The BAD-LAD Split: A Phonetic Investigation

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This dissertation is the result of my own work and includes nothing which is the outcome of work done in collaboration except where specifically indicated in the text.

This dissertation does not exceed 20,000 words.

Contents

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Abstract

Though descriptions of the Received Pronunciation (RP), England's 20th-century acrolectal pronunciation, have long commented upon a lengthening of the short-/æ/ vowel before in an ill-defined subset of words, especially those containing a postvocalic /d/ (Jones 1972 [1918]; Wells 1982; Cruttenden 2001), this phenomenon has never been analysed experimentally. One thorough description of this so-called BAD-LAD split was based only on the intuitive categorisations of a single linguist (Fudge 1977); a similar lengthening was investigated in the English of Melbourne, Australia, but the study's methodology is questionable and its results not necessarily reflective of the current situation in British English (Blake 1985). This thesis is a phonetic investigation of lengthening within words containing the short-/æ/ (TRAP) vowel in Southern Standard British English (SSBE), a successor dialect of RP. As such, it is the first of its kind to thoroughly describe the phonetic conditioning of SSBE /æ/ using acoustic measurements of vowel duration.

Twenty-one native SSBE-speaking students at the University of Cambridge, aged 18 to 24, were recorded reading sentences containing 101 monosyllabic and 53 disyllabic words containing the stressed vowel /æ/. Subsequent computer-aided measurement was carried out in Praat (Boersma & Weenink 2015), with vowel durations noted for each token.

Preaspiration was found in the course of acoustic analysis, and was noted separately; this was entirely unexpected, since preaspiration has apparently never before been observed in SSBE. As in Northern, Welsh, and Scottish English varieties, however, subjects were observed to regularly have a section of breathy voice and/or preaspiration between a modal/creaky section of the vowel and a following consonant in monosyllabic words ending in voiceless fricatives and in disyllabic words containing a voiceless fricative or stop after the stressed /æ/ vowel (Hejná 2014, 2015).

In addition to comparing the results of this experiment to previous /æ/-lengthening descriptions, this thesis situates what is dubbed here *secondary /æ/-lengthening* in the context of theoretical descriptions of the TRAP-BATH split, or *primary /æ/-lengthening*. In SSBE, primary /æ/-lengthening has produced a complete phonemic split between words containing the short [æ] of TRAP and words containing the long [ɑː] of BATH. The extensive literature on diachronic and synchronic phonological aspects of different primary /æ/-lengthening patterns across English dialects is directly relevant to the under-researched secondary lengthening of /æ/: the TRAP-BATH split is thought to have originated as durational allophony in 17th-18th century reflexes of the short low Middle English vowel /a/, the same situation as is apparently present in SSBE /æ/ today. Proponents of Lexical Phonology (Harris 1986, 1989; Kiparsky 1988) have analysed /æ/-raising, the qualitative outcome of primary /æ/-lengthening in North America, arguing that the different phonological operations underlying the wide variety of dialectal patterns represent stages in the evolution of a phonemic split. They model this in terms of the lexical or postlexical rules that produce lengthened /æ/ allophones as well as in terms of implicational weighting hierarchies emergent from a comparison of following segment environments conditioning /æ/-lengthening.

It is demonstrated that the BAD-LAD split represents a deviation from Peterson & Lehiste's (1960) hierarchy of co-articulatory segmental effects on vowel length as well as the patterns of primary /æ/-lengthening described by Harris (1986, 1989) and Labov (1971, 2007). It also does not represent a full phonemic split analogous to the TRAP-BATH split in SSBE; however, diagnostics previously developed for analysing the synchronic and diachronic patterning of primary /æ/-lengthening fail to resolve whether the BAD-LAD split operates as a lexical or

postlexical rule, with consequences for Lexical Phonology's assertion that allophonic contrasts, processed post-lexically, are never involved in lexically-selective change (Harris 1989).

1. Introduction

The vowels of English not only differ between accents, but are also known to have undergone numerous changes throughout history. Long vowels and diphthongs – such as those in the words *beet, bait, bite, boat, boot, bout* – changed especially radically from the Middle English (11th-15th century) to Modern English (16th century onward) periods in what is known as the Great Vowel Shift (Jespersen 1909; Lass 1992). The short vowels – such as those in *bet*, *bat, bit* – stayed relatively stable in comparison. However, in Early Modern English, lengthening took place in a subset of words belonging to the short-/æ/ vowel class; the eventual outcome of this lengthening in England's 20th-century acrolectal accent, the Received Pronunciation (RP), and its successors such as Southern Standard British English (SSBE) has been that TRAP is pronounced with a short [æ], while BATH is pronounced with a long [ɑː].

There have been reports that the TRAP vowel in modern dialects such as SSBE and Australian English has a longer in duration in certain words: Wells (1982) observes that *bad* and *glad* may have longer vowels than those of *pad* or *lad*. Existing descriptions of this purported BAD-LAD split in Britain (Jones 1972 [1918]; Fudge 1977; Cruttenden 2001) are inconsistent and occasionally contradictory, and none are based on acoustically analysed phonetic data. A durational lengthening of the low short vowel seems to have been the very first stage of the lengthening of BATH; experimental investigation into secondary /æ/-lengthening phenomena is therefore valuable for testing theories of sound change, diffusion, and transmission previously put forth to account for the origins of TRAP-BATH splits and the phonological history of the low vowel space in general (Gburek 1985; Harris 1986, 1989; Labov 1971, 1981, 1994, 2007).

Chapter 2 of this thesis begins with an overview of the literature on /æ/-lengthening in Modern English, focusing on phonological analyses of the TRAP-BATH split and descriptions of the purported BAD-LAD split. Chapter 3 then describes the methodology of the present experiment. In Chapter 4, the processing of the acoustic data is discussed. In particular, the merits and disadvantages of normalising vowel duration data for utterance rate are considered, and the unexpected appearance of preaspiration in certain phonological environments is addressed. Chapter 5 presents the results of the experiment, followed by a discussion of the findings in Chapter 6. Future directions for research, both in terms of further uses for the data collected in this experiment and in terms of new avenues of inquiry, are suggested in Chapter 7. Chapter 8 concludes this thesis, recapping the experiment and summarising the theoretical implications of the present results.

Especially in dialectology, vowels are often referred to using a word in SMALL CAPITALS representing the set of lexemes containing the same vowel phoneme. While Wells' (1982) lexical set suffices for the treatment of many contemporary shifts in English, the BAD-LAD split falls within what he has defined as the TRAP class. In this paper, BAD will stand for a set of TRAP words purportedly undergoing lengthening, as opposed to LAD words that remain comparatively short. Since this is the first experimental phonetic investigation into the distribution of short-/æ/ between these classes, they should not necessarily be taken to represent lists of lexemes with distributions as definite or consistent as those which Wells (1982) has identified, for instance between TRAP and BATH in RP.

By June 2015, the *Wikipedia* entry for 'Phonological history of English short *A*' had dubbed this phenomenon the BAD-LAD split, though this particular nomenclature does not seem to have originated from any specific study (Wikipedia 2015). Even so, this thesis uses 'BAD-LAD split' as an alternative to 'secondary /æ/-lengthening'.

2. /æ/-lengthening in Modern English: History and Present Status

2.1. Primary /æ/-lengthening: the TRAP-BATH split

In the history of the English language and its progenitors, vowel classes located in the low vowel space have undergone splits and shifts several times. By the 17th century, FACE had risen to approximately a mid-front /eː/ from the Middle English /aː/ in one of the last stages in the Great Vowel Shift (Jespersen 1909; Lass 1992) At first only a handful of words, exemplified by PALM, remained with a long low vowel (Minkova 2014). Words in this remnant long /aː/ lexical set included words with a historical /lm/ coda such as *calm, palm, psalm,* and *alms*; the few native lexical items in English ending with /aː/, such as *ma, pa, mamma, papa, aha, ah, hah, blah,* and *hurrah*; and the rather exceptional word *father* (Wells 1982). Besides these, foreign borrowings into English (like *Bach, façade, Dali*) augmented this class, though varieties have differed in their phoneme assignments for such words (Boberg 1999; Lindsey 1984). The loss of rhoticity in Southern England would also later expand the class to include words like *car* and *start*.

Environment	Current RP /ɑː/	Current RP /æ/
_f#	staff, laugh, giraffe, calf, half	gaff, gaffe, chiffchaff
_fC	craft, shaft, after, laughter	Taft
_θ#	path, bath	math(s), hath, strath
_s#	pass, glass, grass, class, brass	amass, mass, cuirass, bass, ass
_st	last, past, mast, master, disaster, nasty	has, bast, enthusiast, aster, Astor, raster, Rasta(farian)
_sp#	clasp, grasp, rasp, gasp	asp
_sk	ask, flask, mask, basket, casket	Aske, casque, gasket, Ascot, mascot
_sl̩	castle	tassel, hassle, vassal
_sn̩	fasten	Masson
_ns	dance, chance, France, answer, chancel	manse, romance, expanse, cancel, fancy
_nt	grant, slant, aunt, advantage, chanter	rant, ant, cant, extant, banter, canter, antic
_n(t)ʃ	branch, blanch, stanchion	mansion, expansion, scansion
_nd	demand, command, remand, slander, commando	stand, grand, hand, gander, panda, glissando
_mpl	example, sample	ample, trample

Table 1: The incomplete TRAP-BATH split. Adapted from Wells (1982: 232-233).

Short /a/ words (the TRAP vowel class), limited to closed syllables, remained relatively stable among dialects in the Middle English period, with phonetic reflexes ranging from [a] to [æ] (Minkova 2014). In varieties spoken in 17th-18th century southern England, some members of this class, exemplified by BATH, began to lengthen to /aː/, joining the PALM set described above (Wells 1982). This lengthening manifested itself initially as allophonic phonetic variation conditioned by the following segment: TRAP words preceding tautosyllabic voiceless fricatives (e.g. *bath, staff, pass*) were the first to become /aː/. Lengthening also occurred, perhaps slightly later, preceding nasal + fricative clusters (e.g. *dance*, though Wells (1982) does note that some of these entrants to the BATH class originated from a Middle English /aʊ/ rather than /a/) and nasal + voiceless stop clusters (e.g. *can't*). This long allophone – eventually merged completely with PALM – changed in quality, developing a backer, more rounded /ɑː/ (Wells 1982).

Wells (1982: 233) describes this split as "the ossification of a half completed sound change, which seems to have come to a stop well before completing its lexical diffusion through the vocabulary". Table 1 demonstrates this: though lengthening was limited to certain phonological environments, it did not happen categorically within them, only affecting certain words.

	North England	Gen Am	NYC/Phila	RP/Aus		NCS
phonemic inventory	/a/	/æ/	/æ/	/æ/	/ɑː/ (RP) /aː/ (Aus)	/æh/
lexical rules			lengthen before certain tautosyllabic segments, subject to morphological boundaries and various lexical exceptions	BAD-LAD split?		
postlexical rules – extrinsic allophony		lengthen all /æ/ before nasals				
postlexical rules – 'intrinsic' allophony	gradient phonetic conditioning based on voicing, manner, etc. of following segment	gradient raising of lengthened allophones based on manner of following segment	gradient raising of lengthened allophones based on voicing, manner, etc. of following segment, plus sociolinguistic conditioning	gradient phonetic conditioning based on voicing, manner, etc. of following segment		gradient raising of lengthened allophones based on voicing, manner, etc. of following segment

Table 2: Phonological rules governing /æ/ lengthening.

Other dialects of English have also undergone primary /æ/-lengthening in certain words. The diversity of the resulting TRAP-BATH patterns testifies to the various possible outcomes of /æ/-lengthening, and represents different stages of development from gradient allophony to fullblown phonemic split (Harris 1989). Table 2 depicts several of these synchronic patterns, discussed below, in Kiparsky's (1988) Lexical Phonology framework.

In the north of England, to start with, no split has occurred – in such dialects, the PALM class remains unaugmented by arrivals from the TRAP/BATH class. In these cases, there is no phonological rule working on the TRAP/BATH phoneme, and any variation in quality or quantity is of phonetic co-articulatory rather than phonological origin. One example of such variation is the tendency for vowels, *ceteris paribus*, to be longer before voiced consonants than before voiceless consonants. This is so common as to be considered a cross-linguistic universal, though it is magnified in English to the point that vowel duration is a major cue to predicting the voicing specification of a following consonant when it is neutralised through processes like word-final devoicing or glottalisation (Walsh & Parker 1984). In Lexical Phonology, this is seen as a universally-applied postlexical rule operating at the level of phonetic realisation, and as such is forbidden from making reference to higher levels of the grammar such as lexical status or morphological makeup (Harris 1986; Kiparsky 1988).

It is likely that the first English-speaking settlers of North America brought over a long Early Modern English /aː/ allophone, which raised along the front of the vowel space in North America rather than backing and rounding as in RP (Labov 1981). In the case of General American English, regular, phonetically-conditioned allophonic variation has emerged between approximately short [æ] and long [ɛᵊ] reflexes of a single phoneme. The most common system is the raising of /æ/ before nasal and/or velar consonants, producing long/raised/tense/peripheral *can* [kɛᵊn] but lax/short/non-peripheral *trap* [tɹæp] (Labov 2007). This lengthened allophone does not stand alone as its own phoneme; a purely phonological rule conditions lengthening. As a postlexical rule, it again operates regularly and without regard to higher levels of linguistic structure. Unlike in the northern England case, the allophony of the Gen. Am. /æ/ phoneme has undergone what Harris (1986) would deem 'phonologisation as a postlexical rule': an 'intrinsic' contrast, originally emergent from co-articulatory considerations, has become governed by a phonological rule, though without being implicated in a split. In the final level of postlexical rules governing phonetic realisation – applying after the postlexical rules creating 'extrinsic' allophony – the extent of raising of the long pre-nasal allophone may be subject to various intrinsic phonetic factors (Labov 2007).

In New York City, though, the relationship between TRAP and BATH has become phonologised as a lexical rule, operating at a higher level in the linguistic structure; a similar rule operates in Philadelphia (Ferguson 1972; Harris 1989; Labov 2007). Unlike in Gen. Am. English, the rules governing which lexemes lengthen in these dialects are sensitive to syllable structure (barring tensing in open syllables), morphological structure (preserving tensing before inflectional suffixes), and lexical status (barring tensing in function words and foreign or technical terms), with a plethora of exceptions and irregular conditions (Labov 2007). This has led to minimal pairs such as *can* (noun) [kɛᵊn] vs. *can* (modal) [kæn] and *hammer* (someone who 'hams it up') [hɛᵊmə] vs. *hammer* (tool) [hæmə]. Labov (1981) argues that in these dialects, the TRAP-BATH split is a phonemic one, operating not as a phonological rule but rather with words learned as belonging to one class or the other, "a distribution of two dictionary entries" (Labov 1981: 287). On the other hand, Harris (1989) and Kiparsky (1988) argue that NYC and Philadelphia still has one underlying /æ/ phoneme from which a raised allophone bath can be derived via lexical rules, despite their complexity. This is discussed further in Chapter 6; for now, Table 2 follows Harris (1989) and Kiparsky (1988).

Exemplifying another lengthening pattern, dialects spoken in United States cities around the Great Lakes have resolved the complex synchronic lexical rule system of NYC by simply lengthening /æ/ in all environments. This wholesale lengthening of historically short /æ/ to a phonemically long vowel is believed to be the trigger behind the Northern Cities Shift (NCS), a major rearrangement of the vowel system involving nearly the entire short vowel system. As such, Labov, Ash & Boberg (2005) in their *Atlas of North American English* define it as a phonologically long ingliding vowel, using the (non-IPA) notation /æh/. Within this now long TRAP/BATH phoneme, some speakers exhibit gradient variation in the degree (height) of raising along a continuum, with pre-nasal reflexes the highest, followed by voiced stops, fricatives, and voiceless stops (Kiparsky 1988; Labov 2007).

Harris (1989) asserts that the TRAP-BATH split in southern England (and other derived dialects such as Australian English) has reached a more advanced stage of vowel splitting than the NYC system, with the phoneme inventory restructured such that "the majority of words in [the BATH] class are non-alternating, which makes it impossible to motivate æ-Tensing as a synchronic rule" (Harris 1989: 50). In this case, a bifurcation has emerged within the original short-/æ/ set such that in the completed change, BATH words pattern with the PALM (and

START) sets. Apparent allophony in the (now reduced) TRAP class is the principal subject of this thesis, further explored in the following section.

2.2. Secondary /æ/-lengthening: the BAD-LAD split

Evidence of within-TRAP allophony is (rather appropriately) found in the Oxford-Blackwell *Guide to Old English*, which contains a guide to the "approximate pronunciation of OE vowels for those working without a teacher":

> a as the first vowel in 'aha'
> ā as the second vowel in 'aha'
> æ as in 'mat'
> ǣ as in 'bad' (Mitchell & Robinson 2012: 14)

The footnote next to 'bad' matter-of-factly states that "if you experiment, you will notice that the vowel in 'bad' is longer than that in 'mat', though MnE [æ] is frequently described as a 'short vowel'" (Mitchell & Robinson 2012: 14).

Mitchell & Robinson's (2012) implication that /æ/ does not behave quite like other 'short' vowels is, on its surface, reflective of phonetic factors that do not operate only in Southern Standard British English. Wells (1982) describes the [æ] of the TRAP class as "a front nearly open unrounded vocoid… approximately halfway between cardinals 3 and 4" (Wells 1982: 129). This low 'short' vowel, so categorised because it appears only in checked syllables, is intrinsically longer than higher 'short' vowels such as [ɪ] and [ɛ] due to the mechanics of the vowel space; the tongue and jaw must move a greater distance to go from a consonantal constriction and back again in a low vowel than in a high vowel (Peterson & Lehiste 1960).

The observation that there is a difference in length, but not quality, between *mat* and *bad* reflects another established universal of vowel duration: the voicing of the consonant following /æ/, as with other vowels, has an intrinsic effect on its duration. All else being equal, the vowel before a voiced consonant is longer than before its voiceless counterpart (Peterson & Lehiste 1960). In American English, Peterson & Lehiste (1960) found an approximately 2:3 ratio of the duration of vowels before voiceless consonants compared with vowels before voiced consonants in English; vowels before nasal consonants tend to be somewhere in-between.

z	ð	g	v	m	ŋ	n	ʃ	θ	d	b	s	f	dʒ	t	k	tʃ	p
262	260	243	231	220	218	216	212	208	206	203	199	192	191	147	145	145	138

Table 3: Mean durations (ms) of short vowels by following segment. The measurement for /g/ is apparently a typo. Adapted from Peterson & Lehiste (1960).

There is a general trend for following fricatives to lengthen short vowels more than stops, and following voiced consonants to encourage more lengthening than their voiceless counterparts. This holds also for long vowels and diphthongs. The only exceptional case in Peterson & Lehiste's (1960) data is a remarkable amount of lengthening before /g/, which turns out to be a typo; an accompanying figure indicates that mean short vowel length before /g/ is just over 200ms, in line with what was found for /d/ and /b/. Thus for short vowels as a whole, co-articulatory factors based on features of the following segment account for encourage lengthening along the approximate hierarchy (with voiced stops about equal to voiceless fricatives in encouraging lengthening):

voiced fricatives > nasals > voiced stops/affr. ≈ voiceless fricatives > voiceless stops/affr.
z ð v   m ŋ n   g b d dʒ   ʃ θ s f   t k tʃ p

Wiik (1965), cited in Cruttenden (2001), confirms these findings in an unspecified variety of English (Table 4). Short /æ/ falls between long vowels and the other short vowels in terms of average duration, and following voiced consonants lengthen all vowels more than following nasals, which in turn favour lengthening over voiceless consonants.

	Before voiced C	**Before nasal**	**Before voiceless C**
Short vowels	0.172	0.133	0.103
/æ/	0.234	0.196	0.158
Long vowels	0.319	0.233	0.165
Diphthongs	0.357	0.265	0.178

Table 4: Mean measurements for English vowels (seconds). From Wiik (1965), cited in Cruttenden (2001).

But beyond the intrinsic effect of the voicing and manner of articulation of the following consonant, SSBE TRAP seems to lengthen noticeably before specific words. Authoritative descriptions of the RP have long mentioned a possible split between 'long' and 'short' TRAP words.

As far back as 1918, Daniel Jones reported in *An Outline of English Phonetics* that "æ is the so-called 'short' sound of the letter *a*; examples: *glad* **glæd** or **glæːd**, *bag* **bæg** or **bæːg**, *pad* **pæd**, *cat* **kæt**, *lamp* **læmp**" (Jones 1972 [1918]: 72, italics and boldface in original). Already this short initial description contains apparent counter-examples to simple allophony based on the voicing environment, as some words (*glad, bag*) are optionally long. He continues:

> In the South of England a fully long **æ**: is generally used in the adjectives ending in *-ad* (*bad* **bæ:d**, *sad* **sæ:d**, etc.), and is quite common in some nouns, e.g. *man* **mæ:n** or **mæn**, *bag* **bæ:g** or **bæg**, *jam* **dʒæ:m** or **dʒæm**… the **æ** appears to be more usually short in *nouns* ending in *-ad* (*lad* **læd**, *pad* **pæd**, etc.).
>
> Long **æ**: is frequently found before voiced consonants, but is not confined to these situations. Thus the words *back, that* (meaning 'that thing' at the end of a sentence) are often pronounced with long **æ**: by some Southern English people (Jones 1972 [1918]: 235).

The inclusion of *back* and *that* optionally lengthening sentence-finally suggests that the lengthening rule may not only affect vowels before voiced stops, though on the whole this description is far from exhaustive.

