.837	10.821	13.181
S2	F	boor11	*u*	—	515	1482	1972	4.866	11.118	13.013
S2	F	boor21	*u*	—	580	1534	2101	5.418	11.350	13.421
S2	F	boor33	*u*	—	515	1353	2127	4.866	10.505	13.499
S2	F	tour31	*u*	—	502	1508	2076	4.754	11.235	13.344
S2	F	tour44	*u*	—	618	1508	2166	5.732	11.235	13.615
S2	F	tour62	*u*	—	554	1431	1831	5.200	10.882	12.528
S3	F	boor11	*u*	—	696	1573	2101	6.355	11.518	13.421
S3	F	boor21	*u*	—	825	1637	2217	7.323	11.785	13.762
S3	F	boor33	*u*	—	464	1579	2140	4.421	11.544	13.538
S3	F	tour31	*u*	—	528	1650	2205	4.978	11.838	13.728
S3	F	tour44	*u*	—	838	1495	2243	7.416	11.177	13.836
S3	F	tour62	*u*	—	580	1508	2295	5.418	11.235	13.980
S4	F	boor11	*u*	—	438	1392	1740	4.189	10.696	12.192
S4	F	boor21	*u*	—	348	1328	1856	3.369	10.380	12.617
S4	F	boor33	*u*	—	361	1482	1805	3.489	11.118	12.434
S4	F	tour31	*u*	—	425	1379	1755	4.073	10.633	12.248
S4	F	tour44	*u*	—	451	1573	1799	4.305	11.518	12.412
S4	F	tour62	*u*	—	464	1315	1844	4.421	10.314	12.575
S5	F	boor11	*u*	—	593	1818	2772	5.526	12.481	15.134
S5	F	boor21	*u*	—	631	1882	2824	5.838	12.708	15.245
S5	F	boor33	*u*	—	477	1908	2798	4.535	12.798	15.190
S5	F	tour31	*u*	—	502	1908	3301	4.754	12.798	16.159

S5	F	tour44	*u*	—	580	1805	2875	5.418	12.434	15.351
S5	F	tour62	*u*	—	657	1740	2836	6.047	12.192	15.270
S6	F	boor11	*u*	—	533	1616	2309	5.021	11.699	14.018
S6	F	boor21	*u*	—	362	1582	2503	3.498	11.557	14.517
S6	F	boor33	*u*	—	513	1524	2430	4.849	11.306	14.335
S6	F	tour31	*u*	—	426	1525	2335	4.082	11.310	14.088
S6	F	tour44	*u*	—	379	1493	2355	3.655	11.168	14.141
S6	F	tour62	*u*	—	424	1642	2373	4.064	11.806	14.188
S7	F	boor11	*u*	—	472	1307	1811	4.491	10.273	12.456
S7	F	boor21	*u*	—	472	1363	1874	4.491	10.555	12.681
S7	F	boor33	*u*	—	384	1361	1936	3.701	10.545	12.893
S7	F	tour31	*u*	—	352	1324	1943	3.406	10.360	12.917
S7	F	tour44	*u*	—	421	1383	1946	4.037	10.653	12.927
S7	F	tour62	*u*	—	430	1408	1672	4.118	10.773	11.927
S8	F	boor11	*u*	—	588	1556	2007	5.485	11.446	13.127
S8	F	boor21	*u*	—	529	1497	2084	4.987	11.186	13.369
S8	F	boor33	*u*	—	530	1340	2060	4.995	10.440	13.295
S8	F	tour31	*u*	—	515	1509	2044	4.866	11.240	13.244
S8	F	tour44	*u*	—	510	1344	2007	4.823	10.460	13.127
S8	F	tour62	*u*	—	568	1441	2045	5.318	10.929	13.248
S9	F	boor11	*u*	—	446	1588	2038	4.261	11.582	13.225
S9	F	boor21	*u*	—	532	1544	2043	5.013	11.394	13.241
S9	F	boor33	*u*	—	478	1452	1919	4.544	10.981	12.836
S9	F	tour31	*u*	—	453	1438	2056	4.323	10.915	13.282
S9	F	tour44	*u*	—	479	1497	1904	4.553	11.186	12.784
S9	F	tour62	*u*	—	449	1472	2106	4.288	11.073	13.436
Sa	M	boor11	*u*	—	399	1288	1755	3.837	10.175	12.248
Sa	M	boor21	*u*	—	361	1237	1689	3.489	9.904	11.994
Sa	M	boor33	*u*	—	386	1289	1715	3.719	10.180	12.096
Sa	M	tour31	*u*	—	373	1225	1676	3.600	9.839	11.943
Sa	M	tour44	*u*	—	399	1173	1624	3.837	9.551	11.732
Sa	M	tour62	*u*	—	386	1289	1702	3.719	10.180	12.045
Sb	M	boor11	*u*	—	386	1225	1727	3.719	9.839	12.142
Sb	M	boor21	*u*	—	386	1276	1702	3.719	10.112	12.045
Sb	M	boor33	*u*	—	373	1199	1624	3.600	9.696	11.732
Sb	M	tour31	*u*	—	373	1289	1727	3.600	10.180	12.142
Sb	M	tour44	*u*	—	386	1353	1715	3.719	10.505	12.096
Sb	M	tour62	*u*	—	348	1418	1689	3.369	10.821	11.994
Sc	M	boor11	*u*	—	438	1366	1766	4.189	10.570	12.290
Sc	M	boor21	*u*	—	425	1341	1766	4.073	10.445	12.290
Sc	M	boor33	*u*	—	451	1353	1753	4.305	10.505	12.241
Sc	M	tour31	*u*	—	412	1341	1831	3.955	10.445	12.528
Sc	M	tour44	*u*	—	412	1366	1766	3.955	10.570	12.290
Sc	M	tour62	*u*	—	412	1418	1844	3.955	10.821	12.575
Sd	M	boor11	*u*	—	451	1225	1818	4.305	9.839	12.481
Sd	M	boor21	*u*	—	451	1353	1637	4.305	10.505	11.785
Sd	M	boor33	*u*	—	399	1353	1740	3.837	10.505	12.192
Sd	M	tour31	*u*	—	425	1457	1869	4.073	11.004	12.663
Sd	M	tour44	*u*	—	464	1405	1895	4.421	10.759	12.753
Sd	M	tour62	*u*	—	438	1379	1805	4.189	10.633	12.434
Se	M	boor11	*u*	—	464	1276	1715	4.421	10.112	12.096
Se	M	boor21	*u*	—	451	1302	1689	4.305	10.247	11.994
Se	M	boor33	*u*	—	477	1353	1715	4.535	10.505	12.096
Se	M	tour31	*u*	—	477	1276	1689	4.535	10.112	11.994

Se	M	tour44	*u*	—	477	1263	1740	4.535	10.043	12.192
Se	M	tour62	*u*	—	490	1341	1740	4.649	10.445	12.192
Sf	M	boor11	*u*	—	382	1185	1603	3.682	9.618	11.645
Sf	M	boor21	*u*	—	354	1231	1520	3.424	9.872	11.288
Sf	M	boor33	*u*	—	418	1297	1638	4.010	10.221	11.789
Sf	M	tour31	*u*	—	413	1257	1599	3.964	10.011	11.628
Sf	M	tour44	*u*	—	373	1263	1656	3.600	10.043	11.862
Sf	M	tour62	*u*	—	373	1207	1576	3.600	9.741	11.531
S1	F	core43	—	k	644	1405	1818	5.943	10.759	12.481
S1	F	core45	—	k	773	1431	2076	6.942	10.882	13.344
S1	F	core52	—	k	631	1482	1985	5.838	11.118	13.055
S1	F	door10	—	d	554	1470	2037	5.200	11.063	13.222
S1	F	door19	—	d	786	1457	2037	7.039	11.004	13.222
S1	F	door20	—	d	477	1663	2192	4.535	11.891	13.691
S1	F	gore01	—	g	709	1444	1908	6.456	10.943	12.798
S1	F	gore36	—	g	657	1379	2114	6.047	10.633	13.460
S1	F	gore69	—	g	541	1470	1869	5.089	11.063	12.663
S1	F	pore18	—	p	606	1495	1998	5.634	11.177	13.098
S1	F	pore64	—	p	722	1611	2024	6.557	11.678	13.181
S1	F	pore69	—	p	580	1495	1960	5.418	11.177	12.973
S2	F	core43	—	k	386	1508	2127	3.719	11.235	13.499
S2	F	core45	—	k	992	1560	2101	8.459	11.463	13.421
S2	F	core52	—	k	902	1431	2101	7.863	10.882	13.421
S2	F	door10	—	d	541	1379	2114	5.089	10.633	13.460
S2	F	door19	—	d	618	1418	1882	5.732	10.821	12.708
S2	F	door20	—	d	606	1444	2089	5.634	10.943	13.384
S2	F	gore01	—	g	451	1457	2114	4.305	11.004	13.460
S2	F	gore36	—	g	567	1470	1998	5.309	11.063	13.098
S2	F	gore69	—	g	580	1495	2050	5.418	11.177	13.263
S2	F	pore18	—	p	490	1418	2089	4.649	10.821	13.384
S2	F	pore64	—	p	657	1457	2063	6.047	11.004	13.304
S2	F	pore69	—	p	554	1457	2024	5.200	11.004	13.181
S3	F	core43	—	k	528	1586	2140	4.978	11.574	13.538
S3	F	core45	—	k	683	1611	2179	6.253	11.678	13.653
S3	F	core52	—	k	477	1611	2127	4.535	11.678	13.499
S3	F	door10	—	d	631	1573	2127	5.838	11.518	13.499
S3	F	door19	—	d	696	1573	2101	6.355	11.518	13.421
S3	F	door20	—	d	851	1599	2153	7.508	11.628	13.577
S3	F	gore01	—	g	876	1624	2140	7.684	11.732	13.538
S3	F	gore36	—	g	1018	1611	2127	8.625	11.678	13.499
S3	F	gore69	—	g	528	1586	1882	4.978	11.574	12.708
S3	F	pore18	—	p	735	1560	2076	6.656	11.463	13.344
S3	F	pore64	—	p	618	1624	2217	5.732	11.732	13.762
S3	F	pore69	—	p	606	1573	1831	5.634	11.518	12.528
S4	F	core43	—	k	386	1328	1702	3.719	10.380	12.045
S4	F	core45	—	k	477	1637	1934	4.535	11.785	12.886
S4	F	core52	—	k	386	1418	1805	3.719	10.821	12.434
S4	F	door10	—	d	412	1263	1676	3.955	10.043	11.943
S4	F	door19	—	d	361	1353	1727	3.489	10.505	12.142
S4	F	door20	—	d	361	1521	1818	3.489	11.293	12.481
S4	F	gore01	—	g	425	1250	1573	4.073	9.974	11.518
S4	F	gore36	—	g	438	1470	1766	4.189	11.063	12.290
S4	F	gore69	—	g	412	1470	1766	3.955	11.063	12.290
S4	F	pore18	—	p	361	1379	1779	3.489	10.633	12.338

S4	F	pore64	—	p	348	1366	1676	3.369	10.570	11.943
S4	F	pore69	—	p	283	1547	1941	2.759	11.407	12.910
S5	F	core43	—	k	567	1779	2824	5.309	12.338	15.245
S5	F	core45	—	k	606	1805	2746	5.634	12.434	15.078
S5	F	core52	—	k	657	1753	2862	6.047	12.241	15.324
S5	F	door10	—	d	722	1715	2630	6.557	12.096	14.818
S5	F	door19	—	d	606	1895	2785	5.634	12.753	15.162
S5	F	door20	—	d	593	1908	2785	5.526	12.798	15.162
S5	F	gore01	—	g	618	1818	2682	5.732	12.481	14.936
S5	F	gore36	—	g	477	1766	2720	4.535	12.290	15.021
S5	F	gore69	—	g	528	1766	2862	4.978	12.290	15.324
S5	F	pore18	—	p	567	1856	2862	5.309	12.617	15.324
S5	F	pore64	—	p	631	1740	2798	5.838	12.192	15.190
S5	F	pore69	—	p	541	1779	2785	5.089	12.338	15.162
S6	F	core43	—	k	361	1535	2429	3.489	11.354	14.332
S6	F	core45	—	k	419	1545	2326	4.019	11.398	14.063
S6	F	core52	—	k	434	1528	2456	4.154	11.324	14.400
S6	F	door10	—	d	424	1515	2433	4.064	11.266	14.342
S6	F	door19	—	d	498	1841	2445	4.719	12.564	14.373
S6	F	door20	—	d	461	1570	2508	4.394	11.506	14.529
S6	F	gore01	—	g	433	1541	2659	4.145	11.381	14.884
S6	F	gore36	—	g	388	1303	2402	3.737	10.252	14.263
S6	F	gore69	—	g	500	1589	2572	4.736	11.586	14.683
S6	F	pore18	—	p	437	1635	2424	4.180	11.777	14.320
S6	F	pore64	—	p	632	1711	2344	5.846	12.080	14.112
S6	F	pore69	—	p	451	1488	2445	4.305	11.145	14.373
S7	F	core43	—	k	344	1352	1853	3.332	10.500	12.607
S7	F	core45	—	k	484	1416	1823	4.597	10.812	12.499
S7	F	core52	—	k	381	1496	1864	3.673	11.181	12.646
S7	F	door10	—	d	419	1331	1732	4.019	10.395	12.161
S7	F	door19	—	d	435	1351	1995	4.163	10.495	13.088
S7	F	door20	—	d	450	1424	2383	4.296	10.849	14.214
S7	F	gore01	—	g	345	1347	2128	3.341	10.475	13.502
S7	F	gore36	—	g	381	1348	1840	3.673	10.480	12.560
S7	F	gore69	—	g	465	1247	1794	4.430	9.958	12.394
S7	F	pore18	—	p	473	1359	2126	4.500	10.535	13.496
S7	F	pore64	—	p	429	1479	1999	4.109	11.105	13.101
S7	F	pore69	—	p	523	1424	2279	4.935	10.849	13.936
S8	F	core43	—	k	445	1465	2008	4.252	11.041	13.130
S8	F	core45	—	k	508	1366	2013	4.806	10.570	13.146
S8	F	core52	—	k	523	1317	1844	4.935	10.324	12.575
S8	F	door10	—	d	538	1379	1942	5.064	10.633	12.913
S8	F	door19	—	d	497	1588	2089	4.710	11.582	13.384
S8	F	door20	—	d	508	1589	1984	4.806	11.586	13.052
S8	F	gore01	—	g	518	1624	1996	4.892	11.732	13.091
S8	F	gore36	—	g	547	1403	1938	5.140	10.749	12.900
S8	F	gore69	—	g	555	1419	2162	5.208	10.826	13.603
S8	F	pore18	—	p	440	1681	2150	4.207	11.962	13.568
S8	F	pore64	—	p	509	1329	1773	4.815	10.385	12.316
S8	F	pore69	—	p	582	1446	2041	5.435	10.953	13.235
S9	F	core43	—	k	565	1558	1939	5.293	11.454	12.903
S9	F	core45	—	k	478	1560	2119	4.544	11.463	13.475
S9	F	core52	—	k	551	1447	1974	5.174	10.957	13.019
S9	F	door10	—	d	388	1537	1791	3.737	11.363	12.383

S9	F	door19	—	d	509	1567	2069	4.815	11.493	13.323
S9	F	door20	—	d	480	1674	2224	4.562	11.935	13.782
S9	F	gore01	—	g	459	1589	2175	4.376	11.586	13.641
S9	F	gore36	—	g	449	1350	2200	4.288	10.490	13.714
S9	F	gore69	—	g	542	1472	2090	5.098	11.073	13.387
S9	F	pore18	—	p	508	1599	2031	4.806	11.628	13.203
S9	F	pore64	—	p	445	1512	1996	4.252	11.253	13.091
S9	F	pore69	—	p	540	1539	2057	5.081	11.372	13.285
Sa	M	core43	—	k	412	1212	1611	3.955	9.768	11.678
Sa	M	core45	—	k	412	1250	1637	3.955	9.974	11.785
Sa	M	core52	—	k	335	1302	1740	3.248	10.247	12.192
Sa	M	door10	—	d	373	1276	1766	3.600	10.112	12.290
Sa	M	door19	—	d	399	1263	1650	3.837	10.043	11.838
Sa	M	door20	—	d	373	1237	1753	3.600	9.904	12.241
Sa	M	gore01	—	g	412	1263	1676	3.955	10.043	11.943
Sa	M	gore36	—	g	412	1263	1650	3.955	10.043	11.838
Sa	M	gore69	—	g	412	1263	1676	3.955	10.043	11.943
Sa	M	pore18	—	p	412	1186	1715	3.955	9.624	12.096
Sa	M	pore64	—	p	386	1315	1753	3.719	10.314	12.241
Sa	M	pore69	—	p	412	1225	1740	3.955	9.839	12.192
Sb	M	core43	—	k	335	1366	1740	3.248	10.570	12.192
Sb	M	core45	—	k	438	1237	1740	4.189	9.904	12.192
Sb	M	core52	—	k	425	1212	1650	4.073	9.768	11.838
Sb	M	door10	—	d	399	1237	1831	3.837	9.904	12.528
Sb	M	door19	—	d	425	1263	1831	4.073	10.043	12.528
Sb	M	door20	—	d	425	1405	1831	4.073	10.759	12.528
Sb	M	gore01	—	g	490	1379	1727	4.649	10.633	12.142
Sb	M	gore36	—	g	438	1237	1740	4.189	9.904	12.192
Sb	M	gore69	—	g	438	1250	1766	4.189	9.974	12.290
Sb	M	pore18	—	p	412	1263	1753	3.955	10.043	12.241
Sb	M	pore64	—	p	425	1250	1689	4.073	9.974	11.994
Sb	M	pore69	—	p	399	1225	1599	3.837	9.839	11.628
Sc	M	core43	—	k	464	1250	1702	4.421	9.974	12.045
Sc	M	core45	—	k	464	1237	1715	4.421	9.904	12.096
Sc	M	core52	—	k	464	1418	1792	4.421	10.821	12.386
Sc	M	door10	—	d	438	1431	1844	4.189	10.882	12.575
Sc	M	door19	—	d	438	1366	1779	4.189	10.570	12.338
Sc	M	door20	—	d	425	1366	1740	4.073	10.570	12.192
Sc	M	gore01	—	g	438	1328	1779	4.189	10.380	12.338
Sc	M	gore36	—	g	451	1353	1818	4.305	10.505	12.481
Sc	M	gore69	—	g	451	1353	1844	4.305	10.505	12.575
Sc	M	pore18	—	p	477	1315	1818	4.535	10.314	12.481
Sc	M	pore64	—	p	438	1366	1856	4.189	10.570	12.617
Sc	M	pore69	—	p	477	1366	1831	4.535	10.570	12.528
Sd	M	core43	—	k	451	1392	1805	4.305	10.696	12.434
Sd	M	core45	—	k	477	1431	1779	4.535	10.882	12.338
Sd	M	core52	—	k	464	1263	1895	4.421	10.043	12.753
Sd	M	door10	—	d	477	1341	1805	4.535	10.445	12.434
Sd	M	door19	—	d	490	1353	1844	4.649	10.505	12.575
Sd	M	door20	—	d	502	1392	1779	4.754	10.696	12.338
Sd	M	gore01	—	g	438	1341	1753	4.189	10.445	12.241
Sd	M	gore36	—	g	490	1328	1766	4.649	10.380	12.290
Sd	M	gore69	—	g	464	1366	1753	4.421	10.570	12.241
Sd	M	pore18	—	p	464	1328	1779	4.421	10.380	12.338

Sd	M	pore64	—	p	438	1353	1740	4.189	10.505	12.192
Sd	M	pore69	—	p	490	1276	1779	4.649	10.112	12.338
Se	M	core43	—	k	464	1276	1676	4.421	10.112	11.943
Se	M	core45	—	k	502	1353	1715	4.754	10.505	12.096
Se	M	core52	—	k	515	1315	1740	4.866	10.314	12.192
Se	M	door10	—	d	502	1263	1727	4.754	10.043	12.142
Se	M	door19	—	d	438	1302	1740	4.189	10.247	12.192
Se	M	door20	—	d	477	1289	1779	4.535	10.180	12.338
Se	M	gore01	—	g	541	1199	1611	5.089	9.696	11.678
Se	M	gore36	—	g	477	1328	1727	4.535	10.380	12.142
Se	M	gore69	—	g	502	1392	1766	4.754	10.696	12.290
Se	M	pore18	—	p	515	1237	1650	4.866	9.904	11.838
Se	M	pore64	—	p	451	1302	1702	4.305	10.247	12.045
Se	M	pore69	—	p	515	1341	1727	4.866	10.445	12.142
Sf	M	core43	—	k	437	1189	1470	4.180	9.641	11.063
Sf	M	core45	—	k	460	1065	1467	4.385	8.916	11.050
Sf	M	core52	—	k	418	1167	1477	4.010	9.517	11.095
Sf	M	door10	—	d	444	1252	1641	4.243	9.985	11.802
Sf	M	door19	—	d	399	1299	1644	3.837	10.232	11.814
Sf	M	door20	—	d	412	1194	1552	3.955	9.669	11.428
Sf	M	gore01	—	g	434	1203	1573	4.154	9.718	11.518
Sf	M	gore36	—	g	442	1227	1560	4.225	9.850	11.463
Sf	M	gore69	—	g	439	1151	1547	4.198	9.425	11.407
Sf	M	pore18	—	p	391	1157	1517	3.765	9.460	11.275
Sf	M	pore64	—	p	419	1182	1627	4.019	9.601	11.744
Sf	M	pore69	—	p	425	1166	1621	4.073	9.511	11.720

Table B.3. Initial/ɹ/data. "Hi/Lo" represents the categories used in the bimodal analysis of the women's F3 data. "AV" stands for "adjacent vowel". "DC" stands for "distal consonant". "Hz" (Hertz) and "Bk" (Bark) are the units used in the formant columns.

Spkr	*Sex*	*Hi/Lo*	*Token*	*AV*	*DC*	*F1Hz*	*F2Hz*	*F3Hz*	*F1Bk*	*F2Bk*	*F3Bk*
S1	F	HiF3	reap15	i	—	283	1121	2514	2.759	9.251	14.544
S1	F	HiF3	reap24	i	—	257	992	2359	2.512	8.459	14.151
S1	F	HiF3	reap53	i	—	335	1121	2217	3.248	9.251	13.762
S1	F	HiF3	reed42	i	—	270	1160	2321	2.636	9.477	14.050
S1	F	HiF3	reed53	i	—	270	1108	2334	2.636	9.175	14.085
S1	F	HiF3	reed59	i	—	322	1070	2243	3.126	8.947	13.836
S2	F	HiF3	reap15	i	—	283	1147	2295	2.759	9.402	13.980
S2	F	HiF3	reap24	i	—	245	1199	2385	2.397	9.696	14.219
S2	F	HiF3	reap53	i	—	283	1083	2295	2.759	9.026	13.980
S2	F	HiF3	reed42	i	—	296	1225	2462	2.882	9.839	14.415
S2	F	HiF3	reed53	i	—	322	1160	2153	3.126	9.477	13.577
S2	F	HiF3	reed59	i	—	296	1289	2295	2.882	10.180	13.980
S3	F	HiF3	reap15	i	—	270	1276	1882	2.636	10.112	12.708
S3	F	HiF3	reap24	i	—	283	1173	2319	2.759	9.551	14.045
S3	F	HiF3	reap53	i	—	296	1225	2061	2.882	9.839	13.298
S3	F	HiF3	reed42	i	—	245	1134	1891	2.397	9.327	12.740
S3	F	HiF3	reed53	i	—	270	1186	2139	2.636	9.624	13.535
S3	F	HiF3	reed59	i	—	283	1225	2335	2.759	9.839	14.088
S4	F	LoF3	reap15	i	—	245	1212	1598	2.397	9.768	11.624
S4	F	LoF3	reap24	i	—	348	1289	2058	3.369	10.180	13.288
S4	F	LoF3	reap53	i	—	296	1160	1715	2.882	9.477	12.096
S4	F	LoF3	reed42	i	—	480	1495	1972	4.562	11.177	13.013

S4	F	LoF3	reed53	i	—	322	1134	2161	3.126	9.327	13.600
S4	F	LoF3	reed59	i	—	309	1315	1641	3.005	10.314	11.802
S5	F	HiF3	reap15	i	—	283	1470	2514	2.759	11.063	14.544
S5	F	HiF3	reap24	i	—	361	1379	2566	3.489	10.633	14.669
S5	F	HiF3	reap53	i	—	348	1611	2682	3.369	11.678	14.936
S5	F	HiF3	reed42	i	—	322	1560	2540	3.126	11.463	14.606
S5	F	HiF3	reed53	i	—	348	1560	2527	3.369	11.463	14.575
S5	F	HiF3	reed59	i	—	283	1689	2759	2.759	11.994	15.106
S6	F	HiF3	reap15	i	—	445	1101	2000	4.252	9.133	13.104
S6	F	HiF3	reap24	i	—	294	1121	2420	2.863	9.251	14.309
S6	F	HiF3	reed42	i	—	318	1388	2562	3.089	10.677	14.659
S6	F	HiF3	reed53	i	—	315	998	2546	3.061	8.498	14.621
S6	F	HiF3	reed59	i	—	230	1327	2466	2.253	10.375	14.425
S7	F	LoF3	reap15	i	—	226	1080	2115	2.214	9.007	13.463
S7	F	LoF3	reap24	i	—	308	1320	2260	2.995	10.339	13.883
S7	F	LoF3	reap53	i	—	259	1030	2211	2.531	8.700	13.745
S7	F	LoF3	reed42	i	—	329	1202	1852	3.192	9.713	12.603
S7	F	LoF3	reed53	i	—	282	1221	2203	2.750	9.817	13.722
S7	F	LoF3	reed59	i	—	259	1270	2153	2.531	10.080	13.577
S8	F	LoF3	reap15	i	—	235	1237	1744	2.301	9.904	12.207
S8	F	LoF3	reap24	i	—	380	1165	1688	3.664	9.505	11.990
S8	F	LoF3	reap53	i	—	285	1393	1888	2.778	10.701	12.729
S8	F	LoF3	reed42	i	—	312	1264	2019	3.033	10.049	13.165
S8	F	LoF3	reed52	i	—	230	1352	1798	2.253	10.500	12.408
S8	F	LoF3	reed59	i	—	243	1187	1845	2.378	9.629	12.578
S9	F	LoF3	reap15	i	—	309	1115	1622	3.005	9.216	11.724
S9	F	LoF3	reap24	i	—	373	1337	1754	3.600	10.425	12.245
S9	F	LoF3	reap53	i	—	376	1558	2146	3.627	11.454	13.556
S9	F	LoF3	reed42	i	—	275	1301	1841	2.683	10.242	12.564
S9	F	LoF3	reed53	i	—	345	1495	2013	3.341	11.177	13.146
S9	F	LoF3	reed59	i	—	417	1352	1884	4.001	10.500	12.715
Sa	M	MF3	reap15	i	—	257	1044	1420	2.512	8.787	10.831
Sa	M	MF3	reap24	i	—	283	1031	1508	2.759	8.706	11.235
Sa	M	MF3	reap53	i	—	232	988	1293	2.272	8.434	10.201
Sa	M	MF3	reed42	i	—	257	1044	1560	2.512	8.787	11.463
Sa	M	MF3	reed53	i	—	283	1070	1444	2.759	8.947	10.943
Sa	M	MF3	reed59	i	—	270	1062	1492	2.636	8.898	11.163
Sb	M	MF3	reap15	i	—	283	1134	1586	2.759	9.327	11.574
Sb	M	MF3	reap24	i	—	283	1080	1689	2.759	9.007	11.994
Sb	M	MF3	reap53	i	—	283	1134	1637	2.759	9.327	11.785
Sb	M	MF3	reed42	i	—	257	1353	1586	2.512	10.505	11.574
Sb	M	MF3	reed53	i	—	283	1147	1676	2.759	9.402	11.943
Sb	M	MF3	reed59	i	—	283	1160	1766	2.759	9.477	12.290
Sc	M	MF3	reap15	i	—	309	1173	1547	3.005	9.551	11.407
Sc	M	MF3	reap24	i	—	283	1070	1521	2.759	8.947	11.293
Sc	M	MF3	reap53	i	—	283	1134	1727	2.759	9.327	12.142
Sc	M	MF3	reed42	i	—	283	1134	1676	2.759	9.327	11.943
Sc	M	MF3	reed53	i	—	296	1199	1663	2.882	9.696	11.891
Sc	M	MF3	reed59	i	—	283	1096	1702	2.759	9.103	12.045
Sd	M	MF3	reap15	i	—	309	1470	1947	3.005	11.063	12.930
Sd	M	MF3	reap24	i	—	296	915	1457	2.882	7.951	11.004
Sd	M	MF3	reap53	i	—	309	1018	1470	3.005	8.625	11.063
Sd	M	MF3	reed42	i	—	309	992	1431	3.005	8.459	10.882
Sd	M	MF3	reed53	i	—	283	1083	1482	2.759	9.026	11.118