Gimson's Introduction to the Pronunciation of English (Cruttenden 2001) distinguishes between "[æ:] (before /b,d,g,dʒ/) and [æ] – cab, cap; bad, bat; bag, back; badge, batch" (Cruttenden 2001: 111). This lengthened reflex

> …is now generally longer in RP than the other short vowels /ɪ,e,ʌ,ɒ,ʊ/. Such lengthening is particularly apparent before voiced consonants, e.g. in *cab, bad, bag, badge, man*; /æ/ in these contexts is almost equivalent to the long vowels, so *badge* /bædʒ/ and *barge* /bɑ:dʒ/ have vowels of similar length. Moreover, some RP speakers in the south of England appear to have a contrast between short /æ/ and long /æ:/ which shows up in a limited number of minimal pairs like *jam* (to eat) (and probably also *jamb*) as [dʒæm] and *jam* (of traffic) [dʒæ:m] (Cruttenden 2001: 111).

This description is quite different: Cruttenden (2001) mentions no within-/d/ or -/g/ split of nouns and adjectives, describing all TRAP words before voiced stops as long; on the other hand, Jones's (1972 [1918]) mention of optional lengthening in *jam* is described here as a possible lexical split.

Wells (1982) describes this phenomenon as "marginally contrastive long /æ:/", focusing particularly on the vowel in pre-/d/ environments:

> It shows up in pairs such as *bad* [bæ:d] vs. *pad* [pæd], *glad* [glæ:d] vs. *lad* [læd]. Long [æ:] may also occur before other lenis consonants, as *jam* [dʒæ:m], *jazz* [dʒæ:z]; but it is rare to find contrastive length in environments other than that of a following /d/. There are those who have a large number of minimal or near-minimal pairs, as in the speech of south central England… but this is perhaps best regarded as a Near-RP provincialism rather than as a mainstream RP possibility. There are in any case many RP speakers who have no such contrast, making *bad-pad-glad-lad* perfect rhymes. Even those who do potentially make the distinction may in fact make it only in strongly stressed environments. The commonest basis for the contrast is that monosyllabic adjectives end in [-æ:d] but nouns in [-æd].

> Hence *bad, clad, glad, mad, sad* have the long vowel, but *cad, dad, fad, pad* the short one. The verbs *add, had* are variable. The adjective *trad*, being a reduction of the polysyllable *traditional*, is short. The opposition is usually retained before *-ly* and the inflectional endings *-er, -est,* so that *badly* fails to rhyme with *Bradley*, while *mad#der* 'more mad' is [ˈmæːdə], distinct from *madder* '*Rubia* plant, red dye' [mædə] (288-9).

This description is more thorough. Wells (1982) echoes Jones's (1972 [1918]) reporting of lexeme-specific lengthening before /d/, affecting especially adjectives, and adds that shortenings of multisyllabic words have a short vowel, while lengthening is sensitive to morphological composition in disyllabic words incorporating the affected lexemes.

Beyond these descriptions of /æ/-lengthening, only Fudge (1977), a native RP speaker from Hampshire, recorded his own (dizzyingly complex) lexical split between long and short /æ/ in an attempt to find patterns in his own system (Tables 5 and 6).

short [æ]	**uncertain**	**long [æː]**
cab, crab, dab, gab, jab (verb), nab, stab, tab	flab, scab, slab	blab, drab, fab, grab, jab (noun), lab
ad, add, brad, clad, Dad, gad, had, pad, plaid, trad	fad	bad, cad, glad, lad, mad, sad
cadge		badge, Madge
crag, drag (verb), flag (droop), lag (verb), mag, nag, shag, stag, swag, tag, wag (verb)	hag, scrag	bag, brag, drag (something tedious), fag, flag (noun and derived verb), gag, rag, sag, slag, wag (humourist)
have	lav	
as, has	razamatazz	Baz, Daz, jazz
cam, clam, damn, scram, sham, slam, Spam, swam, wham	cram, ham, ma'am	dam, jam, jamb, lamb, Pam, pram, ram, Sam, tram, yam
an, Ann, began, bran, can (modal), can-can, clan, Gran, Nan, pan, plan, Suzanne, tan, than	fan, flan, span, Stan	ban, banns, can (noun and derived verb), man
and, band, bland, brand, expand, gland, grand, land, Rand, strand, Strand		hand, sand, stand, understand
fanned, panned, planned, scanned, spanned, tanned		banned, canned, manned

Table 5: Fudge's (1977) /æ/-lengthening system, monosyllabic words.

short [æ]	long [æː]
bandy, brandy, Mandy, dandy, randy	Andy, candy, handy, sandy, Sandy, shandy
Amanda, panda, propaganda	Veranda
dandle, Mandell, Randall	candle, Handel, handle, sandal, scandal, vandal
Anderson, coriander, glanders, meander, pander, philander, pomander, salamander	gander, sander
banded, branded, landed, stranded	candid, handed, sanded
branding, landing, expanding	handing, sanding, standing, understanding
bandied	candied
Ha(d)dow	shadow
caddy, Daddy, faddy, paddy	baddy
adder, sadder, madder (colour)	bladder, ladder, madder (more mad)
gladden, sadden, Madden (name)	madden (drive mad)
anno (domini), Meccano	piano
annals, channel, panel	flannel
scanner, spanner, tanner	banner, manner, manor
blabber, jabber	drabber (more drab)
cadger	badger
clammy, chamois, Mammy	jammy
damson	Ramsey

Table 6: Fudge's (1977) /æ/-lengthening system, multisyllabic words.

Among the patterns he observes in his own idiolect are that while the short vowel cannot not be replaced by the long vowel, it seems possible to shorten the vowel in 'long' words; monosyllables with voiceless stops in their coda (including nasal + voiceless stop clusters) are always short, in opposition to Jones's (1972 [1918]) suggestion of *that* and *back* lengthening; and all final voiced consonants and clusters permit both long and short /æ/ except for /ŋ/, before which only short /æ/ is allowed. He notes not only a number of minimal pairs (e.g. *drag* verb vs. noun), but several near-minimal triplets such as p[æ]nder vs. g[æː]nder vs. sl[ɑː]nder.

In Melbourne, Australia, Blake (1985) goes a step further than Fudge (1977) in collecting data from his community. Australian English, though distinct from SSBE, is closely related and shares most of the same distribution of environments in its TRAP-BATH split. He finds lengthened tokens in monosyllables before /g/, in the words *mad, bad, glad,* and *sad*, before nasal + voiced obstruent clusters other than /ŋ/, and in diysllables before voiced obstruents, nasals, and coda consonant clusters containing a voiced initial segment (Table 7).

environment	æ (LAD)	ms	æ: (BAD)	ms	a: (BATH)
voiceless stop#		110		-	220
voiced stop#	*pad*, *had*, etc. and short tokens of *lab*, *fab*, etc.	170	*mad*, *bad*, *glad*, *sad*, plus *–ag* words	280	330
voiceless fric#		160		-	250
voiced fric#		230		-	380
nasal+(voiced obs)#	-*ang* words plus short tokens for *am* and *can* (aux)	190		280	320
lateral+(voiced obs)#		180		-	300
nasal+voiceless obs#	*bank*, *thank*	140	*ant*, *camp*	180	210
lateral +voiceless obs#	*shalt* plus nonsense words *hales, halp, halsh*	150		-	-
voicless obs+vowel		100		-	180
voiced obs+vowel		150	*baddie, bagging, madder* (more mad), *sadder*	220	24
nasal or lateral+vowel	*hammer, panel, Canna, clammy, Tammy, planet, palace, malice, personality*	110	*jammy, canner*	180	190
CC [first consonant voiced]	*Hamlet, hamlet, tablet, advent, abdicate, fabric, algebra, palpitate, banker*	110	*anvil, Anzac, cranberry, dandruff, amber, manly, Manly, Tandy, bandit, handy, anthem, antics, chancellor, expansion, fancy, frantic, stampede, answer, Fanta* (soft drink), *magpie* (long tokens), *fragment* (long tokens), *madly, sadly*	180	190

Table 7: Melbourne LAD-BAD-BATH duration comparisons, adapted from Blake (1985).

However, as is clear from Table 7, Blake's (1985) measurements seem to have been problematic. By sorting 'long' from 'short' tokens impressionistically before measuring them – even within lexemes for which he apparently observed alternating lengths – he did not let the data speak for itself. This makes it difficult to directly compare his observations with other descriptions of /æ/-lengthening. In addition, differences between his purported 'long' and 'short' classes are not always large: he reports a mean of 140ms for his 'short' vowels before nasal + voiceless obstruent clusters like *bank* and *thank*, and 180ms for 'long' ones like *ant* and *camp*. This difference of 40ms falls within the range of 'just-noticeable differences' in duration for speech sounds established by Lehiste (1970). This casts some doubt upon Blake's (1985) ability to consistently sort 'long' from 'short' tokens by ear.

In addition, Ferguson (1972), in his treatment of the Philadelphia /æ/-lengthening pattern, notes that alongside a short/lax allophone and a long/raised one, there exists a very small number of words that appear to have a lengthened lax /æː/: these words are *salve* and *baaed* (past tense of a sheep making noise), as well as items normally pronounced with the short allophone in sentence-final contexts or with contrastive stress. As no other studies in North America have mentioned a BAD-LAD split, this comparatively minor observation will not be considered further, though its applicability to current-day Philadelphia speech would be interesting to investigate.

2.3. Phonetic conditioning of both primary and secondary /æ/*-lengthening*

Labov (1971) describes a "rigorous demonstration of a dialect continuum" through the comparison of /æ/-raising patterns in the American Mid-Atlantic states in a "temporal and spatial matrix" (Labov 1971: 427). Table 8 reproduces his matrix, showing that the raising of /æ/ in any particular phonological environment is dependent on the possibility of raising in other environments further down a hierarchy. So, for instance, the NYC system allows raising in environments more favourable than /v/ and /z/ (/m, n, f, θ, s, d, b, ʃ, g/), but not before /p, t, k/; /v/ and /z/ words seem to not pattern regularly (with *avenue* seemingly the only /v/ word raised, and *jazz* raising sporadically) (Labov 2007). In Philadelphia, by contrast, /m, n, f, θ, s/ are consistent raising environments, but *mad, bad,* and *glad* are the only pre-/d/ words to raise. The systems of other smaller towns fill in the gaps in the matrix.

	m, n	f, θ, s	d	b	ʃ	g	v, z	p, t, k
Buffalo	+	+	+	+	+	+	+	+
NYC	+	+	+	+	+	+	±	-
Jackson	+	+	+	+	+	±	-	-
Ringoes	+	+	+	+	±	-	-	-
Mammouth Junction	+	+	+	±	-	-	-	-
Philadelphia	+	+	±	-	-	-	-	-
Birdsboro	+	±	-	-	-	-	-	-

Table 8: Matrix of lengthening environments, adapted from Labov (1971)

Harris (1986, 1989) asserts that /æ/-lengthening takes place along a recurrent hierarchy of implicational weighting, and that the emergence of this hierarchy can be explained as 'intrinsic' constraints on phonetic articulation becoming more and more pronounced. In this way, very minor durational differences due to operations in phonetic spellout may at some point phonologise as rule-governed allophonic variation; after phonologising, they have the potential to become rules operating at the lexical level (as he argues is the case in NYC) or fully phonemicise as a split. Harris (1989) states that "broadly speaking (ignoring place-of-articulation details), the implicational hierarchy is (ordered from most to least favourable): voiceless fricatives > nasals > voiced oral non-continuants > voiceless stops" (Harris 1989: 48). This contradicts both Peterson & Lehiste's (1960) co-articulatory lengthening hierarchy for other short vowels (Table 3) and Labov's (1971) lengthening hierarchy; for now, though, a hybrid of Harris's (1989) hierarchy and Labov's (1971) hierarchy will be used to situate TRAP-BATH splits in relation to each other and reported BAD-LAD patterns (Tables 9 and 10).

Table 8, representing different stages in the development of synchronic systems of /æ/-lengthening, can be augmented by adding other relevant dialects to the comparison. In Table 9, the dialects considered in Section 2.1 are compared in this way. The Northern Cities Shift (classified as 'Buffalo' in Table 8), exhibits lengthening before all segments (shaded dark green), while dialects in the North of England fail to generate any lengthened allophones (shaded red). In-between, the NYC and Philadelphia systems show regular lengthening in certain environments (dark green), no lengthening in some (red), and highly lexically-specified or irregular lengthening in others (light green). The behaviour of vowels before liquids like /r/ and /l/ often patterns separately, so these environments are not considered in this thesis; the comparatively rare /ð/ phoneme is also excluded due to few studies including instances of it, though /ŋ/, glossed over by Labov (1971) (Table 8), is included.

	f	θ	s	m	n	d	dʒ	b	g	ʃ	v	z	ŋ	p	t	tʃ	k
NCS																	
NYC																	
Philadelphia																	
RP																	
AusE																	
Gen Am																	
North England																	

Table 9: TRAP-BATH splits along a lengthening hierarchy.

The TRAP-BATH splits of both RP and Australian English fit broadly into this matrix between the NYC and Philadelphia systems; the lengthening environments for BATH are before voiceless fricatives excluding /ʃ/, and coda clusters beginning with a nasal, excluding /ŋ/. Australian accents variably include these /n/ and /m/ clusters in the lengthened BATH class; varieties that lengthen words such as *dance* and *rant* may be considered to pattern with the row labeled 'RP' in this hierarchy matrix (Horvath & Horvath 2000).

Interestingly, when General American English is included in the matrix, its lengthening pattern does not fit this hierarchy. Labov (1971) puts /m, n/ at the top of his hierarchy (Table 8), and elsewhere states that in North American dialects, "the most favored subset for raising are words ending in final front nasals: *hand, man, ham* etc., which are raised almost everywhere" (Labov 1981: 284). On the other hand, In addition, though /ŋ/ seems to inhibit lengthening in other dialects and is therefore excluded from Labov's (1971) matrix, it is a lengthening environment in General American English. These inconsistencies indicate that perhaps there exists no single 'natural' hierarchy of lengthening.

The BAD-LAD patterns introduced in section 2.2 can be overlayed on this coloured matrix to compare where lengthening of TRAP has been attested (Table 10). The authorities on RP, however, do not always agree on the environments in which /æ/ lengthens. Cruttenden (2001), for instance, fails to mention within-environment splits except for a possible minimal pair between *jam* (preserve) and *jam* (traffic) (marked with a ±), stating only that /æ/ lengthens regularly before /d, dʒ, b, g/ (marked with a +). He also does not explicitly *reject* possible lengthening in other environments, which are left blank. On the other hand, Jones (1972 [1918]) and Fudge (1977) both specify that while short /æ/ is never replaceable by long /æː/, the reverse does not hold; for them, such environments are marked '±', including, for Jones, /t/ and /k/, as he mentions lengthening in *that* and *back*.

	f	θ	s	m	n	d	dʒ	b	g	ʃ	v	z	ŋ	p	t	tʃ	k
NCS																	
NYC																	
Philadelphia																	
RP (Jones)				±	±	±			±						±		±
RP (Cruttenden)				±	±	+	+	+	+								
RP (Wells)				+		±						+					
RP (Fudge)	-	-	-	±	±	±	±	±	±	-	±	±	-	-	-	-	-
AusE (Blake)	-	-	-	±	±	±		-	+	-	±	±	-	-	-		-
Gen Am																	
North England																	

Table 10: TRAP-BATH splits (colour), overlaid with BAD-LAD observations (symbols).

It is striking that the most favourable environment for the historical lengthening of /æ/ according to Harris (1989), voiceless fricatives, has not been implicated in a the BAD-LAD split in any of its descriptions; Fudge (1977) and Blake (1985) explicitly rule out these environments as allowing lengthening, and none of the three general descriptions of RP make any mention of /f, θ, s, ʃ/. If indeed the TRAP-BATH split originated as inherent phonetic variation comparable to what is observed in BAD-LAD phenomena, the failure of /æ/ to lengthen in these leading environments poses another challenge to Harris' (1986, 1989) implicational weighting hypothesis.

As is clear from Table 10, descriptions of the BAD-LAD split in SSBE occasionally contradict each other. None of them to date have involved collecting data from a large number of idiolects or the actual measurement of vowel durations. In the absence of such sociophonetic data, the behaviour of the TRAP vowel in SSBE remains unclear. The present study, described in the following chapters, attempts to fill this gap and thereby enable discussion on the relationship between secondary /æ/-lengthening phenomena and the established TRAP-BATH split as well as apparent inconsistencies between Harris' (1986, 1989) and Labov's (1971) models of 'natural' lengthening condition hierarchies.

3. Experiment

3.1. Preliminary interviews: two linguists' intuitions

In preparation for the phonetic experiment described here, two consultations were carried out with native SSBE speakers in order to gather information on words they each intuited to contain 'long' or 'short' /æ/. This was done firstly to verify the patterns discussed in Chapter 2, and secondly to find possible minimal pairs to test on naïve subjects. Both speakers were postgraduate students in the Department of Theoretical and Applied Linguistics at the University of Cambridge. As trained linguists, they were hardly the type of subjects most experiments aim to recruit. However, their heightened awareness of their own speech and familiarity with mainstream phonemic theory enhanced their ability to target possible minimal pairs and find patterns in their own systems (cf. Fudge 1977).

The linguists hailed from different parts of the South: the first from Chatham, Kent born in 1992 and the second from Bristol, born in 1989. Both had been educated at state schools before university, and both had some level of awareness of a BAD-LAD duration split in their own idiolects. In an informal open-ended elicitation session, Linguist #1 made the following judgments about whether or not he would classify a word as 'long' or 'short' in his own speech (Table 11).

Linguist #1 reported a difference in vowel duration between *ram* (long) and *RAM* (short), as well as *mad* (long) and *MAD* (short), raising the possibility that minimal pairs may exist in which an etymologically longer-attested word contrasts in length with a newer word or acronym (cf. short *trad* mentioned in Wells 1982). However, *cad* and *CAD* were both intuited as short. He observed that several words were thought of as 'American' (*gal, pal*), and thus could not be lengthened. While he originally categorised the onomatopoeic *bam* as short, he later could not decide on its length; after initially not having a strong intuition about *mad*, he later categorised it as long, and decided that *grad*, *brag*, and *jab* were short. When considering *jag*, he raised the possibility of a minimal pair between long *jag* (Jaguar automobile), and short *jag* (sharp projection).

In a similar meeting, Linguist #2 claimed the intuitions outlined in Table 12. For this speaker, Though initially unsure of *damn*, he later decided it was long. In his estimation, strong preterits like *ran, began*, and *rang* were short; this stands in opposition to Linguist #1's intuitions of long *ran* and *began*.

short [æ]	uncertain	long [æː]
pad, lad, fad, tad, cad, CAD, grad, MAD (mutually-assured destruction), Vlad	glad	bad, sad, mad
brag, wag, lag, stag, rag, slag, crag, jag (sharp)		bag, jag (Jaguar)
jab, grab, crab, lab, cab, stab, fab, slab, blab		
can (modal), can (noun)		ran, man, tan, plan, man, began
RAM	ham	ram, Sam, Tam, pram, cram, exam
gang, sang		
pant, pants		
cramp, lamp		
sank, bank, drank		
Sal, gal, pal		
avenue, chav, gavel		
maths		
mafia		

Table 11: Idiolectal intuitions of /æ/ length, from Linguist #1.

short [æ]	uncertain	long [æː]
pad, lad, tad, Vlad, cad, CAD, add		bad, glad, sad
tag, brag, sag		bag
(door) jamb, dam, RAM, ram, swam		Tam, jam (traffic, preserves), damn
ran, began		
rang, sang		
cant (song)		
cash, cache, bash		
badger		badge
	jazz	

Table 12: Idiolectal intuitions of /æ/ length, from Linguist #2.

Both linguists, as well as other Brits consulted, pointed out that *lad* may have northern connotations for some southern speakers. As northerners lack the TRAP-BATH split, southerners may associate short-/æ/ sounds – especially with a centralised [a] quality – with northern words and speech. This raises the possibility that calling this phenomenon the BAD-LAD split may need to be reconsidered in the future if indeed *lad* is an exceptional word in the short class.

3.2. Choice of words

Based on the theoretical importance of establishing the behaviour of /æ/ before voiceless fricatives (Chapter 2) and the patterns emerging from the native speaker interviews (Section 3.1), 101 unique monosyllabic and 53 disyllabic words were chosen for targeting (Appendix A). These included stressed syllables containing /æ/ preceding the range of consonants covered by the hierarchies outlined in Chapter 2. *Began,* the only disyllabic word in the sample with stress on the second syllable, is counted as 'monosyllabic', as its stressed syllable is more comparable with the one in '*a man*' than in '*manning*'. Several homophonous but lexically distinct pairs were targeted, and several pairs of words were balanced such that all segmental features were identical save the voicing of the coda consonant (e.g. *bag*/*back, hag*/*hack*).

Carrier sentences were constructed with two clauses (Appendix B). The first clause could be of varying length and usually established a semantic context for identifying the appropriate target lexeme. The second clause, always following a comma, contained exactly five syllables preceding the targeted stressed syllable containing /æ/. The targeted word was always placed sentence-finally; any effect of utterance-final lengthening would have affected all target words equally.

In addition to /æ/ words targeted, 25 sentences were added targeting the anchor vowels of FLEECE, FACE, PRICE, NORTH, STRUT, BATH, and pre-/l/ THOUGHT and GOOSE. These were collected for the normalisation of the speakers' vowel spaces, an important step in comparing speakers' vowel qualities. Though this thesis does not address vowel quality, future analysis of the data will do so (see Chapter 7).