Sd	M	MF3	reed59	i	—	283	1121	1586	2.759	9.251	11.574
Se	M	MF3	reap15	i	—	335	980	1573	3.248	8.382	11.518
Se	M	MF3	reap24	i	—	322	1005	1611	3.126	8.542	11.678
Se	M	MF3	reap53	i	—	335	902	1457	3.248	7.863	11.004
Se	M	MF3	reed42	i	—	309	1018	1560	3.005	8.625	11.463
Se	M	MF3	reed53	i	—	322	1044	1663	3.126	8.787	11.891
Se	M	MF3	reed59	i	—	296	1031	1586	2.882	8.706	11.574
Sf	M	MF3	reap15	i	—	269	867	1477	2.626	7.621	11.095
Sf	M	MF3	reap24	i	—	299	989	1428	2.910	8.440	10.868
Sf	M	MF3	reap53	i	—	277	838	1354	2.702	7.416	10.510
Sf	M	MF3	reed42	i	—	282	932	1525	2.750	8.066	11.310
Sf	M	MF3	reed53	i	—	237	754	1288	2.320	6.800	10.175
Sf	M	MF3	reed59	i	—	239	733	1222	2.339	6.641	9.823
S1	F	HiF3	rid03	ɪ	d	335	1147	1921	3.248	9.402	12.842
S1	F	HiF3	rid08	ɪ	d	309	1044	2243	3.005	8.787	13.836
S1	F	HiF3	rid68	ɪ	d	270	1057	2398	2.636	8.867	14.253
S1	F	HiF3	rip15	ɪ	p	270	1018	2192	2.636	8.625	13.691
S1	F	HiF3	rip27	ɪ	p	270	1005	2308	2.636	8.542	14.015
S1	F	HiF3	rip49	ɪ	p	232	1134	2372	2.272	9.327	14.185
S2	F	HiF3	rid03	ɪ	d	232	1160	2217	2.272	9.477	13.762
S2	F	HiF3	rid08	ɪ	d	257	1057	2166	2.512	8.867	13.615
S2	F	HiF3	rid68	ɪ	d	257	1096	2346	2.512	9.103	14.117
S2	F	HiF3	rip15	ɪ	p	270	1108	2256	2.636	9.175	13.872
S2	F	HiF3	rip27	ɪ	p	245	1302	2359	2.397	10.247	14.151
S2	F	HiF3	rip49	ɪ	p	270	1341	2437	2.636	10.445	14.353
S3	F	HiF3	rid08	ɪ	d	335	1199	2076	3.248	9.696	13.344
S3	F	HiF3	rid68	ɪ	d	283	1276	2061	2.759	10.112	13.298
S3	F	HiF3	rig07	ɪ	d	245	1237	1792	2.397	9.904	12.386
S3	F	HiF3	rip27	ɪ	p	296	1096	2359	2.882	9.103	14.151
S3	F	HiF3	rip49	ɪ	p	245	1237	2021	2.397	9.904	13.172
S3	F	HiF3	ritt09	ɪ	p	361	1199	2101	3.489	9.696	13.421
S4	F	LoF3	rid03	ɪ	d	322	1160	1454	3.126	9.477	10.990
S4	F	LoF3	rid08	ɪ	d	335	1199	1880	3.248	9.696	12.702
S4	F	LoF3	rid68	ɪ	d	335	1366	1740	3.248	10.570	12.192
S4	F	LoF3	rip15	ɪ	p	386	1431	1796	3.719	10.882	12.401
S4	F	LoF3	rip27	ɪ	p	412	1405	1818	3.955	10.759	12.481
S4	F	LoF3	rip49	ɪ	p	322	1173	1637	3.126	9.551	11.785
S5	F	HiF3	rid03	ɪ	d	245	1560	2488	2.397	11.463	14.480
S5	F	HiF3	rid08	ɪ	d	361	1599	2321	3.489	11.628	14.050
S5	F	HiF3	rid68	ɪ	d	335	1534	2695	3.248	11.350	14.965
S5	F	HiF3	rip15	ɪ	p	584	1560	2771	5.452	11.463	15.132
S5	F	HiF3	rip27	ɪ	p	374	1801	2746	3.609	12.419	15.078
S5	F	HiF3	rip49	ɪ	p	373	1740	2849	3.600	12.192	15.297
S6	F	HiF3	reap53	ɪ	—	355	1173	2386	3.434	9.551	14.222
S6	F	HiF3	rid03	ɪ	d	395	1546	2673	3.801	11.402	14.916
S6	F	HiF3	rid08	ɪ	d	346	1278	2463	3.350	10.122	14.418
S6	F	HiF3	rid68	ɪ	d	366	1133	2508	3.535	9.321	14.529
S6	F	HiF3	rip15	ɪ	p	399	1129	2218	3.837	9.298	13.765
S6	F	HiF3	rip27	ɪ	p	270	1128	2562	2.636	9.292	14.659
S6	F	HiF3	rip49	ɪ	p	373	1213	2315	3.600	9.774	14.034
S7	F	LoF3	rid03	ɪ	d	327	1137	2319	3.173	9.345	14.045
S7	F	LoF3	rid08	ɪ	d	305	1107	2209	2.967	9.169	13.739
S7	F	LoF3	rid68	ɪ	d	333	1158	2452	3.229	9.466	14.390
S7	F	LoF3	rip15	ɪ	p	291	1063	2346	2.835	8.904	14.117

S7	F	LoF3	rip27	I	p	345	1162	2395	3.341	9.488	14.245
S7	F	LoF3	rip49	I	p	316	932	2369	3.070	8.066	14.177
S8	F	LoF3	rid03	I	d	360	1201	1602	3.480	9.707	11.641
S8	F	LoF3	rid08	I	d	382	1104	1649	3.682	9.151	11.834
S8	F	LoF3	rid68	I	d	328	1035	1951	3.183	8.731	12.943
S8	F	LoF3	rip15	I	p	217	953	1668	2.128	8.205	11.911
S8	F	LoF3	rip27	I	p	402	1064	1697	3.865	8.910	12.025
S8	F	LoF3	rip49	I	p	293	1105	1819	2.854	9.157	12.485
S9	F	LoF3	rid03	I	d	328	1169	1620	3.183	9.528	11.716
S9	F	LoF3	rid08	I	d	366	1337	2093	3.535	10.425	13.396
S9	F	LoF3	rid68	I	d	417	1395	1798	4.001	10.711	12.408
S9	F	LoF3	rip15	I	p	414	1305	1589	3.973	10.263	11.586
S9	F	LoF3	rip27	I	p	373	1323	1783	3.600	10.355	12.353
S9	F	LoF3	rip49	I	p	287	1323	1769	2.797	10.355	12.301
Sa	M	MF3	rid03	I	d	232	1018	1489	2.272	8.625	11.150
Sa	M	MF3	rid08	I	d	270	1108	1670	2.636	9.175	11.919
Sa	M	MF3	rid68	I	d	219	1049	1646	2.147	8.818	11.822
Sa	M	MF3	rip15	I	p	270	980	1544	2.636	8.382	11.394
Sa	M	MF3	rip27	I	p	245	992	1511	2.397	8.459	11.248
Sa	M	MF3	rip49	I	p	270	1044	1611	2.636	8.787	11.678
Sb	M	MF3	rid03	I	d	257	1405	1753	2.512	10.759	12.241
Sb	M	MF3	rid08	I	d	232	1208	1715	2.272	9.746	12.096
Sb	M	MF3	rid68	I	d	296	1289	1650	2.882	10.180	11.838
Sb	M	MF3	rip15	I	p	373	1379	1727	3.600	10.633	12.142
Sb	M	MF3	rip27	I	p	257	1225	1663	2.512	9.839	11.891
Sb	M	MF3	rip49	I	p	283	1212	1689	2.759	9.768	11.994
Sc	M	MF3	rid03	I	d	309	1121	1663	3.005	9.251	11.891
Sc	M	MF3	rid08	I	d	296	1147	1663	2.882	9.402	11.891
Sc	M	MF3	rid68	I	d	270	1083	1676	2.636	9.026	11.943
Sc	M	MF3	rip15	I	p	296	1134	1560	2.882	9.327	11.463
Sc	M	MF3	rip27	I	p	334	902	1432	3.239	7.863	10.887
Sc	M	MF3	rip49	I	p	283	1031	1560	2.759	8.706	11.463
Sd	M	MF3	rid03	I	d	270	1173	1676	2.636	9.551	11.943
Sd	M	MF3	rid08	I	d	270	1276	1560	2.636	10.112	11.463
Sd	M	MF3	rid68	I	d	296	1005	1470	2.882	8.542	11.063
Sd	M	MF3	rip15	I	p	270	954	1470	2.636	8.212	11.063
Sd	M	MF3	rip27	I	p	322	992	1547	3.126	8.459	11.407
Sd	M	MF3	rip49	I	p	283	1018	1508	2.759	8.625	11.235
Se	M	MF3	rid03	I	d	309	820	1197	3.005	7.287	9.685
Se	M	MF3	rid08	I	d	296	1083	1599	2.882	9.026	11.628
Se	M	MF3	rid68	I	d	335	1134	1689	3.248	9.327	11.994
Se	M	MF3	rip15	I	p	322	863	1366	3.126	7.593	10.570
Se	M	MF3	rip27	I	p	322	967	1599	3.126	8.297	11.628
Se	M	MF3	rip49	I	p	335	954	1637	3.248	8.212	11.785
Sf	M	MF3	rid03	I	d	233	1113	1635	2.282	9.204	11.777
Sf	M	MF3	rid08	I	d	294	843	1374	2.863	7.452	10.609
Sf	M	MF3	rid68	I	d	293	768	1497	2.854	6.905	11.186
Sf	M	MF3	rip15	I	p	243	891	1462	2.378	7.787	11.027
Sf	M	MF3	rip27	I	p	345	1323	1668	3.341	10.355	11.911
Sf	M	MF3	rip49	I	p	293	828	1398	2.854	7.344	10.725
S1	F	HiF3	raid22	e	—	296	992	2076	2.882	8.459	13.344
S1	F	HiF3	raid44	e	—	309	1031	1985	3.005	8.706	13.055
S1	F	HiF3	raid55	e	—	309	1134	2256	3.005	9.327	13.872
S1	F	HiF3	rape08	e	—	232	1121	2127	2.272	9.251	13.499

S1	F	HiF3	rape24	e	—	283	1005	2385	2.759	8.542	14.219
S1	F	HiF3	rape55	e	—	296	1096	2398	2.882	9.103	14.253
S2	F	HiF3	raid22	e	—	257	1134	2295	2.512	9.327	13.980
S2	F	HiF3	raid44	e	—	296	1108	2282	2.882	9.175	13.944
S2	F	HiF3	raid55	e	—	296	1121	2334	2.882	9.251	14.085
S2	F	HiF3	rape08	e	—	180	1263	2166	1.769	10.043	13.615
S2	F	HiF3	rape24	e	—	309	1160	2321	3.005	9.477	14.050
S2	F	HiF3	rape55	e	—	296	1147	2411	2.882	9.402	14.286
S3	F	HiF3	raid22	e	—	309	1237	2145	3.005	9.904	13.553
S3	F	HiF3	raid44	e	—	245	1184	2143	2.397	9.613	13.547
S3	F	HiF3	raid55	e	—	283	1186	2392	2.759	9.624	14.237
S3	F	HiF3	rape08	e	—	219	1186	1779	2.147	9.624	12.338
S3	F	HiF3	rape24	e	—	270	1173	2022	2.636	9.551	13.175
S3	F	HiF3	rape55	e	—	309	1147	1405	3.005	9.402	10.759
S4	F	LoF3	raid22	e	—	386	1237	1611	3.719	9.904	11.678
S4	F	LoF3	raid44	e	—	270	1061	1628	2.636	8.892	11.749
S4	F	LoF3	raid55	e	—	309	1108	1663	3.005	9.175	11.891
S4	F	LoF3	rape08	e	—	386	1212	1856	3.719	9.768	12.617
S4	F	LoF3	rape24	e	—	348	1328	1740	3.369	10.380	12.192
S4	F	LoF3	rape55	e	—	399	1818	2450	3.837	12.481	14.385
S5	F	HiF3	raid22	e	—	348	1508	2437	3.369	11.235	14.353
S5	F	HiF3	raid44	e	—	456	1551	2516	4.350	11.424	14.548
S5	F	HiF3	raid55	e	—	451	1547	2424	4.305	11.407	14.320
S5	F	HiF3	rape08	e	—	477	1599	2617	4.535	11.628	14.788
S5	F	HiF3	rape24	e	—	399	1405	2462	3.837	10.759	14.415
S5	F	HiF3	rape55	e	—	399	1470	2579	3.837	11.063	14.699
S6	F	HiF3	raid22	e	—	338	1272	2317	3.276	10.091	14.039
S6	F	HiF3	raid44	e	—	385	1137	2449	3.710	9.345	14.383
S6	F	HiF3	raid55	e	—	374	1131	2368	3.609	9.310	14.175
S6	F	HiF3	rape08	e	—	349	1127	2321	3.378	9.286	14.050
S6	F	HiF3	rape24	e	—	348	1115	2190	3.369	9.216	13.685
S6	F	HiF3	rape55	e	—	315	1385	2248	3.061	10.663	13.850
S7	F	LoF3	raid22	e	—	308	1095	2264	2.995	9.097	13.894
S7	F	LoF3	raid44	e	—	337	934	2138	3.267	8.079	13.532
S7	F	LoF3	raid55	e	—	349	1112	1607	3.378	9.198	11.662
S7	F	LoF3	rape08	e	—	241	1042	2126	2.359	8.775	13.496
S7	F	LoF3	rape24	e	—	254	1088	2462	2.483	9.056	14.415
S7	F	LoF3	rape55	e	—	293	1024	1994	2.854	8.663	13.085
S8	F	LoF3	raid22	e	—	338	964	1763	3.276	8.278	12.279
S8	F	LoF3	raid44	e	—	338	932	1600	3.276	8.066	11.633
S8	F	LoF3	raid55	e	—	278	1012	1941	2.712	8.587	12.910
S8	F	LoF3	rape08	e	—	314	1066	1765	3.051	8.922	12.286
S8	F	LoF3	rape24	e	—	316	1021	1682	3.070	8.644	11.966
S8	F	LoF3	rape55	e	—	318	1160	1937	3.089	9.477	12.896
S9	F	LoF3	raid22	e	—	367	1245	1686	3.544	9.947	11.982
S9	F	LoF3	raid44	e	—	445	1366	1869	4.252	10.570	12.663
S9	F	LoF3	raid55	e	—	341	1413	1939	3.304	10.797	12.903
S9	F	LoF3	rape08	e	—	358	1274	1838	3.461	10.101	12.553
S9	F	LoF3	rape24	e	—	388	1237	1826	3.737	9.904	12.510
S9	F	LoF3	rape55	e	—	417	1280	1812	4.001	10.133	12.460
Sa	M	MF3	raid22	e	—	245	980	1350	2.397	8.382	10.490
Sa	M	MF3	raid44	e	—	270	967	1560	2.636	8.297	11.463
Sa	M	MF3	raid55	e	—	270	1044	1667	2.636	8.787	11.907
Sa	M	MF3	rape08	e	—	270	1083	1521	2.636	9.026	11.293

Sa	M	MF3	rape24	e	—	257	1005	1617	2.512	8.542	11.703
Sa	M	MF3	rape55	e	—	257	992	1482	2.512	8.459	11.118
Sb	M	MF3	raid22	e	—	283	1470	1805	2.759	11.063	12.434
Sb	M	MF3	raid44	e	—	296	1263	1547	2.882	10.043	11.407
Sb	M	MF3	raid55	e	—	322	1147	1611	3.126	9.402	11.678
Sb	M	MF3	rape08	e	—	309	1005	1495	3.005	8.542	11.177
Sb	M	MF3	rape24	e	—	296	1225	1637	2.882	9.839	11.785
Sb	M	MF3	rape55	e	—	335	1328	1689	3.248	10.380	11.994
Sc	M	MF3	raid22	e	—	283	1031	1444	2.759	8.706	10.943
Sc	M	MF3	raid44	e	—	296	1173	1534	2.882	9.551	11.350
Sc	M	MF3	raid55	e	—	296	1044	1470	2.882	8.787	11.063
Sc	M	MF3	rape08	e	—	283	1134	1457	2.759	9.327	11.004
Sc	M	MF3	rape24	e	—	309	1031	1521	3.005	8.706	11.293
Sc	M	MF3	rape55	e	—	296	1147	1547	2.882	9.402	11.407
Sd	M	MF3	raid22	e	—	270	941	1405	2.636	8.126	10.759
Sd	M	MF3	raid44	e	—	309	980	1482	3.005	8.382	11.118
Sd	M	MF3	raid55	e	—	309	967	1482	3.005	8.297	11.118
Sd	M	MF3	rape08	e	—	270	928	1495	2.636	8.039	11.177
Sd	M	MF3	rape24	e	—	322	992	1495	3.126	8.459	11.177
Sd	M	MF3	rape55	e	—	270	980	1482	2.636	8.382	11.118
Se	M	MF3	raid22	e	—	335	1057	1560	3.248	8.867	11.463
Se	M	MF3	raid44	e	—	335	992	1547	3.248	8.459	11.407
Se	M	MF3	raid55	e	—	309	1057	1599	3.005	8.867	11.628
Se	M	MF3	rape08	e	—	309	1005	1624	3.005	8.542	11.732
Se	M	MF3	rape24	e	—	361	980	1470	3.489	8.382	11.063
Se	M	MF3	rape55	e	—	348	1108	1521	3.369	9.175	11.293
Sf	M	MF3	raid22	e	—	283	968	1383	2.759	8.304	10.653
Sf	M	MF3	raid44	e	—	297	1011	1477	2.891	8.581	11.095
Sf	M	MF3	raid55	e	—	281	771	1439	2.740	6.927	10.920
Sf	M	MF3	rape08	e	—	272	977	1326	2.655	8.362	10.370
Sf	M	MF3	rape24	e	—	297	1036	1433	2.891	8.738	10.892
Sf	M	MF3	rape55	e	—	285	927	1395	2.778	8.032	10.711
S1	F	HiF3	red07	ε	—	296	1057	2133	2.882	8.867	13.517
S1	F	HiF3	red19	ε	—	283	1005	2050	2.759	8.542	13.263
S1	F	HiF3	red43	ε	—	361	1031	2089	3.489	8.706	13.384
S1	F	HiF3	rep33	ε	—	322	1070	2166	3.126	8.947	13.615
S1	F	HiF3	rep37	ε	—	257	1147	2346	2.512	9.402	14.117
S1	F	HiF3	rep47	ε	—	373	915	2228	3.600	7.951	13.793
S2	F	HiF3	red07	ε	—	270	1173	2424	2.636	9.551	14.320
S2	F	HiF3	red19	ε	—	270	1121	2346	2.636	9.251	14.117
S2	F	HiF3	red43	ε	—	412	1230	2296	3.955	9.866	13.982
S2	F	HiF3	rep33	ε	—	245	1276	2398	2.397	10.112	14.253
S2	F	HiF3	rep37	ε	—	283	1121	2256	2.759	9.251	13.872
S2	F	HiF3	rep47	ε	—	257	1353	2282	2.512	10.505	13.944
S3	F	HiF3	red07	ε	—	309	1276	1831	3.005	10.112	12.528
S3	F	HiF3	red19	ε	—	322	1173	2166	3.126	9.551	13.615
S3	F	HiF3	red43	ε	—	296	1121	2127	2.882	9.251	13.499
S3	F	HiF3	rep33	ε	—	257	1186	2346	2.512	9.624	14.117
S3	F	HiF3	rep37	ε	—	245	1173	2359	2.397	9.551	14.151
S3	F	HiF3	rep47	ε	—	257	1096	2269	2.512	9.103	13.908
S4	F	LoF3	red07	ε	—	495	1349	1533	4.693	10.485	11.346
S4	F	LoF3	red19	ε	—	322	1263	1740	3.126	10.043	12.192
S4	F	LoF3	red43	ε	—	322	1406	2114	3.126	10.764	13.460
S4	F	LoF3	rep33	ε	—	296	1225	1730	2.882	9.839	12.153

S4	F	LoF3	rep37	ε	—	296	1089	1616	2.882	9.062	11.699
S4	F	LoF3	rep47	ε	—	373	1289	1650	3.600	10.180	11.838
S5	F	HiF3	red07	ε	—	245	1470	2501	2.397	11.063	14.512
S5	F	HiF3	red19	ε	—	309	1482	2411	3.005	11.118	14.286
S5	F	HiF3	red43	ε	—	361	1482	2308	3.489	11.118	14.015
S5	F	HiF3	rep33	ε	—	412	1470	2424	3.955	11.063	14.320
S5	F	HiF3	rep37	ε	—	412	1521	2553	3.955	11.293	14.638
S5	F	HiF3	rep47	ε	—	373	1470	2540	3.600	11.063	14.606
S6	F	HiF3	red07	ε	—	411	1459	2381	3.946	11.013	14.209
S6	F	HiF3	red19	ε	—	382	1289	2312	3.682	10.180	14.026
S6	F	HiF3	red43	ε	—	400	1282	2318	3.847	10.143	14.042
S6	F	HiF3	rep33	ε	—	307	1135	2504	2.986	9.333	14.519
S6	F	HiF3	rep37	ε	—	381	1223	2165	3.673	9.828	13.612
S6	F	HiF3	rep47	ε	—	375	1173	2284	3.618	9.551	13.950
S7	F	LoF3	red07	ε	—	294	999	2026	2.863	8.504	13.187
S7	F	LoF3	red19	ε	—	332	1149	2284	3.220	9.414	13.950
S7	F	LoF3	red43	ε	—	262	935	2347	2.559	8.086	14.119
S7	F	LoF3	rep33	ε	—	242	1042	2573	2.368	8.775	14.685
S7	F	LoF3	rep37	ε	—	316	966	1514	3.070	8.291	11.262
S7	F	LoF3	rep47	ε	—	349	903	2258	3.378	7.870	13.878
S8	F	LoF3	red07	ε	—	273	1192	1746	2.664	9.657	12.214
S8	F	LoF3	red19	ε	—	420	990	1752	4.028	8.446	12.237
S8	F	LoF3	red43	ε	—	233	1226	1653	2.282	9.845	11.850
S8	F	LoF3	rep33	ε	—	229	1101	1640	2.243	9.133	11.798
S8	F	LoF3	rep37	ε	—	352	952	1723	3.406	8.199	12.126
S8	F	LoF3	rep47	ε	—	245	1162	1959	2.397	9.488	12.970
S9	F	LoF3	red07	ε	—	391	1211	1801	3.765	9.763	12.419
S9	F	LoF3	red19	ε	—	267	1166	1861	2.607	9.511	12.635
S9	F	LoF3	red43	ε	—	316	1265	1841	3.070	10.054	12.564
S9	F	LoF3	rep33	ε	—	337	1130	1595	3.267	9.304	11.612
S9	F	LoF3	rep37	ε	—	388	1165	1769	3.737	9.505	12.301
S9	F	LoF3	rep47	ε	—	330	1208	1582	3.201	9.746	11.557
Sa	M	MF3	red07	ε	—	257	1044	1669	2.512	8.787	11.915
Sa	M	MF3	red19	ε	—	270	1057	1431	2.636	8.867	10.882
Sa	M	MF3	red43	ε	—	257	885	1265	2.512	7.746	10.054
Sa	M	MF3	rep33	ε	—	270	1031	1586	2.636	8.706	11.574
Sa	M	MF3	rep37	ε	—	245	967	1704	2.397	8.297	12.053
Sa	M	MF3	rep47	ε	—	257	963	1398	2.512	8.271	10.725
Sb	M	MF3	red07	ε	—	270	1031	1715	2.636	8.706	12.096
Sb	M	MF3	red19	ε	—	412	1057	1740	3.955	8.867	12.192
Sb	M	MF3	red43	ε	—	283	1302	1676	2.759	10.247	11.943
Sb	M	MF3	rep33	ε	—	322	1018	1534	3.126	8.625	11.350
Sb	M	MF3	rep37	ε	—	283	1005	1573	2.759	8.542	11.518
Sb	M	MF3	rep47	ε	—	283	992	1534	2.759	8.459	11.350
Sc	M	MF3	red07	ε	—	296	1134	1547	2.882	9.327	11.407
Sc	M	MF3	red19	ε	—	270	1199	1611	2.636	9.696	11.678
Sc	M	MF3	red43	ε	—	283	1134	1495	2.759	9.327	11.177
Sc	M	MF3	rep33	ε	—	309	980	1482	3.005	8.382	11.118
Sc	M	MF3	rep37	ε	—	309	1044	1547	3.005	8.787	11.407
Sc	M	MF3	rep47	ε	—	296	1044	1534	2.882	8.787	11.350
Sd	M	MF3	red07	ε	—	245	941	1366	2.397	8.126	10.570
Sd	M	MF3	red19	ε	—	270	980	1482	2.636	8.382	11.118
Sd	M	MF3	red43	ε	—	257	954	1418	2.512	8.212	10.821
Sd	M	MF3	rep33	ε	—	296	1315	1611	2.882	10.314	11.678

Sd	M	MF3	rep37	ε	—	245	928	1276	2.397	8.039	10.112
Sd	M	MF3	rep47	ε	—	219	1134	1379	2.147	9.327	10.633
Se	M	MF3	red07	ε	—	335	954	1353	3.248	8.212	10.505
Se	M	MF3	red19	ε	—	335	954	1560	3.248	8.212	11.463
Se	M	MF3	red43	ε	—	322	941	1650	3.126	8.126	11.838
Se	M	MF3	rep33	ε	—	322	967	1599	3.126	8.297	11.628
Se	M	MF3	rep37	ε	—	322	1005	1495	3.126	8.542	11.177
Se	M	MF3	rep47	ε	—	309	928	1573	3.005	8.039	11.518
Sf	M	MF3	red07	ε	—	297	1017	1514	2.891	8.618	11.262
Sf	M	MF3	red19	ε	—	288	952	1428	2.806	8.199	10.868
Sf	M	MF3	red43	ε	—	281	863	1497	2.740	7.593	11.186
Sf	M	MF3	rep33	ε	—	317	1166	1460	3.080	9.511	11.018
Sf	M	MF3	rep37	ε	—	256	937	1464	2.502	8.099	11.036
Sf	M	MF3	rep47	ε	—	373	959	1475	3.600	8.245	11.086
S1	F	HiF3	rad16	æ	—	296	1044	1972	2.882	8.787	13.013
S1	F	HiF3	rad58	æ	—	270	1070	2140	2.636	8.947	13.538
S1	F	HiF3	rad63	æ	—	361	1070	2166	3.489	8.947	13.615
S1	F	HiF3	rap26	æ	—	399	992	2127	3.837	8.459	13.499
S1	F	HiF3	rap51	æ	—	257	1057	2011	2.512	8.867	13.139
S1	F	HiF3	rap58	æ	—	322	1044	2127	3.126	8.787	13.499
S2	F	HiF3	rad16	æ	—	245	1108	2269	2.397	9.175	13.908
S2	F	HiF3	rad58	æ	—	283	1096	2282	2.759	9.103	13.944
S2	F	HiF3	rad63	æ	—	309	1057	2411	3.005	8.867	14.286
S2	F	HiF3	rap26	æ	—	302	1093	1682	2.939	9.086	11.966
S2	F	HiF3	rap51	æ	—	257	980	2256	2.512	8.382	13.872
S2	F	HiF3	rap58	æ	—	257	1147	2321	2.512	9.402	14.050
S3	F	HiF3	rad16	æ	—	245	1121	2127	2.397	9.251	13.499
S3	F	HiF3	rad58	æ	—	270	1186	2068	2.636	9.624	13.319
S3	F	HiF3	rad63	æ	—	245	1147	2256	2.397	9.402	13.872
S3	F	HiF3	rap26	æ	—	322	1147	2070	3.126	9.402	13.326
S3	F	HiF3	rap51	æ	—	270	1199	2179	2.636	9.696	13.653
S3	F	HiF3	rap58	æ	—	296	1083	2063	2.882	9.026	13.304
S4	F	LoF3	rad16	æ	—	373	1225	1552	3.600	9.839	11.428
S4	F	LoF3	rad58	æ	—	309	1165	1733	3.005	9.505	12.165
S4	F	LoF3	rad63	æ	—	425	1276	1740	4.073	10.112	12.192
S4	F	LoF3	rap26	æ	—	373	1401	1824	3.600	10.740	12.503
S4	F	LoF3	rap51	æ	—	373	1263	1702	3.600	10.043	12.045
S4	F	LoF3	rap58	æ	—	322	1057	1433	3.126	8.867	10.892
S5	F	HiF3	rad16	æ	—	393	1631	2449	3.783	11.761	14.383
S5	F	HiF3	rad58	æ	—	451	1599	2682	4.305	11.628	14.936
S5	F	HiF3	rad63	æ	—	309	1482	2665	3.005	11.118	14.898
S5	F	HiF3	rap26	æ	—	348	1573	2411	3.369	11.518	14.286
S5	F	HiF3	rap51	æ	—	451	1573	2540	4.305	11.518	14.606
S5	F	HiF3	rap58	æ	—	386	1534	2540	3.719	11.350	14.606
S6	F	HiF3	rad16	æ	—	392	1240	2330	3.774	9.920	14.074
S6	F	HiF3	rad58	æ	—	265	1412	2577	2.588	10.793	14.695
S6	F	HiF3	rad63	æ	—	335	1424	2013	3.248	10.849	13.146
S6	F	HiF3	rap26	æ	—	287	1130	2306	2.797	9.304	14.010
S6	F	HiF3	rap51	æ	—	560	1280	2358	5.250	10.133	14.149
S6	F	HiF3	rap58	æ	—	429	1331	2209	4.109	10.395	13.739
S7	F	LoF3	rad16	æ	—	331	815	2255	3.211	7.251	13.869
S7	F	LoF3	rad58	æ	—	292	977	2269	2.844	8.362	13.908
S7	F	LoF3	rad63	æ	—	234	1021	1401	2.291	8.644	10.740
S7	F	LoF3	rap26	æ	—	420	1199	2456	4.028	9.696	14.400