3.3. Subjects

Twenty-seven students from the University of Cambridge, aged 18 to 24, were recruited through departmental listservs and college Facebook groups and were paid £3.50 for completing the approximately 15 minute task (in conjunction with another MPhil candidate, who paid them another £3.50 for their participation in her unrelated task in the same visit). Information on participants' ages, where they were raised, where they had gone to school, and their parents' educational and occupational backgrounds was collected. Of these 27 recordings, 21 were chosen for further analysis; six were excluded due to erratic utterance rates, towns of origin outside the typical area covered by SSBE, and other technical issues.

Fifteen of the participants analysed in this study identified as white British, while two identified as mixed ethnicity, one as Indian, and one as Chinese. Two others declined to provide race/ethnicity identification. Most participants were not the first in their families to attend university.

Subject (M/F)	*Age*	*Origin*
F01	19	Sevenoaks
F02	19	Bury St Edmunds
F03	21	East Sussex
F04	22	Hastings
F05	20	Oxford
F06	20	London
F07	24	Cambridge
F08	19	Somerset
F09	24	Leicester
F10	23	Cambridge
F11	21	Surrey
F12	18	Oxford
F13	21	London
F14	23	London
F15	20	Margate
M01	19	London
M02	18	Crowborough
M03	20	London
M04	18	Denham
M05	24	Surrey
M06	23	Radlett

Table 13: Subjects of this experiment

Participants in this experiment were required to be speakers of SSBE, though the definition of 'Southern England' was deliberately left open-ended. The sample ended up containing students from across southern England, mostly from London and the home counties but also one from Leicester farther north, one from Somerset in the west, two from Oxford, and three from East Anglia (Figure 1).

SSBE shares most key features with RP, and can be considered its successor dialect. While RP is a social variety defined not by its geographic spread but by its historical status as a target for well-educated Brits and foreign learners, SSBE is an accent of the south-east of England that similarly holds influence as a prestige norm (Jones 1972 [1918]). It is 'standard' in that English speakers who gain education and social mobility are likely to modify their accents in the direction of SSBE and away from other regional characteristics (Nolan et al. 2009). Though certainly not as extensively as in the past, students at the University of Cambridge still tend to conform to this standard pronunciation, especially in formal settings such as reading sentences into a microphone. Thus, for instance, Cambridge students from London would be unlikely to utilise non-standard features such as /th/-fronting in their most formal styles.

It was checked that the speech of all participants contained the most salient features of SSBE, namely an open back [ɑː] in the BATH vowel and fully vocalised non-prevocalic /r/. Nolan et al. (2009) excluded from their DyViS sample speakers who fronted /θ/ to [f] and vocalised coda /l/; though /th/-fronting was not observed in the recordings, again perhaps due to the formal nature of the task, there were many instances of /l/-vocalisation. Speakers with tokens exhibiting /l/-vocalisation were still included in the sample.

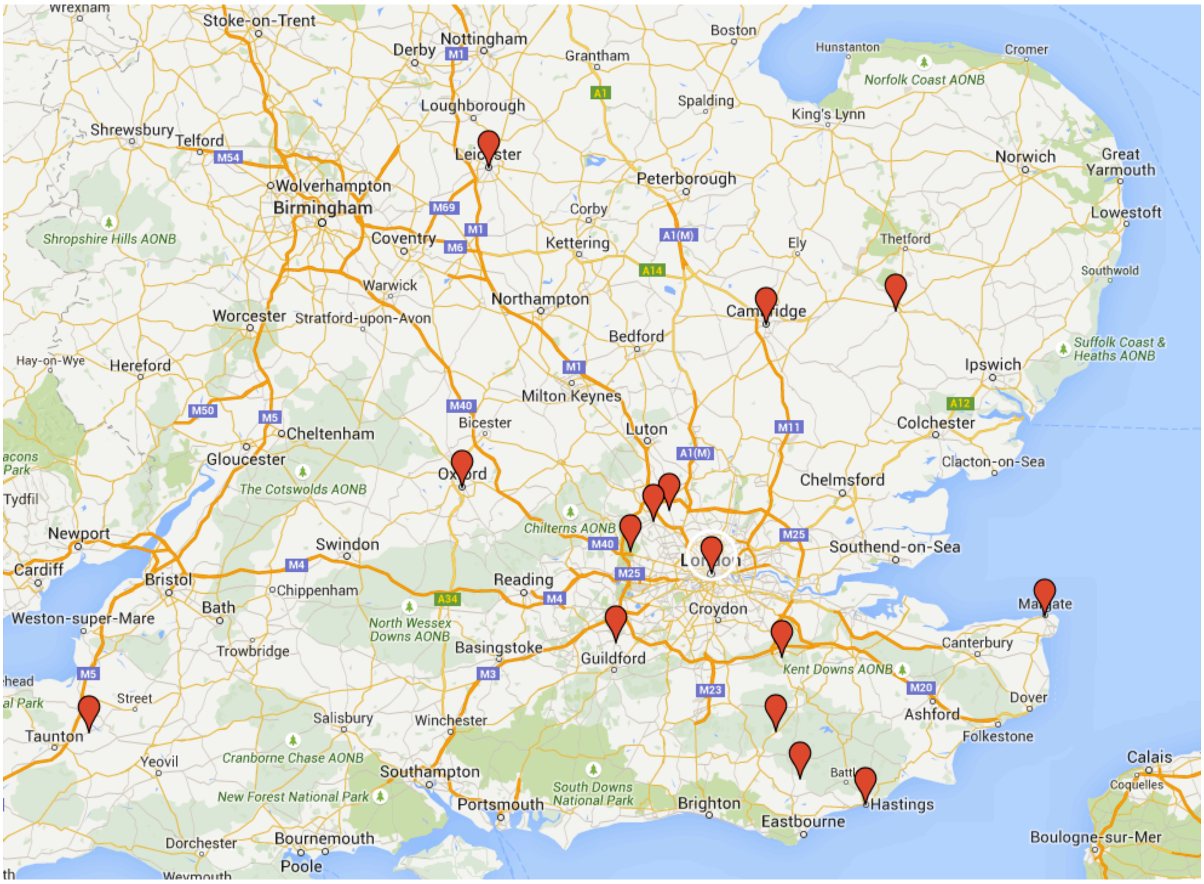

Figure 1: Map of participants' towns of origin. Note that multiple participants came from Cambridge, Surrey, and London, though only one locator denotes these locations.

4. Data Processing

4.1. Utterance rate and duration: to normalise or not?

Piercy (2010), in her investigation of the TRAP-BATH split in Dorset English, also wished to compare the durations of vowels in historical short-/æ/ words. Duration was important to her investigation because the initial stage of the TRAP-BATH split is agreed to have been allophonic lengthening of short-/æ/ in certain environments, followed by a phonemicisation of the length distinction that then allowed for BATH to be backed toward [ɑː] (Wells 1982; Minkova 2014). In order to accurately determine the phonemic status of speakers' BATH words, she wanted her vowel duration data to be comparable both within speakers and across speakers, necessitating some sort of normalisation to account for speech rate.

In deciding whether to normalise or not, Piercy ran tests on two principle sets of duration data, dubbed RAW and NEW. The RAW set was comprised of non-normalised vowel lengths, while the NEW set normalised these lengths by multiplying the duration of the vowel in seconds by the speech rate; the speech rate itself was calculated by dividing the number of syllables in the intonation phrase (IP) by the duration of the IP in seconds. She decided to use the NEW dataset after running various statistical tests on both sets, finding that NEW, but not RAW, revealed a bimodal distribution of durations for the TRAP/BATH vowel in a speaker who otherwise made no distinction between the two classes in quality.

However, in the case of the current study, several of the advantages of normalisation seem not to apply. For one, Piercy (2010) analysed casual freely-produced speech, which is liable to changes in utterance rate between intonation phrases, even within speakers. Data for the present study was elicited in a controlled environment, with subjects reading sentences for approximately 15 minutes in a sound booth. Within-speaker utterance rates would therefore be less likely to vary as widely. Sentences were also constructed such that targeted words always came at the end of their constituent utterance, with five syllables preceding the accented syllable of the target word. This would further discourage large deviations in utterance rate, making vowel length measurements comparable.

Ideally, for each token in the dataset as a whole, there would be corresponding measurements for vowel duration as well as utterance duration; Piercy (2010) made her normalisation decision based on comparing normalised and non-normalised TRAP durations for her entire dataset. However, using Praat to mark the beginning and end of each utterance as well as the beginning and end of each vowel more or less doubles the amount of time spent on measurement. It was therefore decided that a subset of three subjects would have both their vowels and utterances measured in order to test whether normalisation had a positive effect and should be carried out with the rest of the data.

Since each utterance – counted as the second clause of the presented sentence, separated from the first by a comma – contained five syllables preceding the targeted stressed syllable, calculation of utterance rate (syllables per second) was relatively straightforward. It was occasionally the case that speakers paused in the middle of the clause; these utterances were not measured, and those tokens could not be included in the normalised set.

In addition to the 150 words tested once for each individual, the target words *bad, glad, sad,* and *mad* were included four times each, embedded in four different sentences. These four iterations of the same word, in clauses constructed to have a variety of foot structures and possible carriers of emphasis, provided an important measure of intra-word variation. Since the BAD-LAD split, in all prior literature, has been described as a relatively consistent lengthening of a set of TRAP words, any study trying to quantify 'short' and 'long' by experimental means must take into account each lexical item's natural intra-speaker degree of vowel length variation. If the point of normalisation is to account for such inherent variation, the best dataset should be the one in which intra-speaker, intra-word variation is minimal.

For each of the three speakers chosen for this test, two datasets were first created: a raw, non-normalised set of their monosyllabic tokens and a normalised set of their monosyllabic tokens passed through Piercy's NEW normalisation formula (duration of a token's vowel times the speech rate of that token's IP). In order to make these two sets comparable, the numbers in each set were converted to percentiles; in the case of the RAW set, this calculation involved taking a token's raw duration minus the speaker's lowest monosyllabic vowel duration and dividing that by the speaker's maximum monosyllabic vowel duration minus their minimum monosyllabic vowel duration. Thus the lowest duration would be set to 0 and the highest would be set to 1, with each one in-between scaled to an intermediate percentile. The same formula was applied to the normalised set, but using the normalised durations in place of the raw durations.

After these percentiles had been calculated, it was possible to focus only on *bad, glad, mad* and *sad*. For each person, there were four observations of each word. Since the point of normalisation is to make words more comparable by eliminating duration differences stemming from speech rate, a useful normalised set should minimise intra-word duration differences. In this test, that would mean that the range between the lowest-percentile and highest-percentile tokens of each individual word should be reduced.

ID	word	normalised range	raw range
M01	*bad*	0.1867179	0.270147
	glad	0.1784296	0.264927
	mad	0.266178	0.2297314
	sad	0.375664	0.2635296
F01	*bad*	0.1137587	0.344408
	glad	0.32422	0.1465707
	mad	0.395663	0.1114837
	sad	0.202227	0.1648936
F06	*bad*	0.136264	0.175256
	glad	0.247506	0.2463225
	mad	0.130508	0.1157395
	sad	0.241785	0.1413222
total		**2.79892**	**2.4743307**

Table 14: Normalised vs raw percentiles, within-word range.

Table 14 compares the range of percentiles in the normalised vs. raw datasets for each of the four words with four tokens for speakers M01, F01, and F06. Highlighted in green is the ‘winning’ condition: for instance, the spread of the percentiles representing M01’s *bad* durations was about 0.27 in the raw non-normalised dataset, but just under 0.19 in the normalised dataset. However, for most of the pairs of ranges compared, it seems as though Piercy’s (2010) normalisation formula makes within-word ranges larger rather than smaller; added up, the total within-word ranges are less for the raw data than for the normalised data.

Though each of the constructed IPs contained five syllables before the stressed syllable of each target word, utterances consisted of varying foot structures; this could mean that they were not controlled closely enough, skewing the normalisation results. It is conceivable that the formula for calculating utterance rate is flawed in that (hypothetically) words like *twirl* and *at* would both be counted as a single syllable, though they naturally have quite different durations. On the other hand, phoneticians recognise that English monosyllables “tend to be of the same length under similar circumstances” (Abercrombie 1967: 81), with segments temporally compressing to fit into approximately isometric stressed syllables; the utterances should therefore have been comparable.

Piercy also noted that the speaker in her sample with the most rapid rate of speech spoke on average 53% faster than the slowest speaker, but the vowels of the fastest speaker were on average only 11% shorter than those of the slowest speaker, indicating that though there is a strong linear relation between speech rate and vowel length – namely, vowels in faster speech are compressed – the correlation is not 1:1. The normalisation method may thus overcompensate for utterance rate-related variation.

In any case, since there seemed to be no consistent benefit to normalising in this subset of data from three participants – and, in fact, normalisation seems to increase intra-word variability rather than decrease it – it was decided not to spend extra time measuring utterance length for every token of every participant. There is an inherent downside to any sort of data processing, as noted by Piercy: "errors from word segmentation and syllable counts compound potential error… It seems desirable to avoid over-processing the data where possible" (Piercy 2010: 148). The decision to not normalise is therefore in keeping with the principle of avoiding processing when it does not have a demonstrable benefit. Impressionistically, it does not seem as though the data analysis has suffered from this, since interesting within-individual duration patterns can still be detected (see Chapter 5).

4.2. /æ/ *after /w/, /h/, and /r/*

While measuring speakers' vowel durations in Praat, it proved nearly impossible to separate the vowel from preceding /w/, /h/, and /r/ segments. With /w/, the problem lies in how vowel-like the segment is; it is difficult to decide where in to set the boundary between [u]-like formants and the beginning of [æ] (Figure 2). English /r/ is also quite vowel-like. At first, an attempt was made to rely on the F3 minimum as an indicator of where /r/ ended and the vowel began. However, when analysed acoustically, this segmentation did not always sound like the best division between /r/ and the vowel, and in many cases it was impossible to locate the appropriate formants in the spectrogram (Figure 3). Many speakers also exhibited especially voiced /h/ onsets, which, combined with rather breathy vowel qualities, made it exceedingly difficult to say with any certainty where the consonant ended and the vowel began (Figure 4).

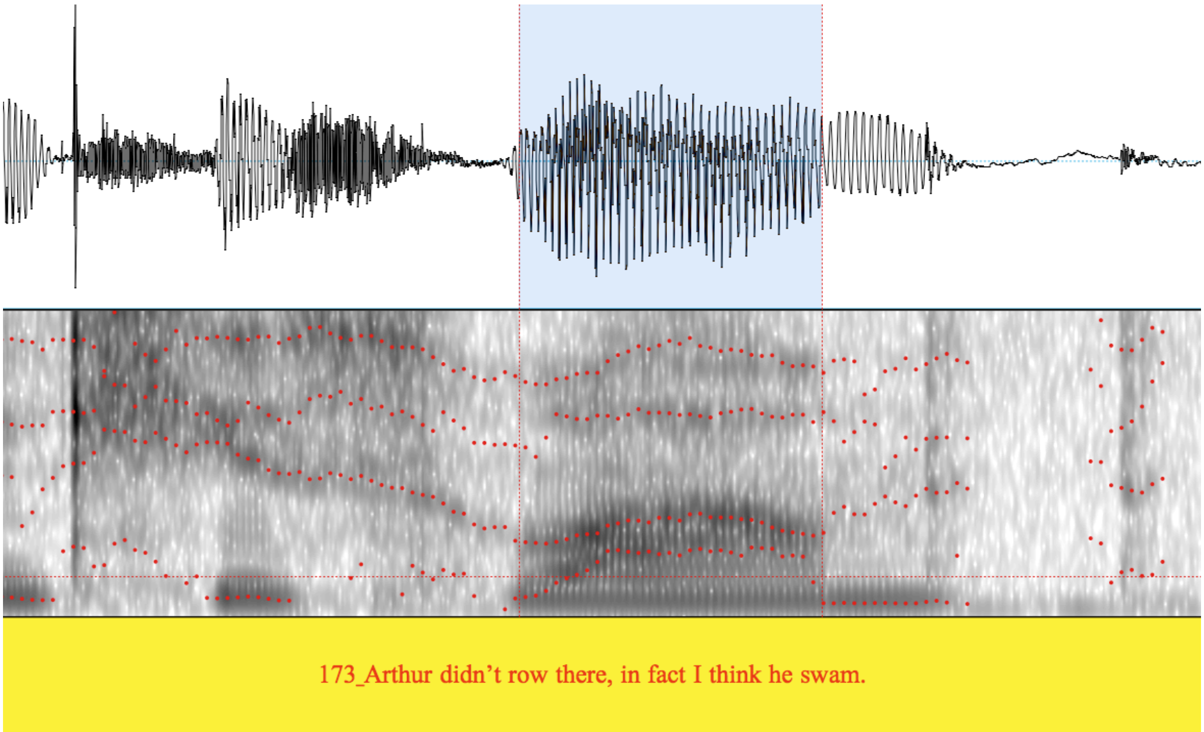

Figure 2: Speaker F04, 'swam', vowel highlighted in blue. Note the difficulty of defining the end of /w/ and the beginning of /æ/.

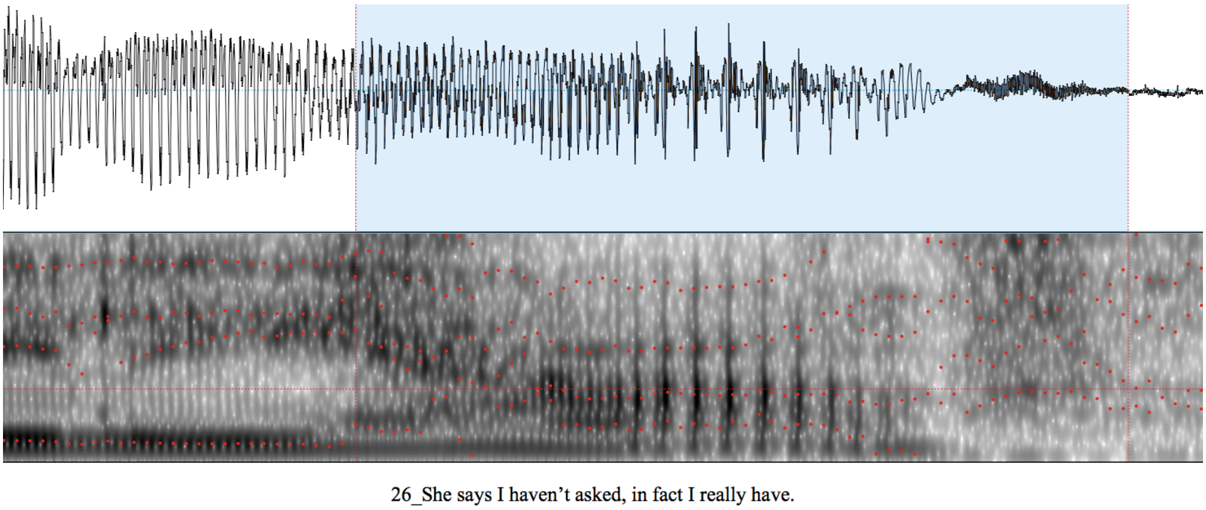

Figure 3: Speaker F02, 'have', word highlighted in blue. Note the difficulty of defining the end of /h/ and the beginning of /æ/.

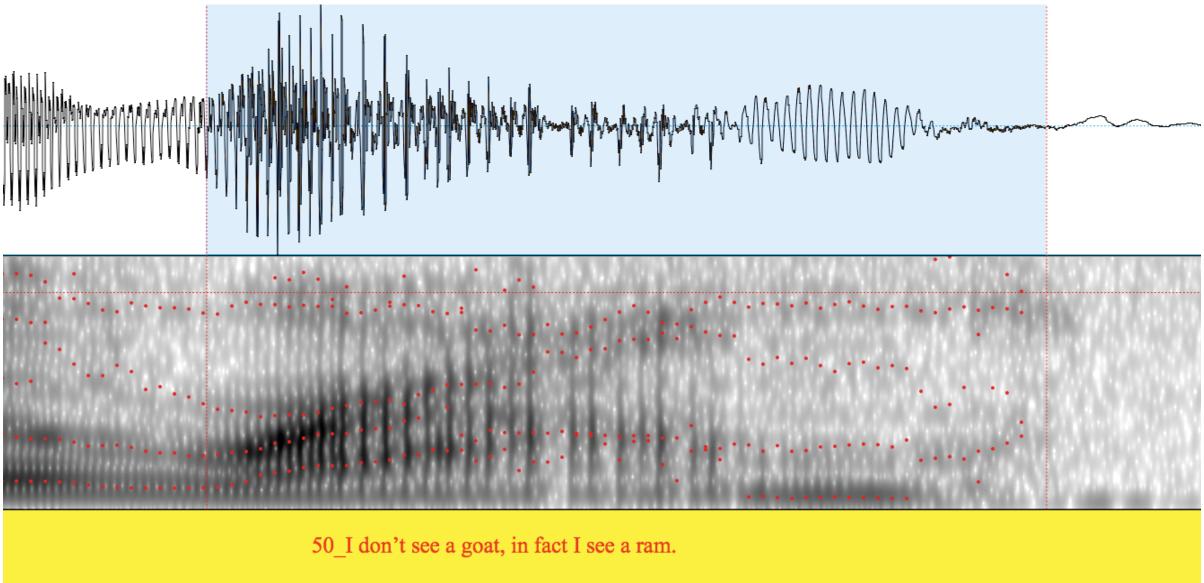

Figure 4: Speaker F02, 'ram', word highlighted in blue. Note the difficulty of defining the end of the /r/ and the beginning of the /æ/.