S7	F	LoF3	rap51	æ	—	267	896	2243	2.607	7.822	13.836
S7	F	LoF3	rap58	æ	—	253	920	2494	2.473	7.985	14.495
S8	F	LoF3	rad16	æ	—	385	977	1562	3.710	8.362	11.471
S8	F	LoF3	rad58	æ	—	341	960	1790	3.304	8.251	12.379
S8	F	LoF3	rad63	æ	—	364	855	1779	3.517	7.537	12.338
S8	F	LoF3	rap26	æ	—	372	1062	2089	3.590	8.898	13.384
S8	F	LoF3	rap51	æ	—	390	962	1855	3.755	8.265	12.614
S8	F	LoF3	rap58	æ	—	293	955	1884	2.854	8.219	12.715
S9	F	LoF3	rad16	æ	—	417	1241	1734	4.001	9.926	12.169
S9	F	LoF3	rad58	æ	—	388	1323	1956	3.737	10.355	12.960
S9	F	LoF3	rad63	æ	—	402	1280	1869	3.865	10.133	12.663
S9	F	LoF3	rap26	æ	—	392	1237	1798	3.774	9.904	12.408
S9	F	LoF3	rap51	æ	—	460	1251	1582	4.385	9.979	11.557
S9	F	LoF3	rap58	æ	—	388	1179	1754	3.737	9.585	12.245
Sa	M	MF3	rad16	æ	—	245	1044	1573	2.397	8.787	11.518
Sa	M	MF3	rad58	æ	—	245	919	1407	2.397	7.978	10.769
Sa	M	MF3	rad63	æ	—	257	865	1327	2.512	7.607	10.375
Sa	M	MF3	rap26	æ	—	270	1044	1560	2.636	8.787	11.463
Sa	M	MF3	rap51	æ	—	283	1031	1575	2.759	8.706	11.527
Sa	M	MF3	rap58	æ	—	270	902	1443	2.636	7.863	10.939
Sb	M	MF3	rad16	æ	—	335	1134	1650	3.248	9.327	11.838
Sb	M	MF3	rad58	æ	—	386	1031	1547	3.719	8.706	11.407
Sb	M	MF3	rad63	æ	—	348	1250	1676	3.369	9.974	11.943
Sb	M	MF3	rap26	æ	—	348	1005	1586	3.369	8.542	11.574
Sb	M	MF3	rap51	æ	—	373	1302	1676	3.600	10.247	11.943
Sb	M	MF3	rap58	æ	—	412	1057	1495	3.955	8.867	11.177
Sc	M	MF3	rad16	æ	—	296	1031	1508	2.882	8.706	11.235
Sc	M	MF3	rad58	æ	—	296	928	1470	2.882	8.039	11.063
Sc	M	MF3	rad63	æ	—	296	1031	1508	2.882	8.706	11.235
Sc	M	MF3	rap26	æ	—	322	1031	1521	3.126	8.706	11.293
Sc	M	MF3	rap51	æ	—	322	1070	1560	3.126	8.947	11.463
Sc	M	MF3	rap58	æ	—	348	1057	1560	3.369	8.867	11.463
Sd	M	MF3	rad16	æ	—	348	1083	1482	3.369	9.026	11.118
Sd	M	MF3	rad58	æ	—	322	889	1470	3.126	7.774	11.063
Sd	M	MF3	rad63	æ	—	322	889	1508	3.126	7.774	11.235
Sd	M	MF3	rap26	æ	—	283	902	1521	2.759	7.863	11.293
Sd	M	MF3	rap51	æ	—	373	1083	1547	3.600	9.026	11.407
Sd	M	MF3	rap58	æ	—	283	915	1444	2.759	7.951	10.943
Se	M	MF3	rad16	æ	—	322	915	1547	3.126	7.951	11.407
Se	M	MF3	rad58	æ	—	296	1044	1547	2.882	8.787	11.407
Se	M	MF3	rad63	æ	—	322	1070	1586	3.126	8.947	11.574
Se	M	MF3	rap26	æ	—	283	941	1586	2.759	8.126	11.574
Se	M	MF3	rap51	æ	—	348	928	1508	3.369	8.039	11.235
Se	M	MF3	rap58	æ	—	322	928	1547	3.126	8.039	11.407
Sf	M	MF3	rad16	æ	—	300	1155	1455	2.920	9.448	10.994
Sf	M	MF3	rad58	æ	—	297	848	1276	2.891	7.487	10.112
Sf	M	MF3	rad63	æ	—	298	804	1383	2.901	7.171	10.653
Sf	M	MF3	rap26	æ	—	279	924	1449	2.721	8.012	10.967
Sf	M	MF3	rap51	æ	—	315	923	1408	3.061	8.005	10.773
Sf	M	MF3	rap58	æ	—	308	899	1279	2.995	7.842	10.128
S1	F	HiF3	rube12	u	—	257	1108	2308	2.512	9.175	14.015
S1	F	HiF3	rube22	u	—	309	1018	2372	3.005	8.625	14.185
S1	F	HiF3	rube32	u	—	296	1083	2424	2.882	9.026	14.320
S1	F	HiF3	rude20	u	—	257	1237	2321	2.512	9.904	14.050

S1	F	HiF3	rude28	u	—	257	1263	2359	2.512	10.043	14.151
S1	F	HiF3	rude37	u	—	257	1070	2385	2.512	8.947	14.219
S2	F	HiF3	rube12	u	—	245	1199	2282	2.397	9.696	13.944
S2	F	HiF3	rube22	u	—	257	1096	2205	2.512	9.103	13.728
S2	F	HiF3	rube32	u	—	283	1225	2346	2.759	9.839	14.117
S2	F	HiF3	rude20	u	—	283	1160	2398	2.759	9.477	14.253
S2	F	HiF3	rude28	u	—	245	1237	2334	2.397	9.904	14.085
S2	F	HiF3	rude37	u	—	270	1108	2346	2.636	9.175	14.117
S3	F	HiF3	rube12	u	—	335	1366	1740	3.248	10.570	12.192
S3	F	HiF3	rube22	u	—	257	1213	2379	2.512	9.774	14.204
S3	F	HiF3	rube32	u	—	270	1173	2205	2.636	9.551	13.728
S3	F	HiF3	rude20	u	—	335	1237	1755	3.248	9.904	12.248
S3	F	HiF3	rude28	u	—	257	1315	2501	2.512	10.314	14.512
S3	F	HiF3	rude37	u	—	270	1237	2166	2.636	9.904	13.615
S4	F	LoF3	rube12	u	—	232	1044	1908	2.272	8.787	12.798
S4	F	LoF3	rube22	u	—	309	1250	1702	3.005	9.974	12.045
S4	F	LoF3	rube32	u	—	373	1276	1818	3.600	10.112	12.481
S4	F	LoF3	rude20	u	—	335	1353	1586	3.248	10.505	11.574
S4	F	LoF3	rude28	u	—	348	1392	1663	3.369	10.696	11.891
S4	F	LoF3	rude37	u	—	399	1289	1560	3.837	10.180	11.463
S5	F	HiF3	rube12	u	—	296	1470	2695	2.882	11.063	14.965
S5	F	HiF3	rube22	u	—	283	1311	2437	2.759	10.293	14.353
S5	F	HiF3	rube32	u	—	373	1418	2475	3.600	10.821	14.448
S5	F	HiF3	rude20	u	—	419	1645	2624	4.019	11.818	14.804
S5	F	HiF3	rude28	u	—	464	1534	2553	4.421	11.350	14.638
S5	F	HiF3	rude37	u	—	296	1547	2579	2.882	11.407	14.699
S6	F	HiF3	rube12	u	—	313	1289	2238	3.042	10.180	13.822
S6	F	HiF3	rube22	u	—	229	1364	2624	2.243	10.560	14.804
S6	F	HiF3	rube32	u	—	384	1283	2474	3.701	10.149	14.445
S6	F	HiF3	rude20	u	—	401	1509	2046	3.856	11.240	13.251
S6	F	HiF3	rude28	u	—	297	936	2198	2.891	8.093	13.708
S6	F	HiF3	rude37	u	—	325	1145	2253	3.155	9.391	13.864
S7	F	LoF3	rube12	u	—	304	1108	2257	2.957	9.175	13.875
S7	F	LoF3	rube22	u	—	288	1179	2200	2.806	9.585	13.714
S7	F	LoF3	rube32	u	—	269	1104	2276	2.626	9.151	13.928
S7	F	LoF3	rude20	u	—	282	1303	1913	2.750	10.252	12.815
S7	F	LoF3	rude28	u	—	300	1256	2297	2.920	10.006	13.985
S7	F	LoF3	rude37	u	—	284	1120	2103	2.769	9.246	13.427
S8	F	LoF3	rope49	u	—	310	974	1726	3.014	8.343	12.138
S8	F	LoF3	rube12	u	—	300	1060	1669	2.920	8.886	11.915
S8	F	LoF3	rube22	u	—	349	1075	1721	3.378	8.977	12.119
S8	F	LoF3	rube32	u	—	319	1131	1861	3.098	9.310	12.635
S8	F	LoF3	rude20	u	—	385	1227	1732	3.710	9.850	12.161
S8	F	LoF3	rude28	u	—	312	1180	1754	3.033	9.590	12.245
S8	F	LoF3	rude37	u	—	339	1155	1745	3.285	9.448	12.211
S9	F	LoF3	rope48	u	—	381	1208	1726	3.673	9.746	12.138
S9	F	LoF3	rube12	u	—	374	1346	1929	3.609	10.470	12.870
S9	F	LoF3	rube22	u	—	376	1319	1739	3.627	10.334	12.188
S9	F	LoF3	rube32	u	—	376	1201	1856	3.627	9.707	12.617
S9	F	LoF3	rude20	u	—	363	1240	1653	3.508	9.920	11.850
S9	F	LoF3	rude28	u	—	302	1337	1783	2.939	10.425	12.353
S9	F	LoF3	rude37	u	—	417	1294	1754	4.001	10.206	12.245
Sa	M	MF3	rube12	u	—	257	1018	1355	2.512	8.625	10.515
Sa	M	MF3	rube22	u	—	235	952	1562	2.301	8.199	11.471

Sa	M	MF3	rube32	u	—	270	1005	1573	2.636	8.542	11.518
Sa	M	MF3	rude20	u	—	245	1098	1412	2.397	9.115	10.793
Sa	M	MF3	rude28	u	—	270	1083	1586	2.636	9.026	11.574
Sa	M	MF3	rude37	u	—	257	1005	1418	2.512	8.542	10.821
Sb	M	MF3	rube12	u	—	270	1070	1521	2.636	8.947	11.293
Sb	M	MF3	rube22	u	—	270	1392	1663	2.636	10.696	11.891
Sb	M	MF3	rube32	u	—	257	1315	1676	2.512	10.314	11.943
Sb	M	MF3	rude20	u	—	283	1263	1702	2.759	10.043	12.045
Sb	M	MF3	rude28	u	—	270	1457	1676	2.636	11.004	11.943
Sb	M	MF3	rude37	u	—	283	1134	1508	2.759	9.327	11.235
Sc	M	MF3	rube12	u	—	283	1083	1663	2.759	9.026	11.891
Sc	M	MF3	rube22	u	—	283	1070	1637	2.759	8.947	11.785
Sc	M	MF3	rube32	u	—	322	1108	1624	3.126	9.175	11.732
Sc	M	MF3	rude20	u	—	296	980	1508	2.882	8.382	11.235
Sc	M	MF3	rude28	u	—	270	1083	1637	2.636	9.026	11.785
Sc	M	MF3	rude37	u	—	309	1083	1624	3.005	9.026	11.732
Sd	M	MF3	rube12	u	—	296	902	1521	2.882	7.863	11.293
Sd	M	MF3	rube22	u	—	296	928	1560	2.882	8.039	11.463
Sd	M	MF3	rube32	u	—	283	980	1534	2.759	8.382	11.350
Sd	M	MF3	rude20	u	—	283	902	1457	2.759	7.863	11.004
Sd	M	MF3	rude28	u	—	270	954	1586	2.636	8.212	11.574
Sd	M	MF3	rude37	u	—	283	915	1521	2.759	7.951	11.293
Se	M	MF3	rube12	u	—	309	992	1547	3.005	8.459	11.407
Se	M	MF3	rube22	u	—	283	941	1534	2.759	8.126	11.350
Se	M	MF3	rube32	u	—	283	1018	1611	2.759	8.625	11.678
Se	M	MF3	rude20	u	—	322	967	1534	3.126	8.297	11.350
Se	M	MF3	rude28	u	—	322	980	1547	3.126	8.382	11.407
Se	M	MF3	rude37	u	—	322	992	1624	3.126	8.459	11.732
Sf	M	MF3	rube12	u	—	264	932	1435	2.578	8.066	10.901
Sf	M	MF3	rube22	u	—	265	905	1449	2.588	7.883	10.967
Sf	M	MF3	rube32	u	—	264	968	1478	2.578	8.304	11.100
Sf	M	MF3	rude20	u	—	260	934	1352	2.540	8.079	10.500
Sf	M	MF3	rude28	u	—	278	971	1406	2.712	8.323	10.764
Sf	M	MF3	rude37	u	—	284	1139	1546	2.769	9.356	11.402
S1	F	HiF3	rode38	o	—	270	1121	1856	2.636	9.251	12.617
S1	F	HiF3	rode41	o	—	309	1096	2256	3.005	9.103	13.872
S1	F	HiF3	rode42	o	—	257	1263	2269	2.512	10.043	13.908
S1	F	HiF3	rope22	o	—	296	1018	2373	2.882	8.625	14.188
S1	F	HiF3	rope34	o	—	322	1044	2063	3.126	8.787	13.304
S1	F	HiF3	rope49	o	—	283	1031	2192	2.759	8.706	13.691
S2	F	HiF3	rode38	o	—	257	1147	2334	2.512	9.402	14.085
S2	F	HiF3	rode41	o	—	296	1212	2372	2.882	9.768	14.185
S2	F	HiF3	rode42	o	—	232	1341	2488	2.272	10.445	14.480
S2	F	HiF3	rope22	o	—	257	1096	2127	2.512	9.103	13.499
S2	F	HiF3	rope34	o	—	219	1147	2321	2.147	9.402	14.050
S2	F	HiF3	rope49	o	—	257	1302	2321	2.512	10.247	14.050
S3	F	HiF3	rode38	o	—	257	1173	1957	2.512	9.551	12.963
S3	F	HiF3	rode41	o	—	257	1147	2050	2.512	9.402	13.263
S3	F	HiF3	rode42	o	—	283	1147	1650	2.759	9.402	11.838
S3	F	HiF3	rope22	o	—	296	1134	2121	2.882	9.327	13.481
S3	F	HiF3	rope34	o	—	245	1096	2385	2.397	9.103	14.219
S3	F	HiF3	rope49	o	—	232	1160	2527	2.272	9.477	14.575
S4	F	LoF3	rode38	o	—	283	1225	1637	2.759	9.839	11.785
S4	F	LoF3	rode41	o	—	322	1353	1767	3.126	10.505	12.294

S4	F	LoF3	rode42	o	—	322	1199	1586	3.126	9.696	11.574
S4	F	LoF3	rope22	o	—	270	1225	1676	2.636	9.839	11.943
S4	F	LoF3	rope34	o	—	361	1276	1715	3.489	10.112	12.096
S4	F	LoF3	rope49	o	—	296	1134	1482	2.882	9.327	11.118
S5	F	HiF3	rode38	o	—	373	1573	2553	3.600	11.518	14.638
S5	F	HiF3	rode41	o	—	438	1495	2501	4.189	11.177	14.512
S5	F	HiF3	rode42	o	—	245	1431	2553	2.397	10.882	14.638
S5	F	HiF3	rope22	o	—	265	1594	2547	2.588	11.607	14.623
S5	F	HiF3	rope34	o	—	296	1482	2385	2.882	11.118	14.219
S5	F	HiF3	rope49	o	—	438	1689	2617	4.189	11.994	14.788
S6	F	HiF3	rode38	o	—	331	1086	2488	3.211	9.044	14.480
S6	F	HiF3	rode41	o	—	272	965	2132	2.655	8.284	13.514
S6	F	HiF3	rode43	o	—	387	1214	2309	3.728	9.779	14.018
S6	F	HiF3	rope22	o	—	300	986	2180	2.920	8.421	13.656
S6	F	HiF3	rope34	o	—	359	1135	1855	3.471	9.333	12.614
S6	F	HiF3	rope49	o	—	421	1609	2335	4.037	11.670	14.088
S7	F	LoF3	rode38	o	—	292	1057	2156	2.844	8.867	13.586
S7	F	LoF3	rode41	o	—	263	1181	1885	2.569	9.596	12.719
S7	F	LoF3	rode42	o	—	308	1021	2090	2.995	8.644	13.387
S7	F	LoF3	rope22	o	—	281	1164	1943	2.740	9.500	12.917
S7	F	LoF3	rope34	o	—	327	1112	2288	3.173	9.198	13.960
S7	F	LoF3	rope49	o	—	281	962	1358	2.740	8.265	10.530
S8	F	LoF3	rode38	o	—	313	945	1614	3.042	8.152	11.691
S8	F	LoF3	rode41	o	—	326	985	1667	3.164	8.414	11.907
S8	F	LoF3	rode42	o	—	381	946	1912	3.673	8.159	12.812
S8	F	LoF3	rope22	o	—	412	1063	1769	3.955	8.904	12.301
S8	F	LoF3	rope34	o	—	286	998	1783	2.787	8.498	12.353
S9	F	LoF3	rode38	o	—	246	1225	1614	2.407	9.839	11.691
S9	F	LoF3	rode41	o	—	388	1220	1609	3.737	9.812	11.670
S9	F	LoF3	rode42	o	—	407	1270	1770	3.910	10.080	12.305
S9	F	LoF3	rope22	o	—	380	1215	1824	3.664	9.785	12.503
S9	F	LoF3	rope34	o	—	281	1224	1598	2.740	9.834	11.624
Sa	M	MF3	rode38	o	—	257	980	1534	2.512	8.382	11.350
Sa	M	MF3	rode41	o	—	257	943	1611	2.512	8.139	11.678
Sa	M	MF3	rode42	o	—	322	967	1446	3.126	8.297	10.953
Sa	M	MF3	rope22	o	—	257	980	1661	2.512	8.382	11.883
Sa	M	MF3	rope34	o	—	245	885	1297	2.397	7.746	10.221
Sa	M	MF3	rope49	o	—	309	953	1614	3.005	8.205	11.691
Sb	M	MF3	rode38	o	—	296	1237	1650	2.882	9.904	11.838
Sb	M	MF3	rode41	o	—	283	1096	1586	2.759	9.103	11.574
Sb	M	MF3	rode42	o	—	283	1108	1521	2.759	9.175	11.293
Sb	M	MF3	rope22	o	—	270	1160	1521	2.636	9.477	11.293
Sb	M	MF3	rope34	o	—	335	1005	1431	3.248	8.542	10.882
Sb	M	MF3	rope49	o	—	296	941	1482	2.882	8.126	11.118
Sc	M	MF3	rode38	o	—	309	1005	1521	3.005	8.542	11.293
Sc	M	MF3	rode41	o	—	322	1044	1586	3.126	8.787	11.574
Sc	M	MF3	rode42	o	—	322	967	1470	3.126	8.297	11.063
Sc	M	MF3	rope22	o	—	322	980	1495	3.126	8.382	11.177
Sc	M	MF3	rope34	o	—	322	1005	1444	3.126	8.542	10.943
Sc	M	MF3	rope49	o	—	309	1031	1534	3.005	8.706	11.350
Sd	M	MF3	rode38	o	—	348	1108	1573	3.369	9.175	11.518
Sd	M	MF3	rode41	o	—	335	838	1353	3.248	7.416	10.505
Sd	M	MF3	rode42	o	—	335	915	1470	3.248	7.951	11.063
Sd	M	MF3	rope22	o	—	270	902	1431	2.636	7.863	10.882

Sd	M	MF3	rope34	o	—	296	863	1379	2.882	7.593	10.633
Sd	M	MF3	rope49	o	—	309	915	1521	3.005	7.951	11.293
Se	M	MF3	rode38	o	—	309	941	1586	3.005	8.126	11.574
Se	M	MF3	rode41	o	—	309	928	1534	3.005	8.039	11.350
Se	M	MF3	rode42	o	—	335	980	1611	3.248	8.382	11.678
Se	M	MF3	rope22	o	—	335	1018	1573	3.248	8.625	11.518
Se	M	MF3	rope34	o	—	348	980	1521	3.369	8.382	11.293
Se	M	MF3	rope49	o	—	361	967	1547	3.489	8.297	11.407
Sf	M	MF3	rode38	o	—	264	954	1528	2.578	8.212	11.324
Sf	M	MF3	rode41	o	—	271	829	1445	2.645	7.352	10.948
Sf	M	MF3	rode42	o	—	314	1056	1470	3.051	8.861	11.063
Sf	M	MF3	rope22	o	—	303	833	1393	2.948	7.380	10.701
Sf	M	MF3	rope34	o	—	282	1046	1415	2.750	8.800	10.807
Sf	M	MF3	rope49	o	—	293	1003	1391	2.854	8.530	10.692
S1	F	HiF3	rob30	a	—	296	1057	2205	2.882	8.867	13.728
S1	F	HiF3	rob56	a	—	322	1070	2114	3.126	8.947	13.460
S1	F	HiF3	rob60	a	—	232	1186	2024	2.272	9.624	13.181
S1	F	HiF3	rod05	a	—	335	1031	1831	3.248	8.706	12.528
S1	F	HiF3	rod35	a	—	309	1044	2166	3.005	8.787	13.615
S1	F	HiF3	rod66	a	—	245	1070	1921	2.397	8.947	12.842
S2	F	HiF3	rob30	a	—	219	1173	2243	2.147	9.551	13.836
S2	F	HiF3	rob56	a	—	232	1186	2488	2.272	9.624	14.480
S2	F	HiF3	rob60	a	—	322	1031	2127	3.126	8.706	13.499
S2	F	HiF3	rod05	a	—	232	1070	2076	2.272	8.947	13.344
S2	F	HiF3	rod35	a	—	283	1121	2450	2.759	9.251	14.385
S2	F	HiF3	rod66	a	—	283	1108	2346	2.759	9.175	14.117
S3	F	HiF3	rob56	a	—	245	1134	1727	2.397	9.327	12.142
S3	F	HiF3	rob60	a	—	270	1108	2162	2.636	9.175	13.603
S3	F	HiF3	rod03	a	—	335	1147	2127	3.248	9.402	13.499
S3	F	HiF3	rod05	a	—	560	1165	1754	5.250	9.505	12.245
S3	F	HiF3	rod35	a	—	245	1160	2011	2.397	9.477	13.139
S3	F	HiF3	rod66	a	—	373	1199	1663	3.600	9.696	11.891
S4	F	LoF3	rob30	a	—	438	1212	1560	4.189	9.768	11.463
S4	F	LoF3	rob56	a	—	283	1134	1482	2.759	9.327	11.118
S4	F	LoF3	rob60	a	—	270	1160	1534	2.636	9.477	11.350
S4	F	LoF3	rod05	a	—	373	1018	1393	3.600	8.625	10.701
S4	F	LoF3	rod35	a	—	283	1264	1707	2.759	10.049	12.064
S4	F	LoF3	rod66	a	—	309	1108	1482	3.005	9.175	11.118
S5	F	HiF3	rob30	a	—	490	1444	2527	4.649	10.943	14.575
S5	F	HiF3	rob56	a	—	438	1431	2564	4.189	10.882	14.664
S5	F	HiF3	rob60	a	—	438	1379	2656	4.189	10.633	14.877
S5	F	HiF3	rod05	a	—	429	1538	2587	4.109	11.367	14.718
S5	F	HiF3	rod35	a	—	425	1405	2295	4.073	10.759	13.980
S5	F	HiF3	rod66	a	—	425	1495	2669	4.073	11.177	14.907
S6	F	HiF3	rob30	a	—	328	1126	2326	3.183	9.281	14.063
S6	F	HiF3	rob56	a	—	408	1316	1929	3.919	10.319	12.870
S6	F	HiF3	rob60	a	—	282	1168	2429	2.750	9.522	14.332
S6	F	HiF3	rod05	a	—	397	1320	2033	3.819	10.339	13.210
S6	F	HiF3	rod35	a	—	378	1162	2087	3.646	9.488	13.378
S6	F	HiF3	rod66	a	—	342	1320	1895	3.313	10.339	12.753
S7	F	LoF3	rob30	a	—	258	1064	1654	2.521	8.910	11.854
S7	F	LoF3	rob56	a	—	280	909	1475	2.731	7.911	11.086
S7	F	LoF3	rob60	a	—	259	874	1612	2.531	7.670	11.683
S7	F	LoF3	rod05	a	—	365	1010	1433	3.526	8.574	10.892

S7	F	LoF3	rod35	ɑ	—	269	892	1582	2.626	7.794	11.557
S7	F	LoF3	rod66	ɑ	—	347	916	1846	3.360	7.958	12.582
S8	F	LoF3	rob30	ɑ	—	484	1162	1687	4.597	9.488	11.986
S8	F	LoF3	rob56	ɑ	—	245	972	1748	2.397	8.330	12.222
S8	F	LoF3	rob60	ɑ	—	367	1189	1658	3.544	9.641	11.871
S8	F	LoF3	rod05	ɑ	—	259	1159	1641	2.531	9.471	11.802
S8	F	LoF3	rod35	ɑ	—	376	937	1728	3.627	8.099	12.146
S8	F	LoF3	rod66	ɑ	—	280	1080	1568	2.731	9.007	11.497
S9	F	LoF3	rob30	ɑ	—	415	1184	1647	3.983	9.613	11.826
S9	F	LoF3	rob56	ɑ	—	345	1150	1625	3.341	9.420	11.736
S9	F	LoF3	rob60	ɑ	—	402	1222	1855	3.865	9.823	12.614
S9	F	LoF3	rod05	ɑ	—	259	1308	1807	2.531	10.278	12.441
S9	F	LoF3	rod35	ɑ	—	417	1222	1697	4.001	9.823	12.025
S9	F	LoF3	rod66	ɑ	—	445	1280	1812	4.252	10.133	12.460
Sa	M	MF3	rob30	ɑ	—	257	992	1482	2.512	8.459	11.118
Sa	M	MF3	rob56	ɑ	—	270	980	1547	2.636	8.382	11.407
Sa	M	MF3	rob60	ɑ	—	296	1018	1353	2.882	8.625	10.505
Sa	M	MF3	rod05	ɑ	—	270	1057	1509	2.636	8.867	11.240
Sa	M	MF3	rod35	ɑ	—	283	980	1263	2.759	8.382	10.043
Sa	M	MF3	rod66	ɑ	—	245	847	1227	2.397	7.480	9.850
Sb	M	MF3	rob30	ɑ	—	322	1018	1508	3.126	8.625	11.235
Sb	M	MF3	rob56	ɑ	—	348	1044	1495	3.369	8.787	11.177
Sb	M	MF3	rob60	ɑ	—	348	992	1457	3.369	8.459	11.004
Sb	M	MF3	rod05	ɑ	—	348	1147	1547	3.369	9.402	11.407
Sb	M	MF3	rod35	ɑ	—	399	1044	1508	3.837	8.787	11.235
Sb	M	MF3	rod66	ɑ	—	322	928	1444	3.126	8.039	10.943
Sc	M	MF3	rob30	ɑ	—	322	980	1457	3.126	8.382	11.004
Sc	M	MF3	rob56	ɑ	—	361	1044	1470	3.489	8.787	11.063
Sc	M	MF3	rob60	ɑ	—	348	980	1418	3.369	8.382	10.821
Sc	M	MF3	rod05	ɑ	—	335	928	1353	3.248	8.039	10.505
Sc	M	MF3	rod35	ɑ	—	361	1057	1534	3.489	8.867	11.350
Sc	M	MF3	rod66	ɑ	—	348	1057	1534	3.369	8.867	11.350
Sd	M	MF3	rob30	ɑ	—	309	941	1457	3.005	8.126	11.004
Sd	M	MF3	rob56	ɑ	—	322	1083	1495	3.126	9.026	11.177
Sd	M	MF3	rob60	ɑ	—	309	786	1379	3.005	7.039	10.633
Sd	M	MF3	rod05	ɑ	—	322	863	1341	3.126	7.593	10.445
Sd	M	MF3	rod35	ɑ	—	270	980	1418	2.636	8.382	10.821
Sd	M	MF3	rod66	ɑ	—	373	1057	1418	3.600	8.867	10.821
Se	M	MF3	rob30	ɑ	—	322	980	1508	3.126	8.382	11.235
Se	M	MF3	rob56	ɑ	—	322	928	1560	3.126	8.039	11.463
Se	M	MF3	rob60	ɑ	—	348	967	1470	3.369	8.297	11.063
Se	M	MF3	rod05	ɑ	—	335	980	1470	3.248	8.382	11.063
Se	M	MF3	rod35	ɑ	—	309	941	1508	3.005	8.126	11.235
Se	M	MF3	rod66	ɑ	—	386	1108	1508	3.719	9.175	11.235
Sf	M	MF3	rob30	ɑ	—	348	1128	1413	3.369	9.292	10.797
Sf	M	MF3	rob56	ɑ	—	354	1122	1419	3.424	9.257	10.826
Sf	M	MF3	rob60	ɑ	—	315	948	1350	3.061	8.172	10.490
Sf	M	MF3	rod05	ɑ	—	325	961	1465	3.155	8.258	11.041
Sf	M	MF3	rod35	ɑ	—	294	804	1398	2.863	7.171	10.725
Sf	M	MF3	rod66	ɑ	—	325	1050	1297	3.155	8.824	10.221
S1	F	HiF3	rub26	ʌ	—	257	1044	1869	2.512	8.787	12.663
S1	F	HiF3	rub57	ʌ	—	232	1212	2269	2.272	9.768	13.908
S1	F	HiF3	rub66	ʌ	—	245	1160	2193	2.397	9.477	13.693
S1	F	HiF3	rut35	ʌ	—	296	1070	2243	2.882	8.947	13.836