It was therefore decided that for the purposes of this analysis, all tokens with /w/, /r/, or /h/ in the onset would be excluded. This has the unfortunate effect of eliminating from analysis the possible *RAM*/*ram* minimal pair, reducing the number of strong preterites in the sample (*drank*, *sprang*, *swam*), reducing the number of adjectives considered (*drab*, *drably*), and reducing the number of lexical/function word pairs (*have*/*have*, *has*/*has*). In exchange, however, the dataset is cleaner on the whole, and effects of following segments can be reported with more confidence in the accuracy of each measurement.

4.3. Preaspiration

In addition to difficulties segmenting vowels based on the previous segment, it was sometimes also difficult to decide where vowels ended: it seemed like there was often a section of the word which sounded vowel-like, but lacked glottal pulses carrying clear formant information. This was due to a significant amount of breathy voice and/or preaspiration in many tokens. Unlike the issues with segmentation based on preceding segments, which could have been predicted going into this study, the presence of preaspiration was unexpected, as it has never been reported for SSBE. Given the original research aims of this thesis, it seemed important to know whether such preaspiration should be counted as part of the vowel for the purposes of describing possible /æ/-lengthening environments, or whether it should count as part of the following consonant. All instances of preaspiration or similar breathy voice were therefore coded in the Praat vowel duration Textgrid tier so that two data sets, one including and one excluding preaspiration, could be analysed (Figure 5). This section illustrates issues with the identification and measurement of preaspiration.

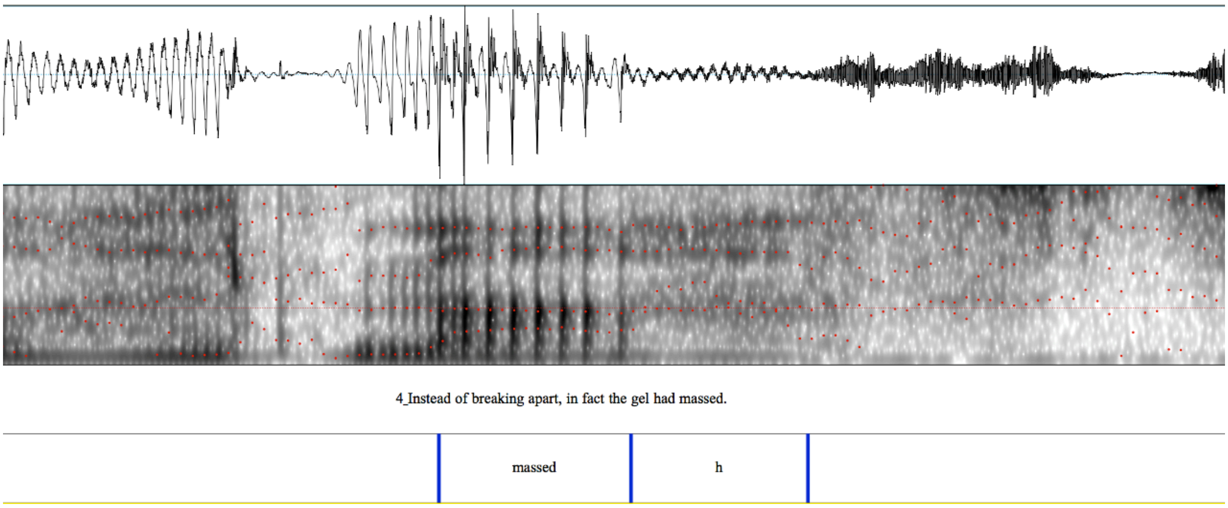

Figure 5: Preaspiration in 'massed' (F11). Modal voice duration of vowel marked 'massed', preaspiration marked 'h'.

The beginning of preaspiration was marked where modal and/or creaky voice ended, as indicated by the last formant pulse seen in the spectrogram (Figure 5). The end of preaspiration was marked where acoustic evidence of a breathy vowel-like sound ceased and only a consonant could be heard; this correlated with a clear change in the sound pressure waveform. In some cases, there may be two separate sections to what is called here ‘preaspiration’, namely a breathy voiced vowel and ‘true’ preaspiration, distinguished by the presence or absence of a clear F0 contour (Morris 2010; Hejná 2014). Morris (2010), in examining preaspiration in Welsh and Welsh English, counted both of these parts (labelled B and C in the example in Figure 6) as preaspiration; Hejná (2014), in her work on Welsh English, prefers to count breathy voicing as part of the vowel, and preaspiration only as the portion without an F0 contour. Though Morris’s (2010) method is adopted here, future examination of the data may well involve reconsidering the measurement of preaspirated tokens (see Discussion).

Preaspiration was found in monosyllables preceding a coda /θ/, /s/, /ʃ/, and /f/, and in disyllables preceding /p/, /t/, /k/, /s/, and /ʃ/ (Figures 7-12). It was nearly absent in all other environments tested. Unfortunately, the set of words tested (see Appendix A) did not include examples of disyllables before /f/ or /θ/, though by extension it would be expected in words such as *traffic* or *Kathy*.

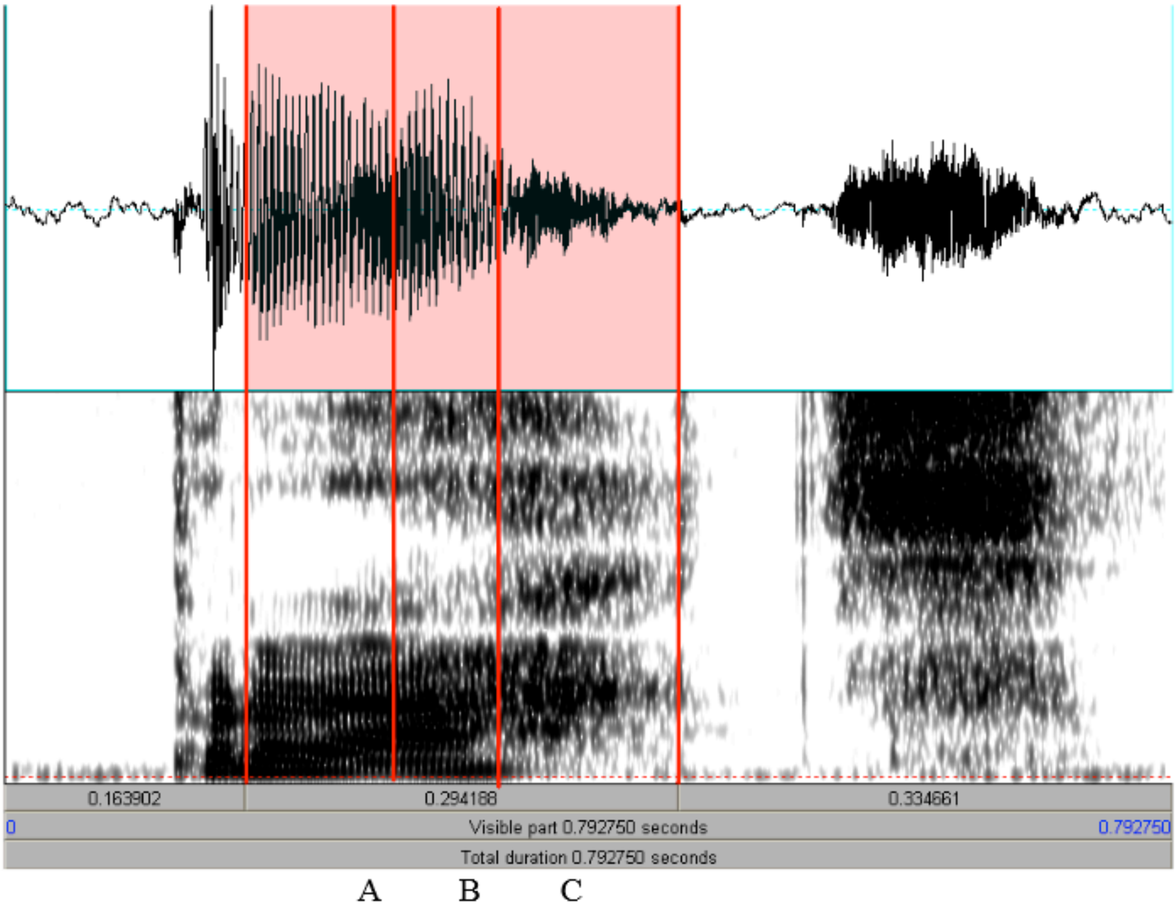

Figure 6: Spectrogram showing preaspiration measurements, Welsh word 'brat' (Eng. *apron*). A = modal voiced vowel, B = breathy voiced vowel, C = pure preaspiration. From Morris (2010: 4).

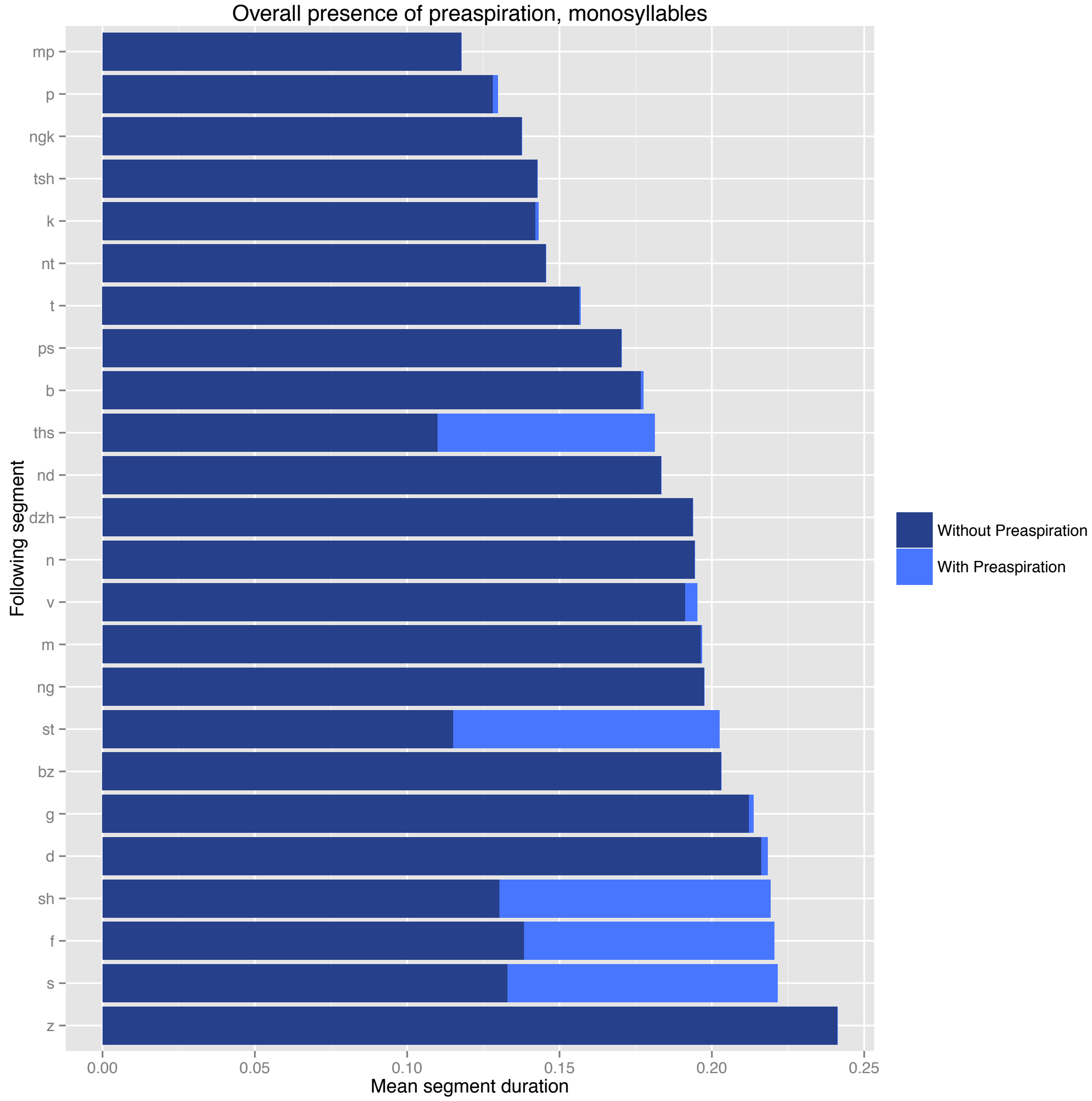

Figure 7: Duration of /æ/ vowels in monosyllabic words, by following segment, averaged over all speakers.

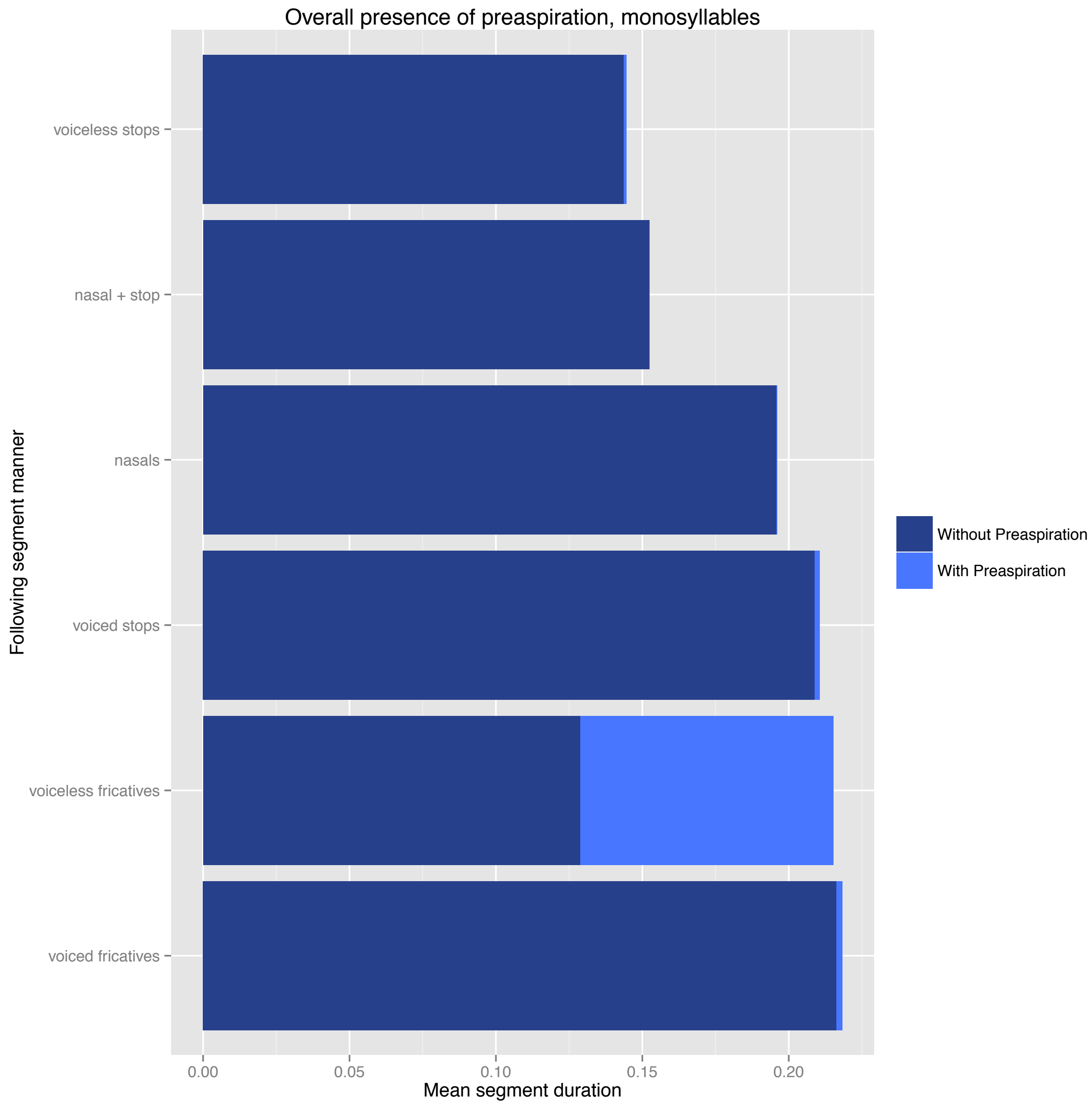

Figure 8: Duration of /æ/ vowels in monosyllabic words, by following segment manner, averaged over all speakers.

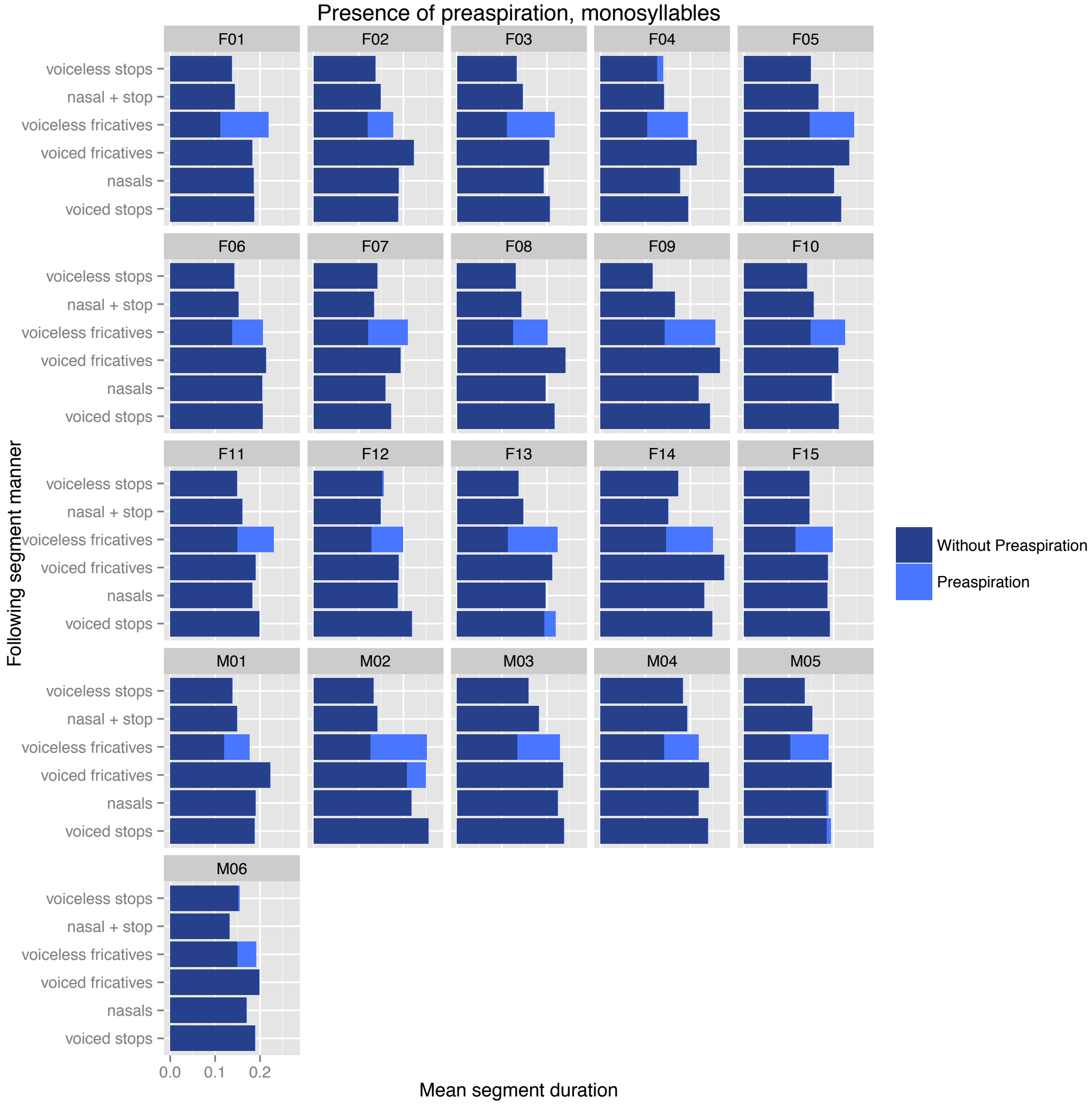

Figure 9: Duration of /æ/ vowels in monosyllabic words, by following segment manner, for each individual.