S1	F	HiF3	rut60	∧	—	257	1173	2295	2.512	9.551	13.980
S1	F	HiF3	rut69	∧	—	206	1121	2462	2.022	9.251	14.415
S2	F	HiF3	rub26	∧	—	245	1057	1895	2.397	8.867	12.753
S2	F	HiF3	rub57	∧	—	270	1199	2385	2.636	9.696	14.219
S2	F	HiF3	rub66	∧	—	232	1096	2037	2.272	9.103	13.222
S2	F	HiF3	rut35	∧	—	257	1160	2424	2.512	9.477	14.320
S2	F	HiF3	rut60	∧	—	309	1096	2385	3.005	9.103	14.219
S2	F	HiF3	rut69	∧	—	309	1173	2372	3.005	9.551	14.185
S3	F	HiF3	rub26	∧	—	245	1173	2321	2.397	9.551	14.050
S3	F	HiF3	rub57	∧	—	257	1134	2217	2.512	9.327	13.762
S3	F	HiF3	rub66	∧	—	302	1193	1596	2.939	9.663	11.616
S3	F	HiF3	rut35	∧	—	348	1147	2321	3.369	9.402	14.050
S3	F	HiF3	rut60	∧	—	270	1108	2531	2.636	9.175	14.585
S3	F	HiF3	rut69	∧	—	309	1160	1726	3.005	9.477	12.138
S4	F	LoF3	rub26	∧	—	445	1193	1841	4.252	9.663	12.564
S4	F	LoF3	rub57	∧	—	309	1147	1656	3.005	9.402	11.862
S4	F	LoF3	rub66	∧	—	348	1173	1624	3.369	9.551	11.732
S4	F	LoF3	rut35	∧	—	245	1418	1753	2.397	10.821	12.241
S4	F	LoF3	rut60	∧	—	425	1199	1650	4.073	9.696	11.838
S4	F	LoF3	rut69	∧	—	309	1237	1715	3.005	9.904	12.096
S5	F	HiF3	rub26	∧	—	283	1482	2385	2.759	11.118	14.219
S5	F	HiF3	rub57	∧	—	490	1560	2591	4.649	11.463	14.727
S5	F	HiF3	rub66	∧	—	386	1457	2617	3.719	11.004	14.788
S5	F	HiF3	rut35	∧	—	219	1573	2629	2.147	11.518	14.816
S5	F	HiF3	rut60	∧	—	412	1534	2733	3.955	11.350	15.049
S5	F	HiF3	rut69	∧	—	322	1534	2759	3.126	11.350	15.106
S6	F	HiF3	rub26	∧	—	247	1072	2499	2.416	8.959	14.507
S6	F	HiF3	rub57	∧	—	361	1087	1701	3.489	9.050	12.041
S6	F	HiF3	rub66	∧	—	357	1296	2104	3.452	10.216	13.430
S6	F	HiF3	rut35	∧	—	322	1109	2083	3.126	9.181	13.366
S6	F	HiF3	rut60	∧	—	258	924	2489	2.521	8.012	14.482
S6	F	HiF3	rut69	∧	—	377	1189	2183	3.636	9.641	13.665
S7	F	LoF3	rub26	∧	—	342	995	1515	3.313	8.479	11.266
S7	F	LoF3	rub57	∧	—	245	951	2154	2.397	8.192	13.580
S7	F	LoF3	rub66	∧	—	288	996	1868	2.806	8.485	12.660
S7	F	LoF3	rut35	∧	—	332	1003	1574	3.220	8.530	11.523
S7	F	LoF3	rut60	∧	—	288	952	2210	2.806	8.199	13.742
S7	F	LoF3	rut69	∧	—	309	953	1779	3.005	8.205	12.338
S8	F	LoF3	rub26	∧	—	309	962	1663	3.005	8.265	11.891
S8	F	LoF3	rub57	∧	—	392	1210	1736	3.774	9.757	12.176
S8	F	LoF3	rub66	∧	—	232	975	1849	2.272	8.349	12.593
S8	F	LoF3	rut35	∧	—	335	1005	1684	3.248	8.542	11.974
S8	F	LoF3	rut60	∧	—	501	1184	1604	4.745	9.613	11.649
S8	F	LoF3	rut69	∧	—	359	1209	1638	3.471	9.752	11.789
S9	F	LoF3	rub26	∧	—	327	1251	1740	3.173	9.979	12.192
S9	F	LoF3	rub57	∧	—	330	1107	1539	3.201	9.169	11.372
S9	F	LoF3	rub66	∧	—	460	1337	1826	4.385	10.425	12.510
S9	F	LoF3	rut35	∧	—	299	1208	1639	2.910	9.746	11.794
S9	F	LoF3	rut60	∧	—	373	1222	1769	3.600	9.823	12.301
S9	F	LoF3	rut69	∧	—	273	1308	1625	2.664	10.278	11.736
Sa	M	MF3	rub26	∧	—	270	992	1431	2.636	8.459	10.882
Sa	M	MF3	rub57	∧	—	219	902	1572	2.147	7.863	11.514
Sa	M	MF3	rub66	∧	—	257	886	1505	2.512	7.753	11.222
Sa	M	MF3	rut35	∧	—	257	980	1405	2.512	8.382	10.759

Sa	M	MF3	rut60	ʌ	—	283	987	1483	2.759	8.427	11.123
Sa	M	MF3	rut69	ʌ	—	232	778	1223	2.272	6.979	9.828
Sb	M	MF3	rub26	ʌ	—	309	1031	1547	3.005	8.706	11.407
Sb	M	MF3	rub57	ʌ	—	322	1031	1508	3.126	8.706	11.235
Sb	M	MF3	rub66	ʌ	—	348	1121	1521	3.369	9.251	11.293
Sb	M	MF3	rut35	ʌ	—	309	1057	1482	3.005	8.867	11.118
Sb	M	MF3	rut60	ʌ	—	373	1057	1508	3.600	8.867	11.235
Sb	M	MF3	rut69	ʌ	—	283	1018	1547	2.759	8.625	11.407
Sc	M	MF3	rub26	ʌ	—	296	980	1482	2.882	8.382	11.118
Sc	M	MF3	rub57	ʌ	—	296	1005	1521	2.882	8.542	11.293
Sc	M	MF3	rub66	ʌ	—	296	992	1521	2.882	8.459	11.293
Sc	M	MF3	rut35	ʌ	—	309	967	1470	3.005	8.297	11.063
Sc	M	MF3	rut60	ʌ	—	322	902	1457	3.126	7.863	11.004
Sc	M	MF3	rut69	ʌ	—	270	941	1470	2.636	8.126	11.063
Sd	M	MF3	rub26	ʌ	—	270	980	1521	2.636	8.382	11.293
Sd	M	MF3	rub57	ʌ	—	270	954	1534	2.636	8.212	11.350
Sd	M	MF3	rub66	ʌ	—	270	967	1495	2.636	8.297	11.177
Sd	M	MF3	rut60	ʌ	—	322	1018	1521	3.126	8.625	11.293
Sd	M	MF3	rut69	ʌ	—	322	1031	1482	3.126	8.706	11.118
Sd	M	MF3	rutt35	ʌ	—	257	1031	1457	2.512	8.706	11.004
Se	M	MF3	rub26	ʌ	—	296	902	1534	2.882	7.863	11.350
Se	M	MF3	rub57	ʌ	—	335	915	1457	3.248	7.951	11.004
Se	M	MF3	rub66	ʌ	—	309	1018	1599	3.005	8.625	11.628
Se	M	MF3	rut35	ʌ	—	322	928	1521	3.126	8.039	11.293
Se	M	MF3	rut60	ʌ	—	322	902	1495	3.126	7.863	11.177
Se	M	MF3	rut69	ʌ	—	322	992	1534	3.126	8.459	11.350
Sf	M	MF3	rub26	ʌ	—	269	1045	1616	2.626	8.793	11.699
Sf	M	MF3	rub57	ʌ	—	298	1050	1441	2.901	8.824	10.929
Sf	M	MF3	rub66	ʌ	—	278	951	1581	2.712	8.192	11.552
Sf	M	MF3	rut35	ʌ	—	305	1291	1458	2.967	10.190	11.008
Sf	M	MF3	rut60	ʌ	—	287	947	1449	2.797	8.166	10.967
Sf	M	MF3	rut69	ʌ	—	301	797	1529	2.929	7.120	11.328
S1	F	HiF3	rib13	—	b	270	1031	2243	2.636	8.706	13.836
S1	F	HiF3	rib15	—	b	322	1057	2166	3.126	8.867	13.615
S1	F	HiF3	rib45	—	b	296	1031	2192	2.882	8.706	13.691
S1	F	HiF3	rick19	—	k	257	1044	2205	2.512	8.787	13.728
S1	F	HiF3	rick26	—	k	245	1186	2295	2.397	9.624	13.980
S1	F	HiF3	rick36	—	k	322	1134	2334	3.126	9.327	14.085
S1	F	HiF3	rig07	—	g	283	1096	2179	2.759	9.103	13.653
S1	F	HiF3	rig40	—	g	283	1083	2205	2.759	9.026	13.728
S1	F	HiF3	rig62	—	g	270	1096	2243	2.636	9.103	13.836
S1	F	HiF3	ritt09	—	t	245	1070	2217	2.397	8.947	13.762
S1	F	HiF3	ritt18	—	t	270	1031	2179	2.636	8.706	13.653
S1	F	HiF3	ritt44	—	t	270	1044	2243	2.636	8.787	13.836
S2	F	HiF3	rib13	—	b	283	1225	2437	2.759	9.839	14.353
S2	F	HiF3	rib15	—	b	245	1044	2321	2.397	8.787	14.050
S2	F	HiF3	rib45	—	b	335	1186	2166	3.248	9.624	13.615
S2	F	HiF3	rick19	—	k	257	1237	2372	2.512	9.904	14.185
S2	F	HiF3	rick26	—	k	270	1263	2359	2.636	10.043	14.151
S2	F	HiF3	rick36	—	k	232	1289	2372	2.272	10.180	14.185
S2	F	HiF3	rig07	—	g	270	1160	2450	2.636	9.477	14.385
S2	F	HiF3	rig40	—	g	257	1108	2437	2.512	9.175	14.353
S2	F	HiF3	rig62	—	g	348	1225	2450	3.369	9.839	14.385
S2	F	HiF3	ritt09	—	t	257	1083	2321	2.512	9.026	14.050

S2	F	HiF3	ritt18	—	t	270	1160	2308	2.636	9.477	14.015
S2	F	HiF3	ritt44	—	t	309	1186	2269	3.005	9.624	13.908
S3	F	HiF3	rib13	—	b	270	1199	1880	2.636	9.696	12.702
S3	F	HiF3	rib15	—	b	296	1134	1972	2.882	9.327	13.013
S3	F	HiF3	rib45	—	b	219	1108	2088	2.147	9.175	13.381
S3	F	HiF3	rick19	—	k	296	1276	1766	2.882	10.112	12.290
S3	F	HiF3	rick26	—	k	283	1160	2033	2.759	9.477	13.210
S3	F	HiF3	rick36	—	k	283	1160	2127	2.759	9.477	13.499
S3	F	HiF3	rig40	—	g	283	1186	2288	2.759	9.624	13.960
S3	F	HiF3	rig62	—	g	257	1186	2346	2.512	9.624	14.117
S3	F	HiF3	rip15	—	g	270	1147	2050	2.636	9.402	13.263
S3	F	HiF3	ritt18	—	t	245	1173	2192	2.397	9.551	13.691
S3	F	HiF3	ritt44	—	t	270	1121	2243	2.636	9.251	13.836
S3	F	HiF3	rob30	—	t	257	1108	2236	2.512	9.175	13.816
S4	F	LoF3	rib13	—	b	451	1882	2707	4.305	12.708	14.992
S4	F	LoF3	rib15	—	b	322	1225	1508	3.126	9.839	11.235
S4	F	LoF3	rib45	—	b	361	1328	1818	3.489	10.380	12.481
S4	F	LoF3	rick19	—	k	361	1276	1702	3.489	10.112	12.045
S4	F	LoF3	rick26	—	k	335	1186	1663	3.248	9.624	11.891
S4	F	LoF3	rick36	—	k	373	1121	1650	3.600	9.251	11.838
S4	F	LoF3	rig07	—	g	412	1328	1792	3.955	10.380	12.386
S4	F	LoF3	rig40	—	g	283	1276	1803	2.759	10.112	12.427
S4	F	LoF3	rig62	—	g	257	1253	1795	2.512	9.990	12.397
S4	F	LoF3	Ritt09	—	t	361	1134	1693	3.489	9.327	12.010
S4	F	LoF3	ritt18	—	t	425	1547	1831	4.073	11.407	12.528
S4	F	LoF3	ritt44	—	t	309	1353	1573	3.005	10.505	11.518
S5	F	HiF3	rib13	—	b	404	1509	2495	3.883	11.240	14.497
S5	F	HiF3	rib15	—	b	245	1508	2450	2.397	11.235	14.385
S5	F	HiF3	rib45	—	b	335	1392	2437	3.248	10.696	14.353
S5	F	HiF3	rick19	—	k	489	1534	2669	4.641	11.350	14.907
S5	F	HiF3	rick26	—	k	488	1619	2348	4.632	11.712	14.122
S5	F	HiF3	rick36	—	k	386	1495	2475	3.719	11.177	14.448
S5	F	HiF3	rig07	—	g	257	1482	2247	2.512	11.118	13.847
S5	F	HiF3	rig40	—	g	257	1560	2547	2.512	11.463	14.623
S5	F	HiF3	rig62	—	g	335	1547	2643	3.248	11.407	14.848
S5	F	HiF3	ritt09	—	t	397	1685	2627	3.819	11.978	14.811
S5	F	HiF3	ritt18	—	t	305	1547	2591	2.967	11.407	14.727
S5	F	HiF3	ritt44	—	t	386	1392	2540	3.719	10.696	14.606
S6	F	HiF3	rib13	—	b	405	1350	2502	3.892	10.490	14.514
S6	F	HiF3	rib15	—	b	379	1197	2424	3.655	9.685	14.320
S6	F	HiF3	rib45	—	b	439	1317	2147	4.198	10.324	13.559
S6	F	HiF3	rick19	—	k	368	1411	2443	3.554	10.788	14.368
S6	F	HiF3	rick26	—	k	297	965	2539	2.891	8.284	14.604
S6	F	HiF3	rick36	—	k	350	1305	2398	3.387	10.263	14.253
S6	F	HiF3	rig07	—	g	330	1592	2436	3.201	11.599	14.350
S6	F	HiF3	rig40	—	g	352	1243	2302	3.406	9.937	13.999
S6	F	HiF3	rig62	—	g	233	1603	2442	2.282	11.645	14.365
S6	F	HiF3	ritt09	—	t	366	1260	2266	3.535	10.027	13.900
S6	F	HiF3	ritt18	—	t	363	1336	2358	3.508	10.420	14.149
S6	F	HiF3	ritt44	—	t	293	1112	2468	2.854	9.198	14.430
S7	F	LoF3	rib13	—	b	319	1148	2335	3.098	9.408	14.088
S7	F	LoF3	rib15	—	b	317	1089	2190	3.080	9.062	13.685
S7	F	LoF3	rib40	—	b	300	1171	2197	2.920	9.539	13.705
S7	F	LoF3	rick19	—	k	345	1182	2333	3.341	9.601	14.082