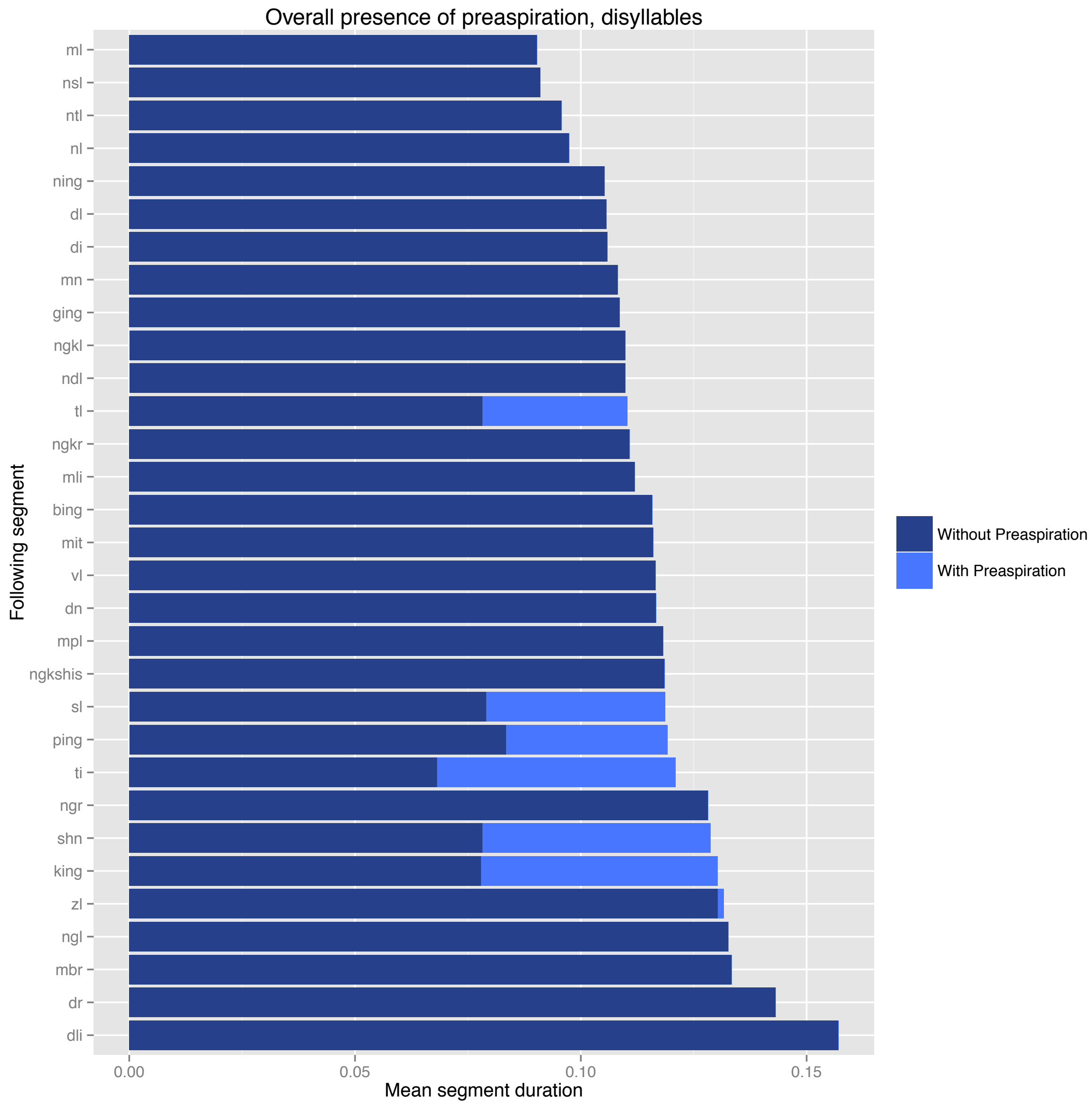

Figure 10: Duration of /æ/ vowels in disyllabic words, by following segment, averaged over all speakers.

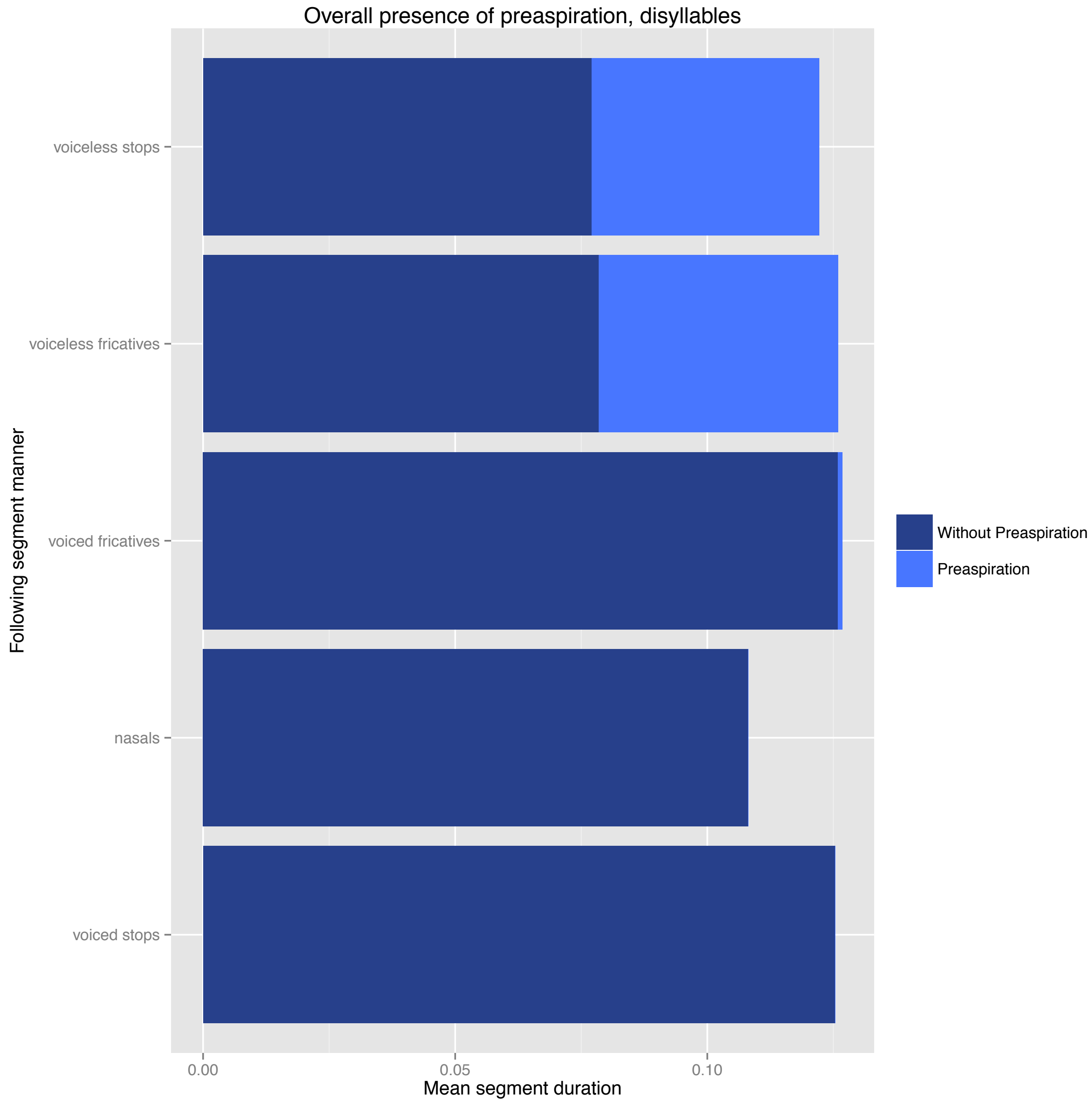

Figure 11: Duration of /æ/ vowels in disyllabic words, by following segment manner, averaged over all speakers.

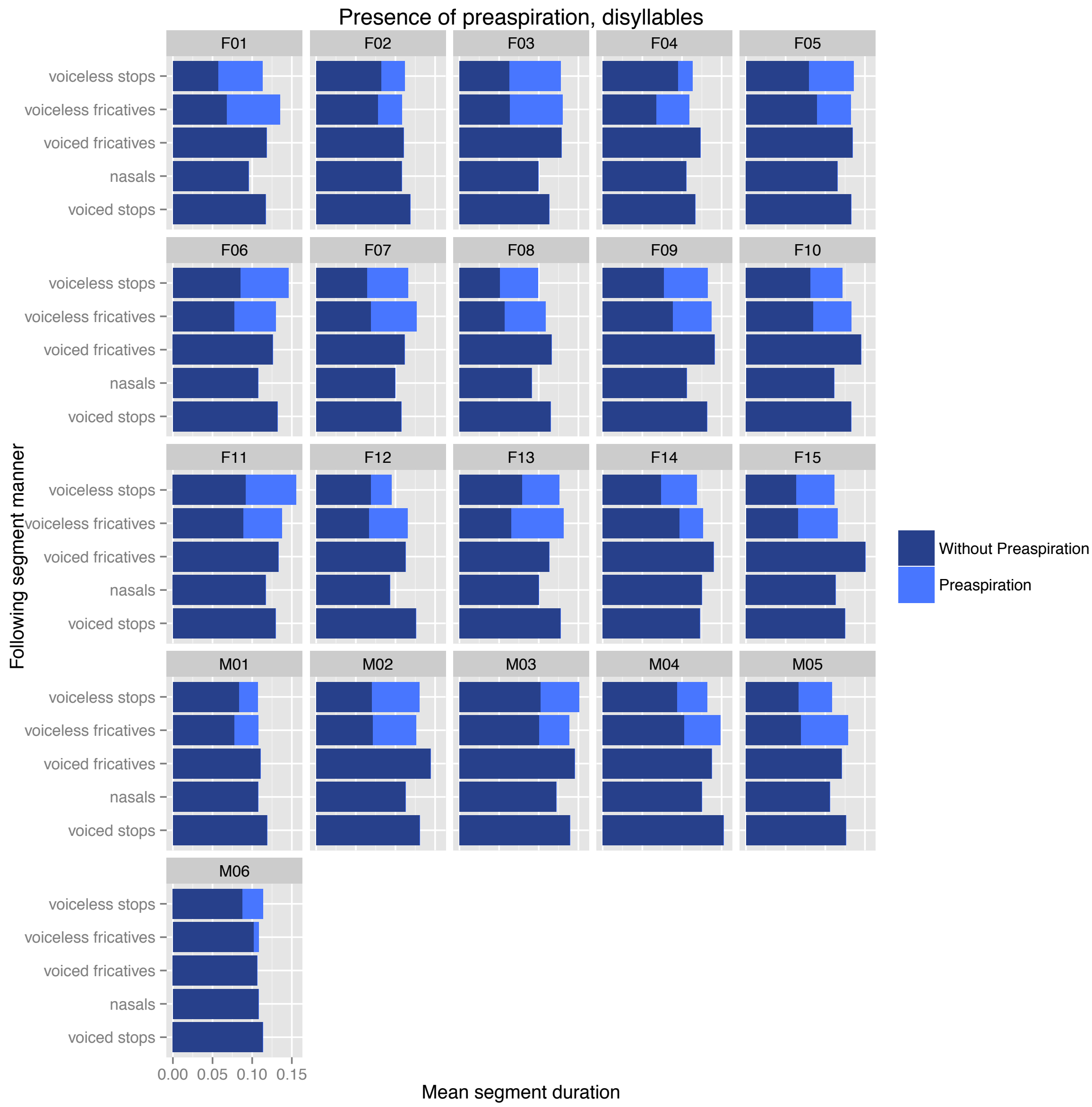

Figure 12: Duration of /æ/ vowels in disyllabic words, by following segment manner, for each individual.

The only subjects who stand out in Figures 9 and 12 are F13, who seems to show some preaspiration preceding voiced stops in monosyllabic words, M02, who preaspirates slightly before voiceless fricatives in monosyllabic words, and M06, who lacks preaspiration before voiceless fricatives in disyllabic words. In considering these particular subjects in more detail, the difficulty of defining the presence and extent of preaspiration becomes clear. While these examples illustrate how subjective and arguable the accurate coding of preaspiration can be, they represent extreme cases; overall, it is undeniable that preaspiration is present for most speakers in the environments previously outlined.

Upon closer inspection, it seems that what was marked as preaspiration in monosyllables preceding voiced stops for F13 may not have been preaspiration or breathy voice *per se*, but rather a raspy voice quality. This voice quality makes it quite difficult to accurately mark the presence or absence of preaspiration. In some cases such as her token of *massed* (Figure 13), there seemed to be an identifiable (if difficult to define) place where the regular pulses in the spectrogram become cloudy and formants are no longer able to be tracked regularly. Figure 13 also happens to illustrate the difference between Morris' (2010) and Hejná's (2014) methods regarding including breathy voice as part of preaspiration; F0 is present in a section of the preaspiration marked 'h' in the TextGrid tier before tapering off into 'true' preaspiration. Under Hejná's (2014) method, these several milliseconds would count as part of the vowel rather than as preaspiration, as coded here.

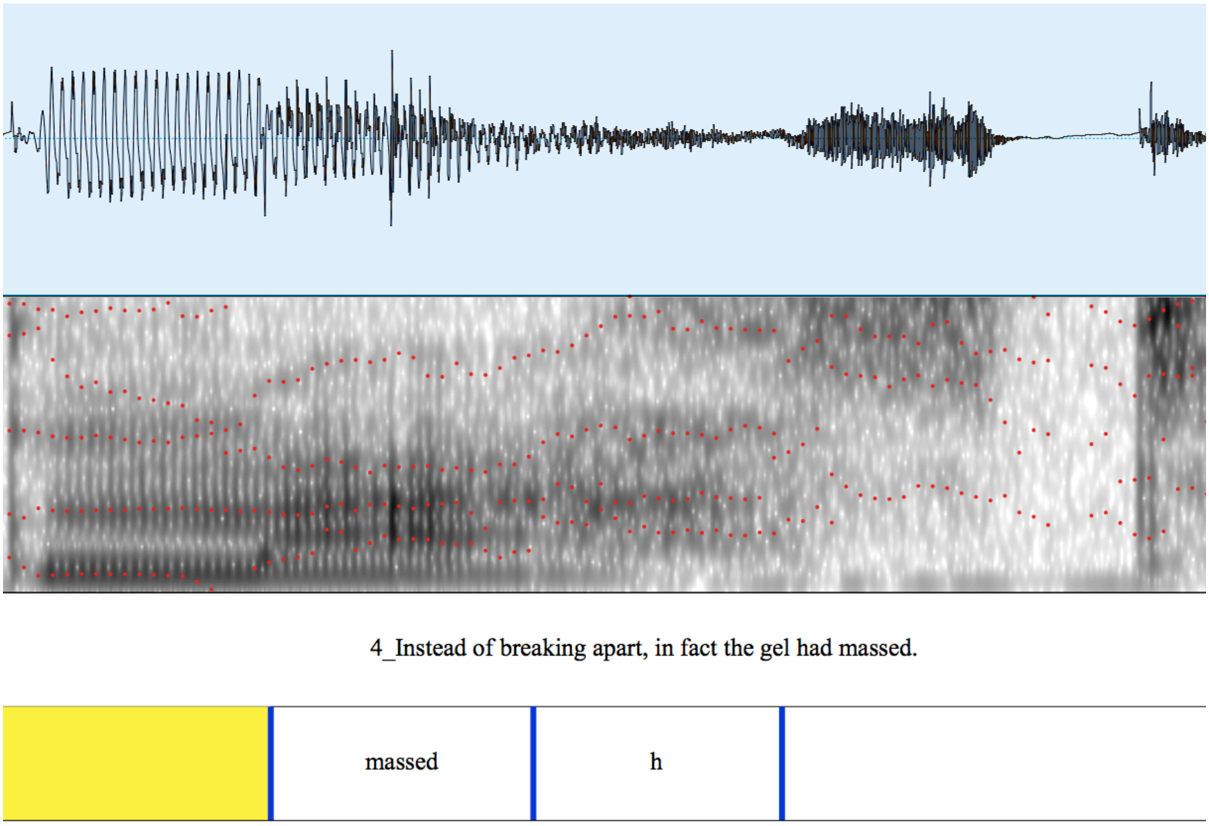

Figure 13: Speaker F13, 'massed'.

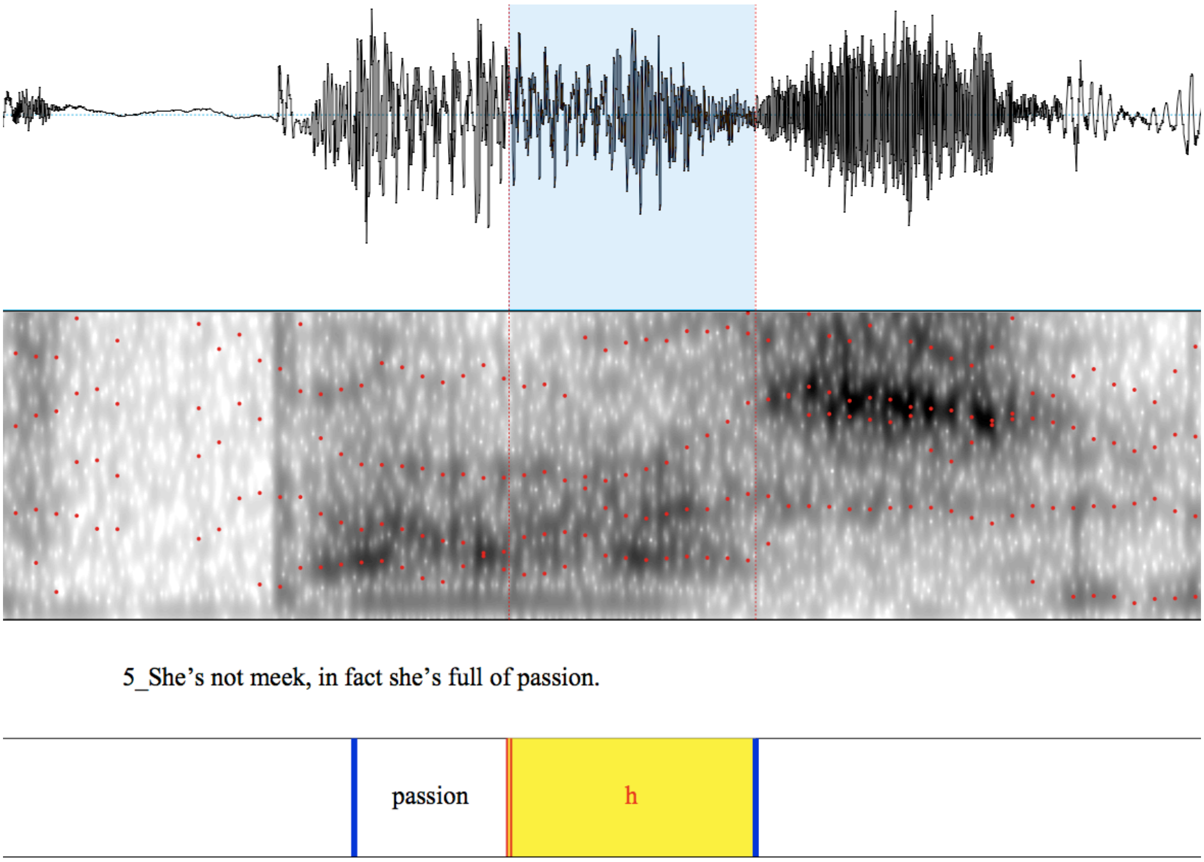

Figure 14: Speaker F13, 'passion'.

In other cases, the entire vowel seems to be breathy, and it is difficult to decide where preaspiration starts or even if it is present. In *passion* (Figure 14), auditory checking made it sound as though the vowel was split into slightly more modal and slightly more breathy parts, but neither the spectrogram nor the sound pressure waveform gives much indication of where this separation should be. There are several possible places such a division could go – or, indeed, it could be said that the entire vowel is breathy or raspy rather than having any truly modal section.

Compare this to F13's first token of *mad* (Figure 15). A divider can be placed where the sound pressure waveform seems to go from higher amplitude waves to lower; the spectrogram also exhibits a slight change at this point, with F0 fading in and out along with two irregular pulses. However, the presence of these very weak pulses may indicate that this is not true breathy voice or preaspiration, but rather a slightly different, more raspy quality that is not quite glottal but not quite breathy. For the sake of comparison, her second token of *bad* does not show any sign of this voice quality (Figure 16). For the measurement of the vowels of F13, an outlier in terms of voice quality, it was decided to err on the side of marking preaspiration in order to not miss possible environments where it might occur.

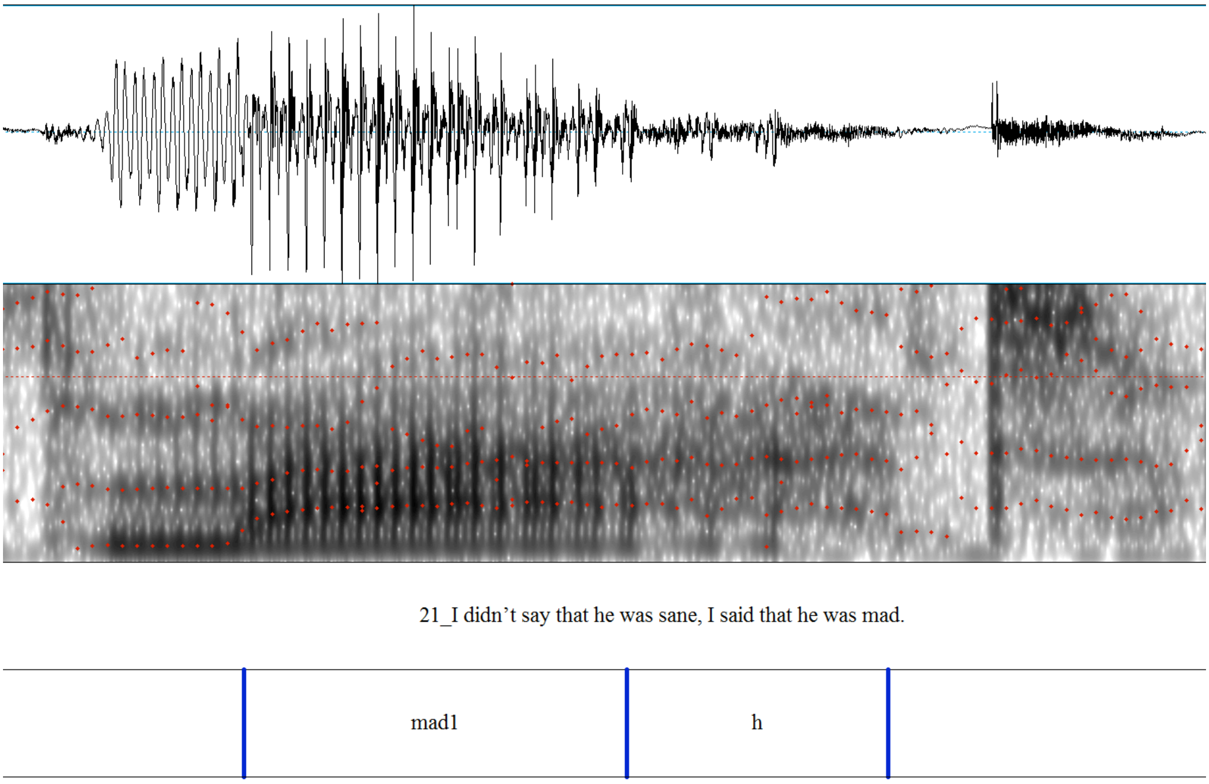

Figure 15: Speaker F13, 'mad'.

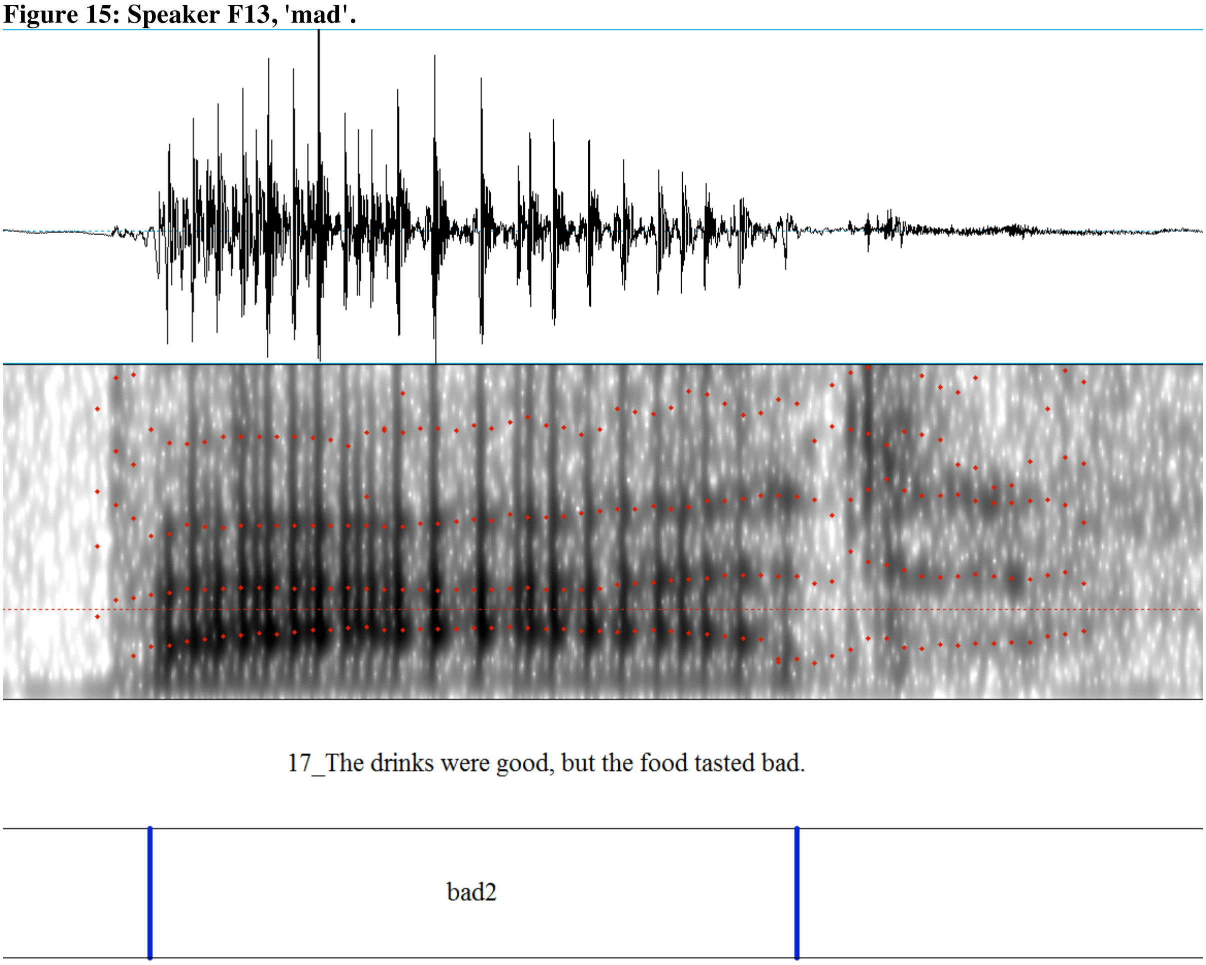

Figure 16: Speaker F13, 'bad'

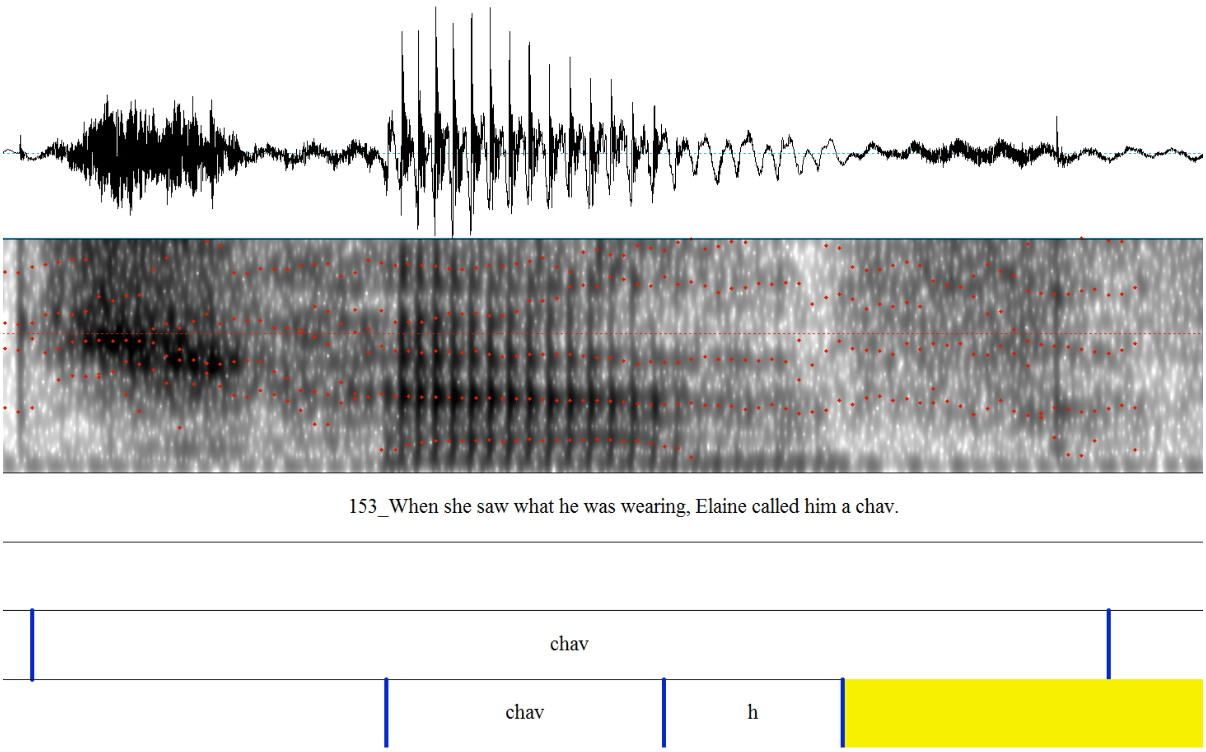

Figure 17: M02, 'chav'

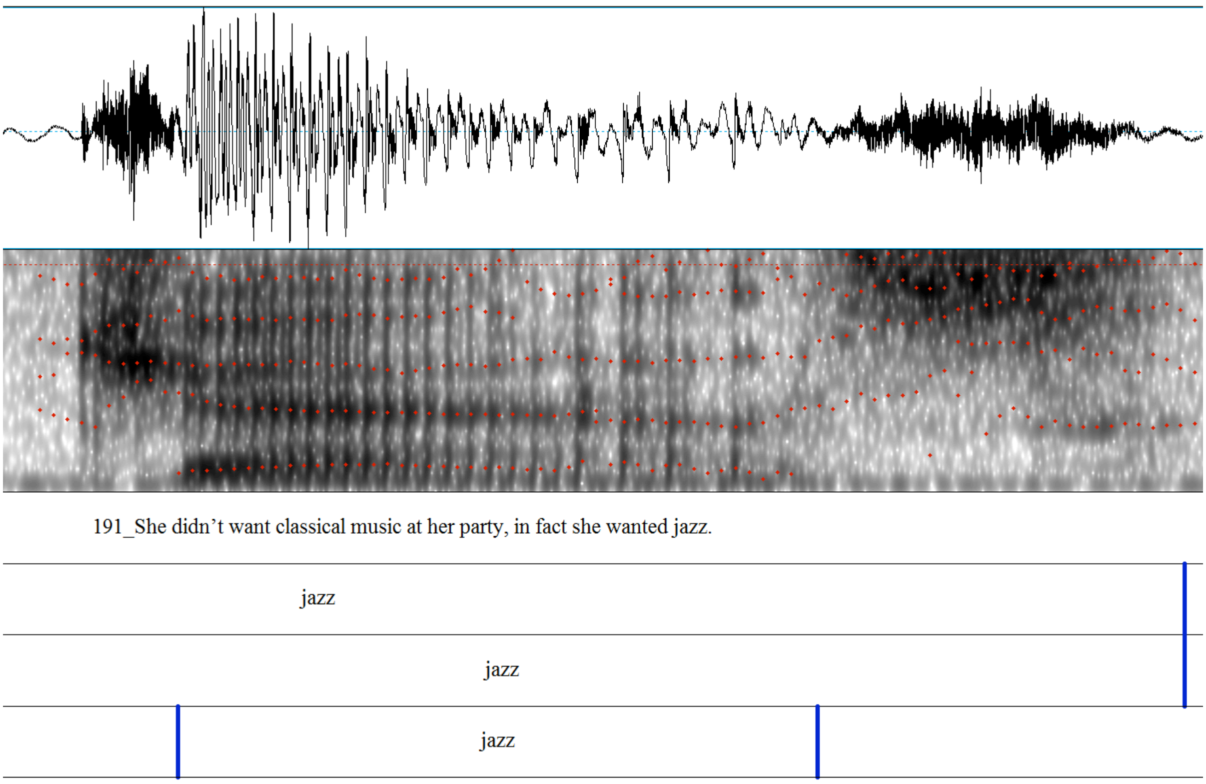

Figure 18: M02, 'jazz'

M02, on the other hand, does seem to genuinely have preaspiration in *chav* (Figure 17). The section marked as preaspiration sounds breathy and 'h'-like. His *jazz*, however, does not show signs of preaspiration, being instead rather creaky (Figure 18). Because this analysis takes into consideration only two tokens of monosyllables preceding voiced fricatives (*jazz* being included, but *has* and *have* being excluded for the previously mentioned issue of segmenting following 'h'), this one strange pronunciation has a noticeable impact in Figure 9.

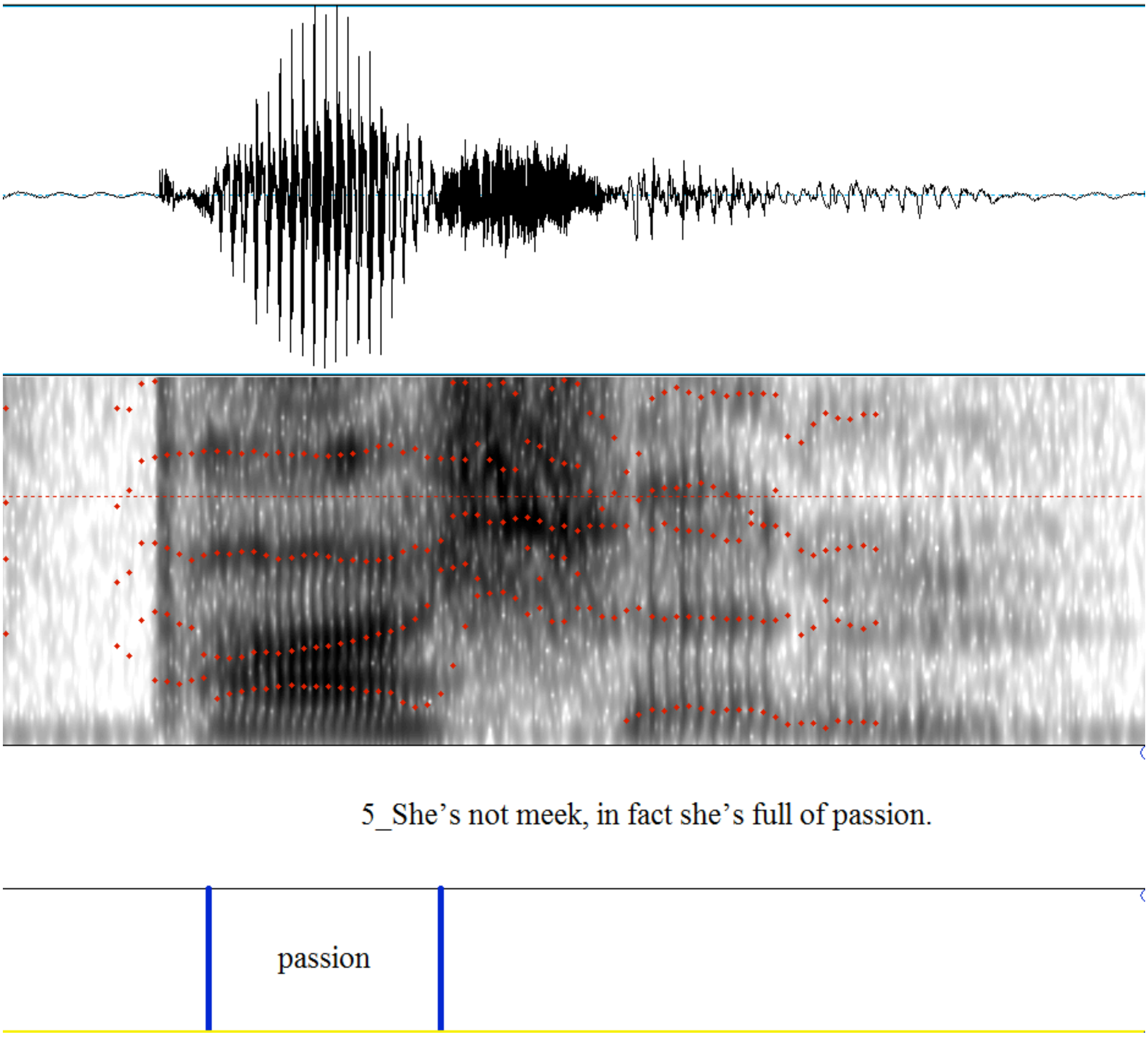

Figure 19: M06, 'passion'.

M06 seems to lack preaspiration before most voiceless fricatives in disyllabic words, but has it before voiceless stops. For instance, his *passion* (Figure 19) contains no trace of preaspiration; *cattle* and other disyllables preceding voiceless stops have very little (Figure 20). Interestingly, it seems that his preaspiration system only includes monosyllables before [s] and [ʃ], but not [f]. His *gaffe* exhibits no preaspiration, as what at first appears to maybe contain some formant tracking in the spectrogram sounds clearly like [f] rather than preaspiration or a breathiness (Figure 21); however, his *gas* exhibits clear preaspiration (Figure 22). This is unlike the other subjects' preaspiration patterns. One possible explanation could lie in his biography; though born in England and considering himself a native speaker of SSBE from Radlett (exhibiting /th/-fronting and other typical non-standard south-east features in casual speech), he spent two years aged 7-9 in China. It is possible that his fluency in Chinese and use of the language in the home could have had an impact on certain aspects of his English.

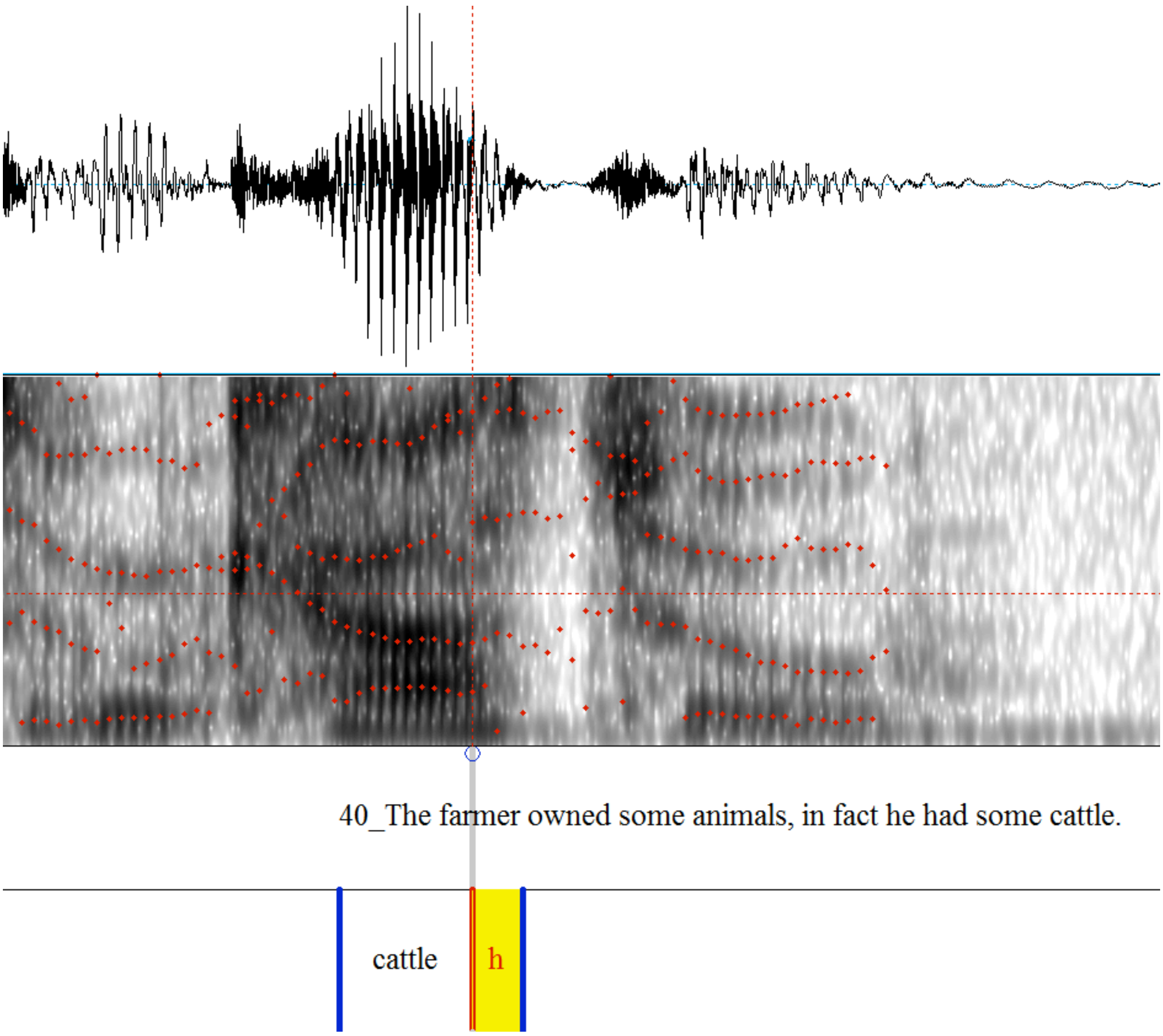

Figure 20: M06, 'cattle'