S7	F	LoF3	rick25	—	k	372	1229	2225	3.590	9.861	13.785
S7	F	LoF3	rick36	—	k	293	1062	2272	2.854	8.898	13.916
S7	F	LoF3	rig07	—	g	273	1032	2232	2.664	8.713	13.805
S7	F	LoF3	rig40	—	g	276	1040	1556	2.693	8.762	11.446
S7	F	LoF3	rig62	—	g	339	1234	1988	3.285	9.888	13.065
S7	F	LoF3	ritt09	—	t	313	1089	2266	3.042	9.062	13.900
S7	F	LoF3	ritt18	—	t	346	1108	2282	3.350	9.175	13.944
S7	F	LoF3	ritt44	—	t	231	977	2581	2.263	8.362	14.704
S8	F	LoF3	rib13	—	b	400	904	1583	3.847	7.877	11.561
S8	F	LoF3	rib15	—	b	328	1000	1655	3.183	8.511	11.858
S8	F	LoF3	rib45	—	b	238	1049	1833	2.330	8.818	12.535
S8	F	LoF3	rick19	—	k	329	1067	1859	3.192	8.929	12.628
S8	F	LoF3	rick26	—	k	309	975	1553	3.005	8.349	11.433
S8	F	LoF3	rick36	—	k	266	1121	1726	2.598	9.251	12.138
S8	F	LoF3	rig07	—	g	427	1223	1817	4.091	9.828	12.478
S8	F	LoF3	rig40	—	g	330	1024	1576	3.201	8.663	11.531
S8	F	LoF3	rig62	—	g	364	1147	1745	3.517	9.402	12.211
S8	F	LoF3	ritt09	—	t	371	1023	1568	3.581	8.656	11.497
S8	F	LoF3	ritt18	—	t	276	1134	1607	2.693	9.327	11.662
S8	F	LoF3	ritt44	—	t	192	1164	1734	1.886	9.500	12.169
S9	F	LoF3	rib13	—	b	410	1365	1873	3.937	10.565	12.677
S9	F	LoF3	rib15	—	b	289	1286	1832	2.816	10.164	12.532
S9	F	LoF3	rib45	—	b	407	1222	1682	3.910	9.823	11.966
S9	F	LoF3	rick19	—	k	317	1202	1644	3.080	9.713	11.814
S9	F	LoF3	rick26	—	k	417	1308	1769	4.001	10.278	12.301
S9	F	LoF3	rick36	—	k	402	1308	1884	3.865	10.278	12.715
S9	F	LoF3	rig07	—	g	367	1132	1618	3.544	9.316	11.707
S9	F	LoF3	rig40	—	g	273	1438	1913	2.664	10.915	12.815
S9	F	LoF3	rig62	—	g	354	1642	1887	3.424	11.806	12.726
S9	F	LoF3	ritt09	—	t	343	1291	1990	3.322	10.190	13.072
S9	F	LoF3	ritt18	—	t	373	1233	1782	3.600	9.883	12.349
S9	F	LoF3	ritt44	—	t	391	1179	1769	3.765	9.585	12.301
Sa	M	MF3	rib13	—	b	270	1031	1704	2.636	8.706	12.053
Sa	M	MF3	rib15	—	b	283	1070	1488	2.759	8.947	11.145
Sa	M	MF3	rib45	—	b	257	1031	1637	2.512	8.706	11.785
Sa	M	MF3	rick19	—	k	283	1057	1495	2.759	8.867	11.177
Sa	M	MF3	rick26	—	k	245	954	1280	2.397	8.212	10.133
Sa	M	MF3	rick36	—	k	283	1057	1380	2.759	8.867	10.638
Sa	M	MF3	rig07	—	g	283	1070	1572	2.759	8.947	11.514
Sa	M	MF3	rig40	—	g	232	938	1280	2.272	8.106	10.133
Sa	M	MF3	rig62	—	g	283	1096	1579	2.759	9.103	11.544
Sa	M	MF3	ritt09	—	t	270	1057	1570	2.636	8.867	11.506
Sa	M	MF3	ritt18	—	t	270	967	1838	2.636	8.297	12.553
Sa	M	MF3	ritt44	—	t	270	1018	1701	2.636	8.625	12.041
Sb	M	MF3	rib13	—	b	232	1108	1650	2.272	9.175	11.838
Sb	M	MF3	rib15	—	b	257	1005	1650	2.512	8.542	11.838
Sb	M	MF3	rib45	—	b	270	1108	1560	2.636	9.175	11.463
Sb	M	MF3	rick19	—	k	322	1083	1650	3.126	9.026	11.838
Sb	M	MF3	rick25	—	k	283	1173	1702	2.759	9.551	12.045
Sb	M	MF3	rick36	—	k	296	1405	1676	2.882	10.759	11.943
Sb	M	MF3	rig07	—	g	270	1070	1637	2.636	8.947	11.785
Sb	M	MF3	rig40	—	g	296	1250	1624	2.882	9.974	11.732
Sb	M	MF3	rig62	—	g	309	1186	1624	3.005	9.624	11.732
Sb	M	MF3	ritt09	—	t	257	1315	1740	2.512	10.314	12.192

Sb	M	MF3	ritt18	—	t	257	1108	1702	2.512	9.175	12.045
Sb	M	MF3	ritt44	—	t	283	1186	1547	2.759	9.624	11.407
Sc	M	MF3	rib13	—	b	296	1070	1611	2.882	8.947	11.678
Sc	M	MF3	rib15	—	b	309	1005	1482	3.005	8.542	11.118
Sc	M	MF3	rib45	—	b	283	1070	1586	2.759	8.947	11.574
Sc	M	MF3	rick19	—	k	283	1018	1521	2.759	8.625	11.293
Sc	M	MF3	rick26	—	k	257	1173	1663	2.512	9.551	11.891
Sc	M	MF3	rick36	—	k	296	1070	1560	2.882	8.947	11.463
Sc	M	MF3	rig07	—	g	296	1173	1599	2.882	9.551	11.628
Sc	M	MF3	rig40	—	g	283	1057	1521	2.759	8.867	11.293
Sc	M	MF3	rig62	—	g	283	1173	1547	2.759	9.551	11.407
Sc	M	MF3	ritt09	—	t	296	1108	1624	2.882	9.175	11.732
Sc	M	MF3	ritt18	—	t	296	1083	1534	2.882	9.026	11.350
Sc	M	MF3	ritt44	—	t	297	868	1393	2.891	7.628	10.701
Sd	M	MF3	rib13	—	b	270	941	1521	2.636	8.126	11.293
Sd	M	MF3	rib15	—	b	270	954	1302	2.636	8.212	10.247
Sd	M	MF3	rib45	—	b	283	889	1431	2.759	7.774	10.882
Sd	M	MF3	rick19	—	k	283	1057	1495	2.759	8.867	11.177
Sd	M	MF3	rick26	—	k	270	1001	1599	2.636	8.517	11.628
Sd	M	MF3	rick26	—	k	296	1031	1457	2.882	8.706	11.004
Sd	M	MF3	rig07	—	g	257	1276	1611	2.512	10.112	11.678
Sd	M	MF3	rig40	—	g	309	1005	1521	3.005	8.542	11.293
Sd	M	MF3	rig62	—	g	257	980	1573	2.512	8.382	11.518
Sd	M	MF3	ritt09	—	t	270	1057	1495	2.636	8.867	11.177
Sd	M	MF3	ritt18	—	t	270	928	1444	2.636	8.039	10.943
Sd	M	MF3	ritt44	—	t	270	888	1454	2.636	7.767	10.990
Se	M	MF3	rib13	—	b	296	1005	1611	2.882	8.542	11.678
Se	M	MF3	rib15	—	b	206	1018	1418	2.022	8.625	10.821
Se	M	MF3	rib45	—	b	309	992	1560	3.005	8.459	11.463
Se	M	MF3	rick19	—	k	309	889	1560	3.005	7.774	11.463
Se	M	MF3	rick26	—	k	309	1018	1560	3.005	8.625	11.463
Se	M	MF3	rick36	—	k	322	889	1276	3.126	7.774	10.112
Se	M	MF3	rig07	—	g	322	992	1715	3.126	8.459	12.096
Se	M	MF3	rig40	—	g	322	1070	1637	3.126	8.947	11.785
Se	M	MF3	rig62	—	g	309	1044	1624	3.005	8.787	11.732
Se	M	MF3	ritt09	—	t	322	851	1560	3.126	7.508	11.463
Se	M	MF3	ritt18	—	t	322	1018	1611	3.126	8.625	11.678
Se	M	MF3	ritt44	—	t	335	967	1418	3.248	8.297	10.821
Sf	M	MF3	rib13	—	b	298	895	1442	2.901	7.815	10.934
Sf	M	MF3	rib15	—	b	298	1009	1405	2.901	8.568	10.759
Sf	M	MF3	rib45	—	b	273	842	1286	2.664	7.444	10.164
Sf	M	MF3	rick19	—	k	299	1000	1459	2.910	8.511	11.013
Sf	M	MF3	rick26	—	k	299	1046	1464	2.910	8.800	11.036
Sf	M	MF3	rick36	—	k	260	819	1392	2.540	7.280	10.696
Sf	M	MF3	rig07	—	g	259	825	1523	2.531	7.323	11.302
Sf	M	MF3	rig40	—	g	305	977	1504	2.967	8.362	11.217
Sf	M	MF3	rig62	—	g	265	800	1508	2.588	7.141	11.235
Sf	M	MF3	ritt09	—	t	245	922	1441	2.397	7.999	10.929
Sf	M	MF3	ritt18	—	t	302	978	1438	2.939	8.369	10.915
Sf	M	MF3	ritt44	—	t	251	711	1474	2.454	6.472	11.082

Bibliography

Bladon, A., C. Henton, & J. B. Pickering (1984). "Towards an auditory theory of speech normalization". *Language and Communication*, **4**.1:59-69.

Boyce, S. & C. Espy-Wilson (1993). "Coarticulatory stability in American English /r/". *Speech Communications Group Working Papers* (RLE/MIT) **9**:81-93.

Boyce S. & C. Espy-Wilson (1994). "Acoustic differences between 'bunched' and 'retroflex' variants of American English /r/". *Journal of the Acoustical Society of America* **95**.5(2):2823.

Byrd, D. (1994). "Relations of sex and dialect to reduction". *Speech Communication* **15**.1:39-54.

Chiba, T. & M. Kajiyama (1941). *The vowel: its nature and structure.* Tokyo-Kaiseikan.

DeCasper, A. J. & W. P. Fifer (1980). "Of human bonding: newborns prefer their mothers' voices". *Science* **208**:1174-1176.

Delattre, P. & D. C. Freeman (1968). "A dialect study of American r's by X-ray motion picture". *Linguistics, an international review* **44**:29-68.

Disner, S. F. (1983). *Vowel quality: the relation between universal and language-specific factors.* UCLA Ph.D. dissertation, distributed as *UCLA Working Papers in Phonetics* **58**.

Eckert, P. (1989). "The whole woman: sex and gender differences in variation". *Language Variation and Change*, **1**:245-267.

Espy-Wilson, C. Y. (1987). *An acoustic-phonetic approach to speech recognition: application to the semivowels.* MIT Ph.D. dissertation, distributed as *RLE Technical Report* **531**.

Fant, G. (1960). *Acoustic theory of speech production.* Mouton.

Fant, G. (1973). *Speech sounds and features.* The MIT Press.

Fernald, A. & P. K. Kuhl (1987). "Acoustic determinants of infant preference for motherese speech". *Infant Behavior and Development* **8**:181-195.

Flege, J. E. & K. P. Massey (1980). "English prevoicing: random or controlled". Written version of paper presented to the Linguistic Society of America, 2 August 1980, Albequerque, NM.

Fougeron, C. & P. Keating (1995). "Demarcating prosodic groups with articulation". *Journal of the Acoustical Society of America* **97**(5.2):3384.

Hagiwara, R. (1994a). "Three types of American /r/". *UCLA Working Papers in Phonetics* **88**:55-62.

Hagiwara, R. (1994b). "Sex, syllabic [ɹ̩], and the American English vowel space." *UCLA Working Papers in Phonetics* **88**:63-90.

Henton, C. G. (1987). "Phonetic considerations for the synthesis of female voices". In *Proceedings of the Eleventh International Congress of Phonetic Sciences* **3**:270-273.

Henton, C. G. (1992). "The abnormality of male speech". In G. Wolf (ed.), *New Departures in Linguistics*, Garland Press.

Henton, C. G. & A. Bladon (1985). "Breathiness in normal female speech". *Language and Communication* **5**.3:221-227.

Henton, C. G. & A. Bladon (1988). "Creak as a sociophonetic marker". In L. M. Hyman & C. N. Lee (eds.), *Language, speech and mind: studies in honor of Victoria A. Fromkin*. Routledge, Chapman & Hall.

Hillenbrand, J., L. A. Getty, M. J. Clark, & K. Wheeler (1995). "Acoustic characteristics of American English vowels". *Journal of the Acoustical Society of America* **97**.5:3099-3111.

Ingenmann, F. (1968). "Identification of the speaker's sex from voiceless fricatives". *Journal of the Acoustical Society of America* **44**.4:1142-1144.

International Phonetic Association (1993). "The International Phonetic Alphabet (revised to 1993)". *Journal of the International Phonetic Association* **23**.1:centerfold.

Johnson, K., P. Ladefoged & M. Lindau (1993). "Individual differences in vowel production. *Journal of the Acoustical Society of America* **94**.2:701-714.

Karlsson, I. (1991). "Female voices in speech synthesis". *Journal of Phonetics* **19**.1:111-120.

Keating, P. (1990). "The window model of coarticulation: articulatory evidence". In J. Kingston & M. Beckman (eds.), *Papers in Laboratory Phonology I.* The Cambridge University Press.

Keating, P. (1995). "Effects of prosodic position on /t,d/ tongue/palate contact". In *Proceedings of the XIIIth International Congress of Phonetic Sciences* **3**:432-435.

Klatt, D. M. & L. C. Klatt (1990). "Analysis, synthesis, and perception of voice quality variations among female and male talkers". *Journal of the Acoustical Society of America* **87**.2:820-857.

Kuhl, P. K. (1987). "Perception of speech and sound in early infancy". In P. Salapatek & L. Cohen (eds.), *Handbook of Infant Perception Volume II: From Perception to Cognition,*. Academic Press.

Labov, W. (1994). *Principles of linguistic change, volume 1: internal factors.* Blackwell.

Ladefoged, P. (1993). *A course in phonetics (third edition).* Harcourt Brace Jovanovich, Inc.

Ladefoged, P. & I. Maddieson (1995). *The sounds of the world's languages*. Blackwell.

Lehiste, I. (1962). "Acoustical characterisitcs of selected English consonants". *Communication Sciences Laboratory Report* **9**.

Lindau, M. (1985). "The story of /r/". In V. A. Fromkin (ed.), *Phonetic linguistics: essasy in honor of Peter Ladefoged.* Academic Press, Inc.

Moonwomon, B. (1991). *Sound change in San Francisco English (California English).* UC Berkeley Ph.D. dissertation.

Narayanan, S. (1995). *Fricative consonants: an articulatory, acoustic, and systems study.* UCLA Ph.D. dissertation.

Narayanan, S., A. Alwan & K. Haker (1995). "An articulatory study of liquid approximants in American English". In *Proceedings of the XIIIth International Congress of Phonetic Sciences* **3**:576-579.

Ohala, J. (1985). "Around flat". In V. A. Fromkin (ed.), *Phonetic linguistics: essasy in honor of Peter Ladefoged*. Academic Press, Inc.

Peterson, G. E. & H. L. Barney (1952). "Control methods used in a study of the vowels". *Journal of the Acoustical Society of America* **24**.2:175-184.

Schwartz, M. F. (1968). "Identification of speaker sex from isolated voiceless fricatives". *Journal of the Acoustical Society of America* **43**.5:1178-1179.

Smith, C. L. (1995). "Contextual influences on devoicing of /z/ in American English". In *Proceedings of the XIIIth International Congress of Phonetic Sciences* **1**:380-383.

Stevens, K. N. (1980). "Acoustic correlates of some phonetic categories". *Journal of the Acoustical Society of America* **68**.3:836-842.

Syrdal, A. K. & H. S. Gopal (1986). "A perceptual model of vowel recognition based on the auditory representation of American English vowels." *Journal of the Acoustical Society of America* **79**.4:1086-1100.

Titze, I. (1989). "Physiologic and acoustic differences between male and female voices". *Journal of the Acoustical Society of America* **85**.4:1699-1707.

Uldall, E. (1958). "American 'molar' r and 'flapped' t". *Revista do Laboratorio de Fonética Experimental da Faculdade de Letras Da Universidade de Colombra*, IV.

UCLA Phonetics Laboratory (1990). "Dissection of the speech production mechanism". Distributed as *UCLA Working Papers in Phonetics* **77**.

Veatch, T. C. (1991). *English vowels: their surface phonology and phonetic implementation in vernacular dialects.* University of Pennsylvania Ph.D. dissertation.

Westbury, J. R., M. Hashi & M. J. Lindstrom (1995). "Differences among speakers in articulation of American English /r/: an X-ray microbeam study". In *Proceedings of the XIIIth International Congress of Phonetic Sciences* **4**:50-57.

Zwicker, E. & E. Terhardt (1980). "Analytical expressions for critical-band rate and critical bandwidth as a function of frequency". *Journal of the Acoustical Society of America* **68**.5:1523-1525.