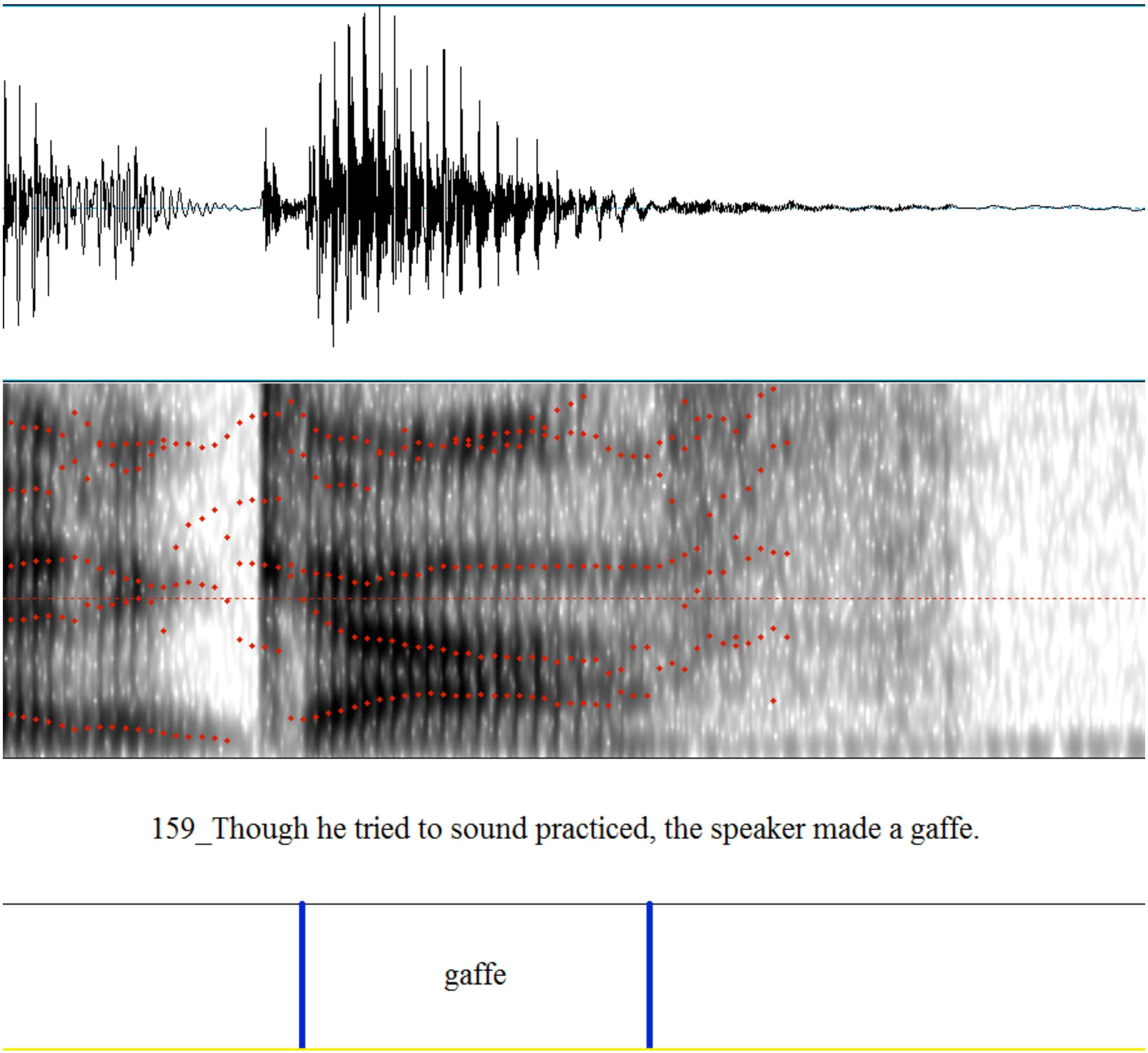

Figure 21: M06, 'gaffe'

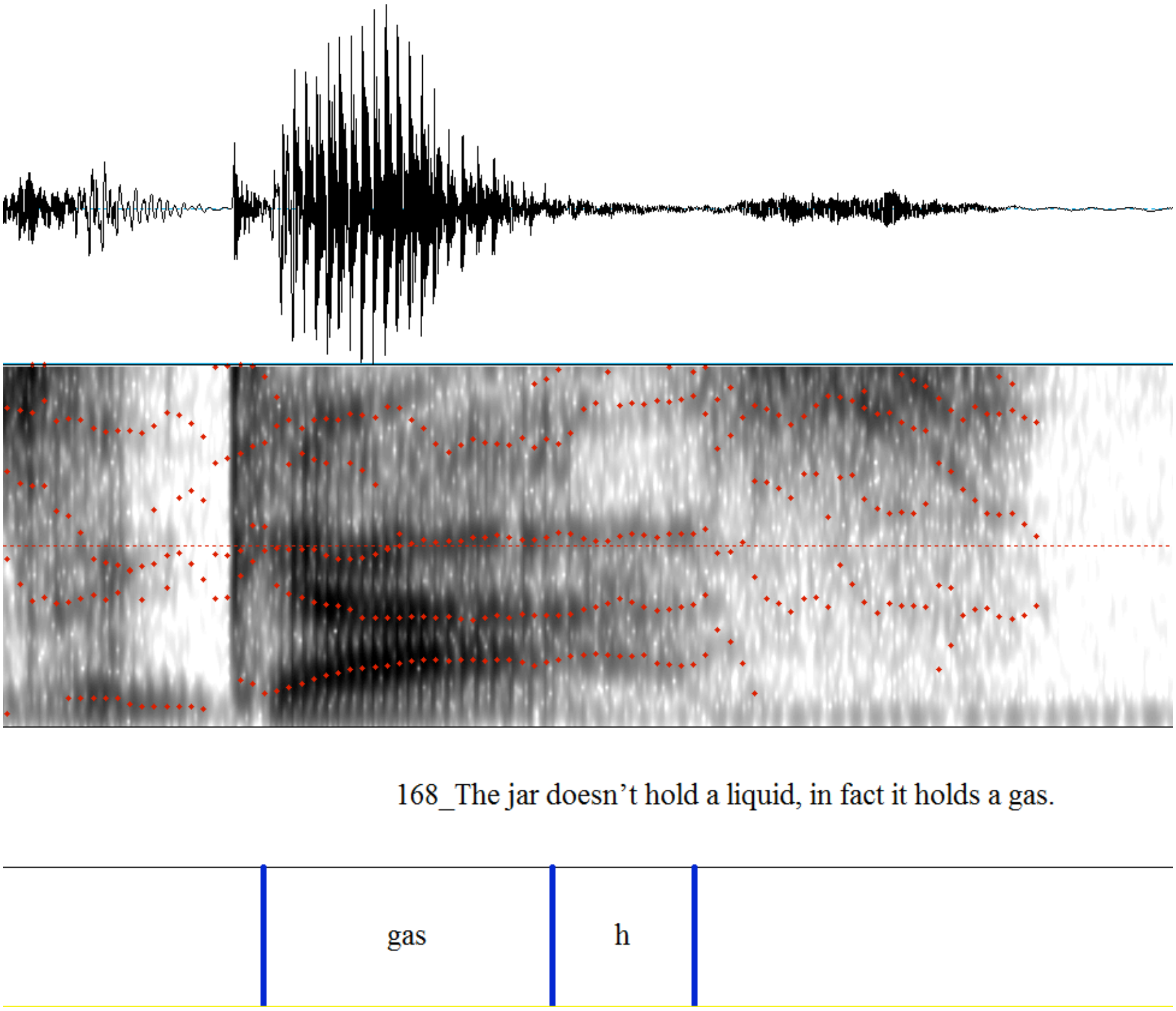

Figure 22: M06, 'gas'.

5. Results

Given the lack of previous phonetic studies investigating secondary /æ/-lengthening in SSBE, the aim of this experiment is chiefly exploratory; besides the four different tokens of *bad, glad, mad*, and *sad*, duration information was only collected for one token per word, per speaker. Though having such a limited set of data for each person has its drawbacks, the results of the vowel measurements still allow an overview of the effect of phonetic environment on the length of /æ/ in an assortment of SSBE speakers. Due to space constraints, this thesis only reports on aspects of lengthening in the set of monosyllabic words tested; disyllabic words will be investigated further in future work (see Chapter 7).

The tokens *abs* and *apps* are not averaged in with the /b/ and /p/ environments, respectively, because these words seem to have patterned uniquely. They were the only tested words before /b/ and /p/ which were vowel-initial, and were the only pluralised tokens in the sample besides *maths*. Being vowel-initial could have contributed to their relative lengthening, while having two consonants in the coda could have exerted the opposite force, shortening the vowel to fit all segments into the syllable (Abercrombie 1967). For these reasons, /bz/ and /ps/ are not considered in the analysis of relative lengthening environments.

The average length of the word *maths* seems to stand out from the rest of the voiceless fricatives. This could again be due to compensatory shortening of the vowel in order to accommodate a two-consonant coda (Abercrombie 1967); unfortunately, SSBE has the BATH vowel in nearly every other instance of historical TRAP/BATH preceding /θ/ in a monosyllable (e.g. *path, bath*). Such compensatory shortening could also account for why TRAP before /dʒ/ and /tʃ/ are slightly shorter than before /d/ and /t/ respectively, /st/ is slightly shorter than /s/, /nd/ is slightly shorter than /n/, and the nasal + voiceless stop clusters are shorter than their nasal counterparts.

Harris (1989) has also pointed out that it may be wise to exclude tautosyllabic voiced oral continuant consonants from consideration because they tend to occur either in typically unstressed contexts (*have, has, as*) or in words coined recently (*jazz*). Indeed, in this experiment, only one monosyllable ending in [z] (*jazz*) and one monosyllable ending in [v] (*chav*) were targeted besides *have* and *has*, which were excluded due to difficulty measuring vowels after ‘h’ (see Section 4.2). Though these are included in the statistical models and plots that follow, results involving these two segments must be taken with a grain of salt.

5.1. Statistical modelling

Since only one token per word per person was collected, save the four tokens each for *mad, bad, glad,* and *sad*, traditional statistical methods cannot be used to establish which specific words are 'long' or 'short' within a single speaker. Attempting to conduct grouping-based analyses within the entire group of subjects is also difficult, as it is a distinct possibility (borne out by the data in Appendices C and D) that different subjects may exhibit differing lengthening patterns. It was therefore decided that the best way to gather descriptive statistics about the data was through performing a linear mixed effects analysis of the relationship between duration and various features of the following segment. This was done using R (R Core Team 2014) and the lme4 package (Bates, Maechler, Bolker & Walker 2014), following a set of tutorials by Winter (2013). As fixed effects, voicing and place and manner of articulation were entered (without interactions) into the model. Importantly, subject and word were defined as random effects. In order to get the p-values reported in the following sections, likelihood ratio tests were conducted between the full model including the effect in question against null models without the effect.

A growing body of literature emphasises the role of frequency in sound change (Bybee 2002; Pierrehumbert 2001). As such, frequency data for each word was gathered from the SUBTLEX-UK corpus (Van Heuven, Mandera, Keuleers & Brysbaert 2014) and also included as a fixed effect. SUBTLEX-UK is a collection of frequency counts based on a corpus of 201.3 million words appearing in the subtitles of 45,099 BBC broadcasts dating between January 2010 and December 2012. Van Heuven et al. (2014) transformed these frequencies to lie along a logarithmic scale usable in linguistic statistical models. For this analysis, homonyms were excluded due to technical issues in separating out the appropriate frequencies. Though frequency itself did not seem to have a statistically significant impact (for both including/excluding preaspiration sets, $\chi^2(1)=0$, $p=1$), it was left as a fixed effect while testing the other effects (cf. Winter 2013).

5.2. Monosyllables, including preaspiration

This section presents the results for /æ/ duration measurements that include acoustically vowel-like sections of the word tagged as being preaspirated/breathy in the original Praat analysis (Boersma & Weenink 2015). The plots were produced on R using the ggplot2 programming package (Wickham 2009).

For Figures 23-26, bars are coloured from darkest to lightest based on how much the consonant type, averaged over the whole subject pool, encourages overall vowel lengthening. /nd/ is plotted separately from both the nasal group and the nasal + voiceless stop group, as words like *band* and *banned* are not joined by words with /mb/ clusters (*lamb* has lost its final stop) and /ŋg/ (as this cluster tends to be reduced to /ŋ/ word-finally). To avoid token-level pseudoreduplication in the data, within-word means were calculated for each subject's *bad, glad, mad*, and *sad*, and each word was only counted once per speaker (Winter 2011).

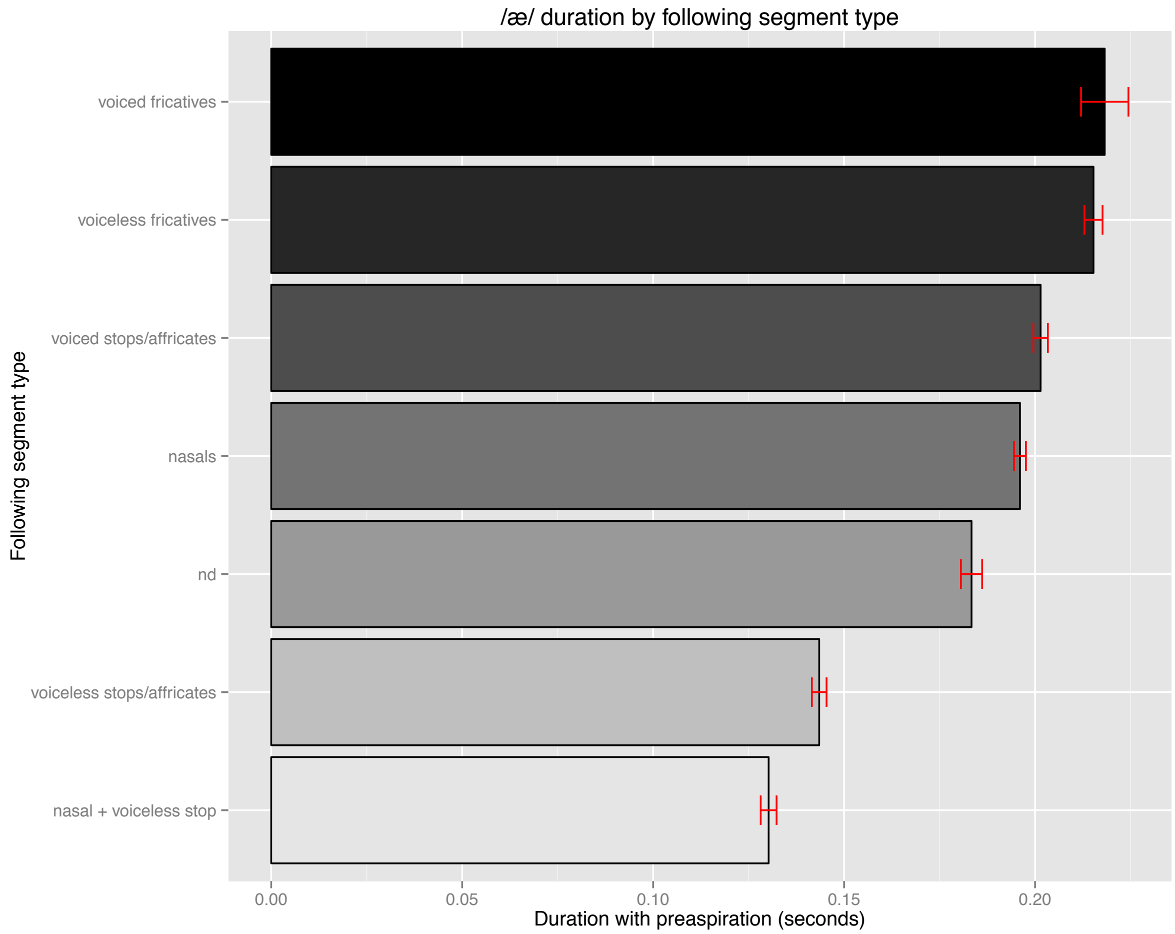

Figure 23: /æ/ duration (including preaspiration) by following segment type, averaged over all speakers

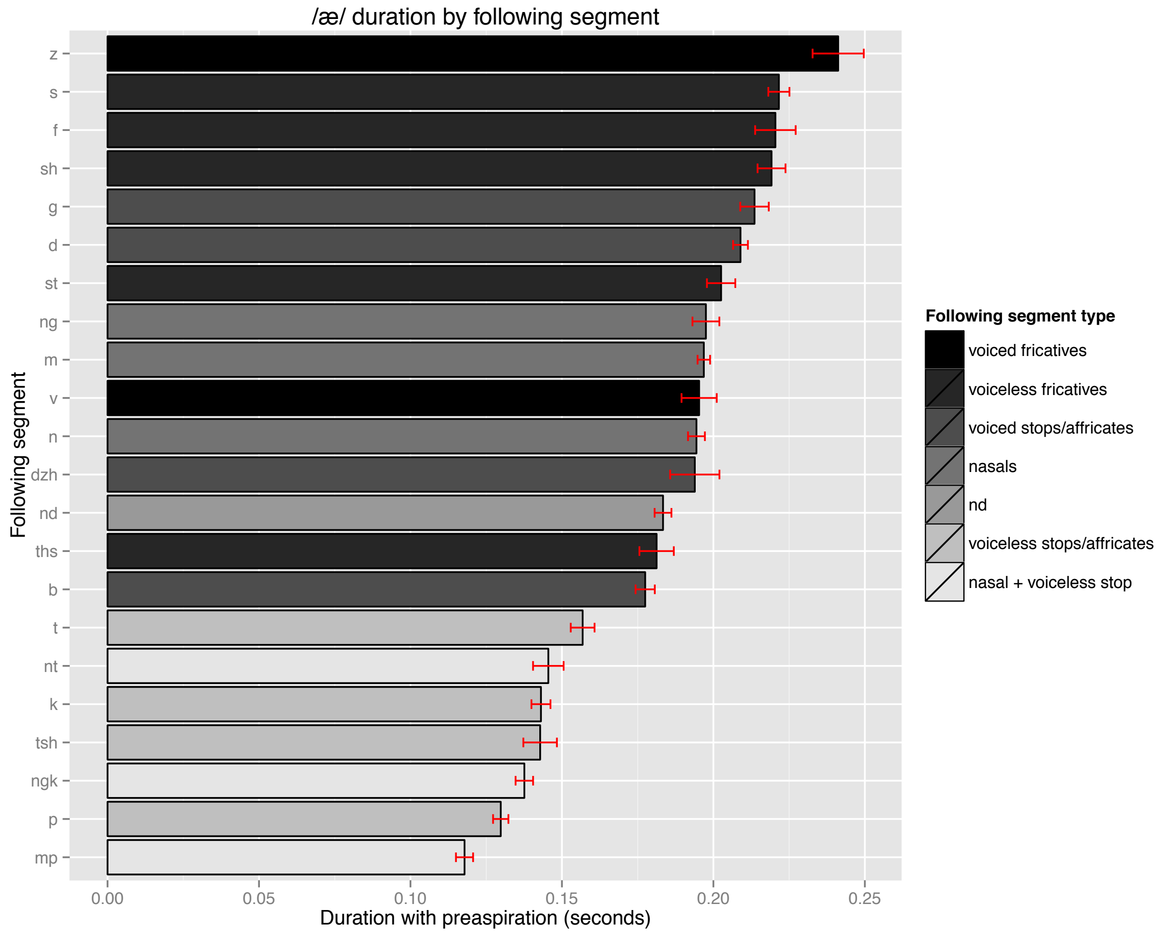

Figure 24: /æ/ duration (including preaspiration) by following segment, averaged over all speakers

Between the mean measurement for /t/, the longest of the voiceless stop/affricate environments, and /b/, the shortest of the voiced stop environments, there is a fairly large gap dividing the environments generally into 'long' (voiceless fricatives, voiced stops/affricates, nasals, and /nd/) and 'short' (voiceless stops/affricates, nasal + voiceless stop), with the standard errors of each of the segments within these groups mostly overlapping (Figure 24).

Voicing, unsurprisingly, significantly affects duration with preaspiration (χ^2 (1)=55.262, p<0.001). Voiceless segments – among which /mp/, /nt/, and /ŋk/ were included in order to differentiate them from /nd/ with a voiced stop – lowered duration by about 0.050s ± 0.005 standard error (p<0.001).

Manner of articulation of the following consonant also affects vowel duration in the overall model (χ^2 (5)=80.162, p<0.0001). Pairwise tests between manners reveal several significant differences between fricatives and other manners of articulation, but not between other sets of manners: vowels before fricatives are on average 0.064s ± 0.012 standard error longer than before stops (p<0.0001); fricatives also lengthened more than nasal + stop clusters by .084s ±

0.012 standard error ($p<0.0001$); more than nasals by 0.067s ± 0.014 standard error ($p=0.0001$); and more than affricates by 0.076s ± 0.018 standard error ($p=0.0004$).

Within groupings of segment type based on manner of articulation and voicing, place of articulation appears to make a difference in lengthening (Figure 24). /æ/ measurements before /g/ and /d/ have overlapping standard errors, but those before /b/ are significantly shorter. Voiceless stops show a slightly different pattern, with /æ/ before /t/ significantly longer than before /k/, which in turn is a longer condition than /p/. This pattern is repeated within the nasal + voiceless stop class: /nt/ lengthens more than /ŋk/, which itself lengthens more than /mp/. There seems to be no overall effect of place of articulation within the nasals, with /ŋ/, /n/, and /m/ showing no identifiable differences in length.

These tendencies can be expressed more formulaically, with > indicating a difference where standard error bars do not overlap, ≥ indicating a difference where there is marginal overlap of error bars, and = indicating a large amount of error bar overlap:

g ≥ d > b
t > k > p
nt ≥ ŋk > mp
ŋ = m = n
s = f = ʃ > st > θs

However, these differences of place are not reflected in the linear mixed effects model (χ^2 (5)=0, p=1), possibly because for different manners – which were not entered as random effects, but rather as independent fixed effects – place of articulation may have differing effects. Teasing apart these differences requires a more in-depth look at how individuals behaved with regard to place of articulation.

Tables 15-17 are matrices showing individual patterns of lengthening for the voiced stops, voiceless stops, and nasals. For voiced stops (Table 15), it can be seen that while the lengthening effects of /g/ and /d/ vary in relation to each other between different individuals, every speaker in the sample has /b/ as the least lengthened environment. For voiceless stops (Table 16), either /p/ or /k/ is the shortest environment for all speakers, but /p/ seems to inhibit lengthening more significantly. In nasals (Table 17), few subjects show significant ordering based on place, but for those who do, /ŋ/ slightly inhibits lengthening.

	F01	F02	F03	F04	F05	F06	F07	F08	F09	F10	F11	F12	F13	F14	F15	M01	M02	M03	M04	M05	M06
g = d > b				■			■	■								■					
d = g > b													■		■					■	
g ≥ d > b		■	■																		■
d ≥ g > b	■																				
g = d ≥ b					■	■			■	■	■							■			
d = g ≥ b												■					■		■		
g > d ≥ b														■							

Table 15: Lengthening ranking of voiced stops by individual.

	F01	F02	F03	F04	F05	F06	F07	F08	F09	F10	F11	F12	F13	F14	F15	M01	M02	M03	M04	M05	M06
t > k > p															■						
t ≥ k > p										■				■							
t = k ≥ p				■	■		■														
t > k = p																					■
t ≥ k ≥ p	■		■								■								■		
t ≥ k = p									■											■	
t > p = k												■									
t ≥ p = k						■															
k ≥ t ≥ p		■														■					
k = t > p													■								
t = p = k																	■				
k = t = p																		■			
t = k = p								■													

Table 16: Lengthening ranking of voiceless stops by individual.

	F01	F02	F03	F04	F05	F06	F07	F08	F09	F10	F11	F12	F13	F14	F15	M01	M02	M03	M04	M05	M06
m ≥ n ≥ ŋ	■									■											
m = n ≥ ŋ						■															
m ≥ n = ŋ															■						
m = n > ŋ																				■	
m = ŋ ≥ n					■																
n ≥ m > ŋ																		■			
n = m > ŋ																	■				■
n = m ≥ ŋ				■																	
ŋ ≥ m ≥ n								■											■		
ŋ > m = n							■						■								
ŋ ≥ n ≥ m		■	■						■			■									
ŋ > n ≥ m											■										
ŋ = m = n														■							
ŋ = n = m																■					

Table 17: Lengthening ranking of nasals by individual.

5.3. Monosyllables, excluding preaspiration

In plotting the monosyllabic dataset excluding preaspiration (Figures 25 and 26; Appendix D), the same colour scheme was kept as for the plots including preaspiration. This was done to emphasise the effect of taking breathy and preaspirated sections of the vowel out of consideration: voiceless fricatives drop from being the leading lengthening environment to the bottom of the lengthening hierarchy. This follows from the observation in Chapter 4 that following voiceless fricatives are the environment that overwhelmingly encourages preaspiration in monosyllabic words.

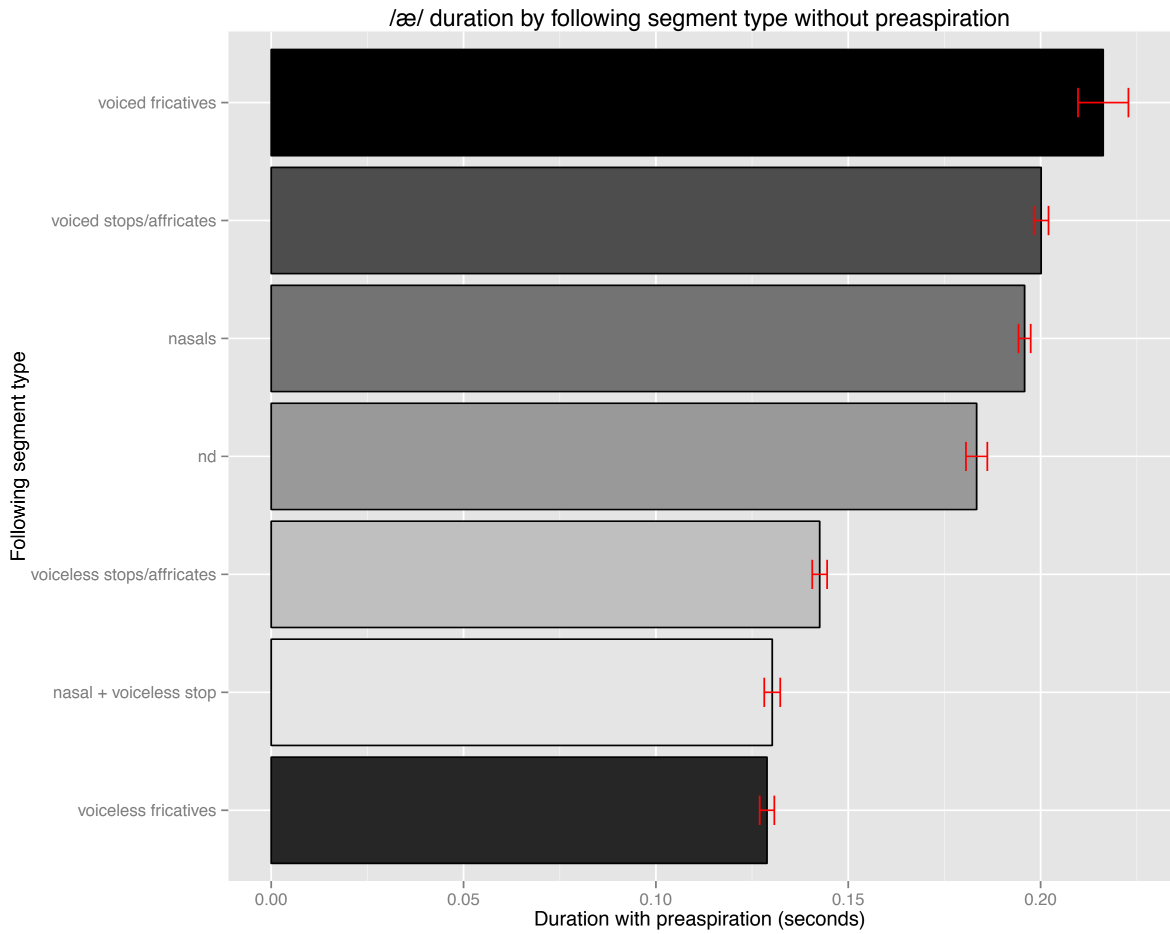

Figure 25: /æ/ duration (excluding preaspiration) by following segment type, averaged over all speakers

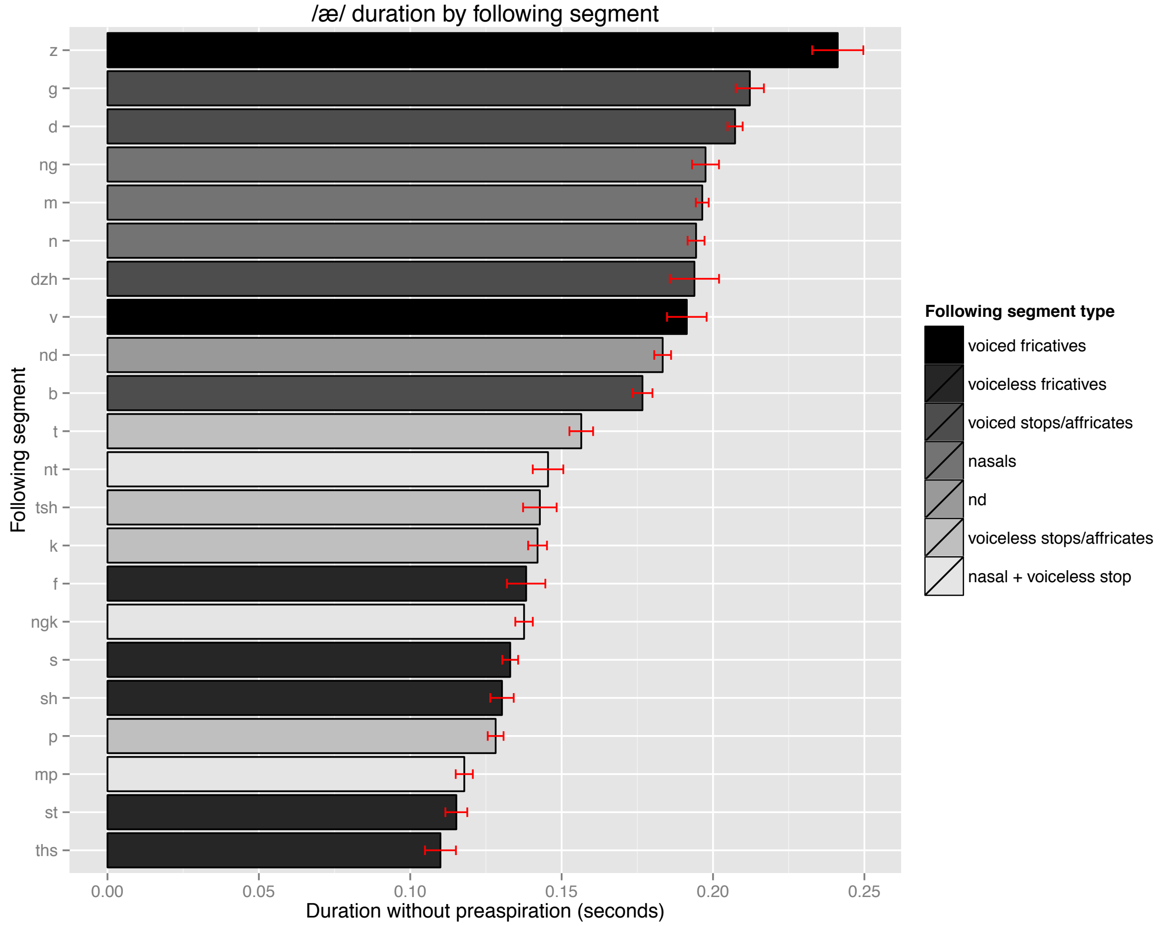

Figure 26: /æ/ duration (excluding preaspiration) by following segment, averaged over all speakers

Voicing of the following segment, again, significantly affects duration without preaspiration (χ^2 (1)=77.595, p<0.001), with voiced segments 0.059s ± 0.005 standard error. Manner of articulation of the following consonant also affected vowel duration in the this model (χ^2 (5)=94.187, p<0.0001), but pairwise tests between manners revealed no significant differences between manners. Place of articulation was not shown to be significant in this model (χ^2 (5)=0, p=1).

Tables 15-17 are not reproduced for this dataset, since the overall hierarchies within types are similar to those for the dataset including preaspiration:

g ≥ d > b
t > k > p
nt ≥ ŋk > mp
ŋ = m = n
f ≥ s = ʃ > st ≥ θs

5.4. Minimal pairs

One of the most compelling arguments for calling the BAD lengthening phenomenon a 'split' is the purported existence of minimal pairs of words distinguished only by the duration of their /æ/. This study tested several minimal pairs:

adder (snake) vs. *adder* (someone who adds)
cad (person) vs. *CAD* (computer-aided design)
can (noun) vs. *can* (modal verb)
dam vs. *damn*
jam (traffic) vs. *jam* (preserve)
lam (escape) vs. *lamb*
manning (of a ship) vs. *Manning* (name)
mass (of an object) vs. *mass* (in a church)
sad vs. *SAD* (Seasonal Affective Disorder)

Based on a comparison of several experimental studies, Lehiste (1970) established that difference limens, or 'just-noticeable differences' in duration for speech sounds below 300ms long are around 10-40ms. According to this estimate, differences below about 40ms in these vowels should be imperceptible. Figure 27 plots the difference in seconds between homophones for each person; subjects are labelled if their difference for a pair was greater than 40ms.

It is clear from Figure 27 that there are no consistent minimal pairs distinguished by perceptible duration differences; the dots representing differences tend to cluster around the centre for each pair, and no pair shows any significant skew toward lengthening of one homophone over another. Though F06 and M05 seem to have a significantly longer *dam* compared with their *damn* token, F03 has an even more extreme difference in the opposite direction. *Sad* seems to be one of the most likely candidates for lengthening based on previous observations of the BAD-LAD split, and it was hypothesised based on the interview with the linguist from Kent that acronyms might stay short compared to homophonous words. Even so, only F10 has a significantly longer *sad* compared with *SAD*, and she was not one of the subjects who showed a marginally significant difference between *cad* and *CAD*. In this pair, F03 had a longer *cad*, but M04 had a longer *CAD*. M02 has a much longer *can* (noun) compared with his *can* (modal), a difference shared by F14, but plenty of subjects also show slight deviations in the opposite direction. Only three subjects showed marginally significant lengthening of *lamb* compared with *lam*.

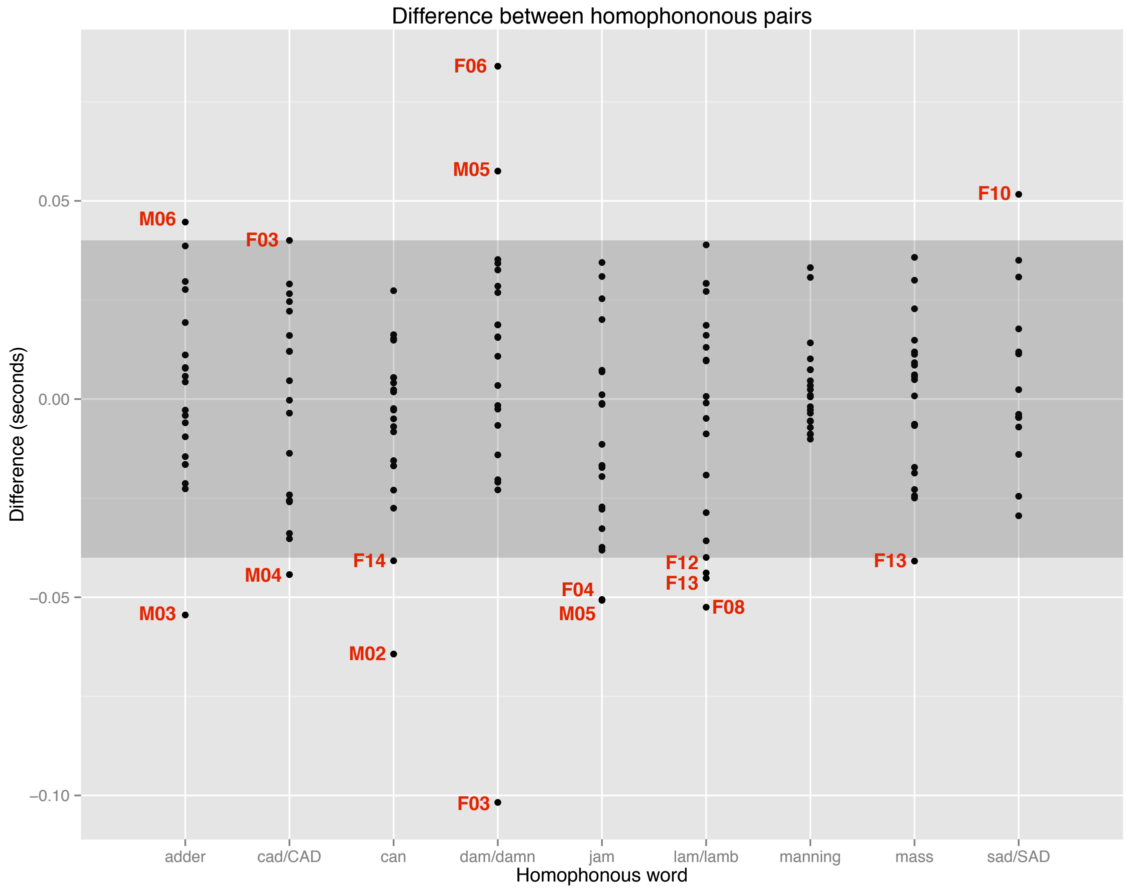

Figure 27: Differences between homphonous pairs of words

5.5. Considering individual words

Figures 28-33 present the vowel lengths of individual words for each speaker and are organised so as to compare durations across monosyllabic words whose coda consonants have previously been implicated in the BAD-LAD split. Only the dataset including preaspiration is considered here; fricatives, which encourage preaspiration (see Chapter 4) are not considered here. Since only one token per word per speaker was elicited, any mistakes a speaker may have made – such as reading out the letters of an acronym instead of pronouncing it as one word – were excluded, and thus there is a blank space in place of a bar.

We start by considering words ending in /d/ (Figure 28), considered by previous studies to be an environment in which there may be lexically-specified duration contrasts. Since *bad, glad, mad*, and *sad* were spoken up to four times by each participant, these words can be plotted with bars representing the standard error of each word's duration measurements.

Subjects differ in both their within-/d/ range of durations and the words that seem to be especially long or short. For instance, F02, F11, and M01 are very consistent in their pre-/d/

durations, and as such seem to have no split in this environment. Others, such as F01, F13, and M05, exhibit large differences between the lengths of their pre-/d/ words. Overall, for people with relatively large differences in this environment, *bad, mad,* and *sad* are especially long, with *glad* slightly shorter. In addition, *add* seems to be longer than others, even surpassing the adjectives for some subjects (F05, F15); this could be an effect of not having an onset consonant, which may encourage the vowel to compensatorily lengthen (Abercrombie 1967).

It is also important to consider words with /t/ in comparison to /d/ words. Looking just within /t/ words (Figure 29), it is notable that several subjects, such as F08, F09, F11, F13, and M04, have a considerably longer vowel in *that* than in other final-/t/ words (cf. Jones 1972 [1918]). When /d/ and /t/ environments are plotted together (along with *badge* and *batch*, their affricate counterparts) (Figure 30), separating out *that* and averaging over the rest of the /t/ words, some other interesting patterns emerge within certain individuals. For F01, for instance, it appears that *that* has a duration more in keeping with her /d/ adjectives, while *pad, cad,* and *CAD* pattern with the other /t/ or /tʃ/ words. For M04, *cad* falls within the /t/ standard error bar, while *that* is even longer than the mean of *bad* tokens; other /d/ words lie in-between these extremes.

Looking at words ending in /g/ or /k/ (Figure 31) it is again seen that different subjects pattern quite differently from each other. While many lengthen *bag* much more than other /g/ words (e.g. F01, F02, F06, F10, F12, M04, M06), others do not: F11, for instance, lengthens *tag* over others. Though F03 does not have a split within her /g/ words, her *back* lengthens considerably (cf. Jones 1972 [1918]), patterning with the /g/ words rather than the /k/ words.

Considering the bilabial stops (Figure 32), few patterns are apparent. F09 has an especially long *lab*, but this is not noted in other speakers. Overall, it seems as though there are less extreme differences between /p/ and /b/ than there are between the other pairs of stops.

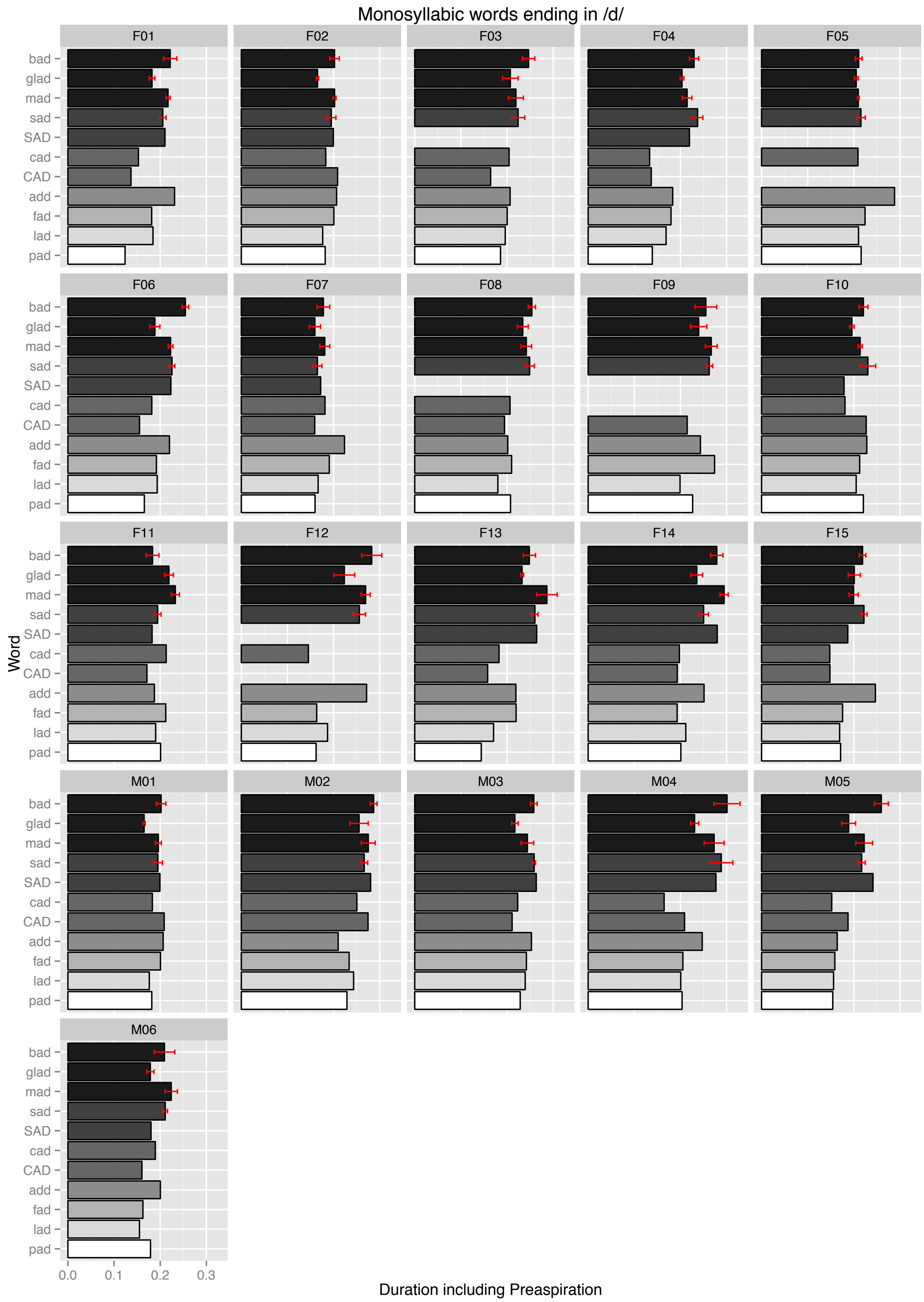

Figure 28: Vowel lengths in words ending in /d/ for each participant.

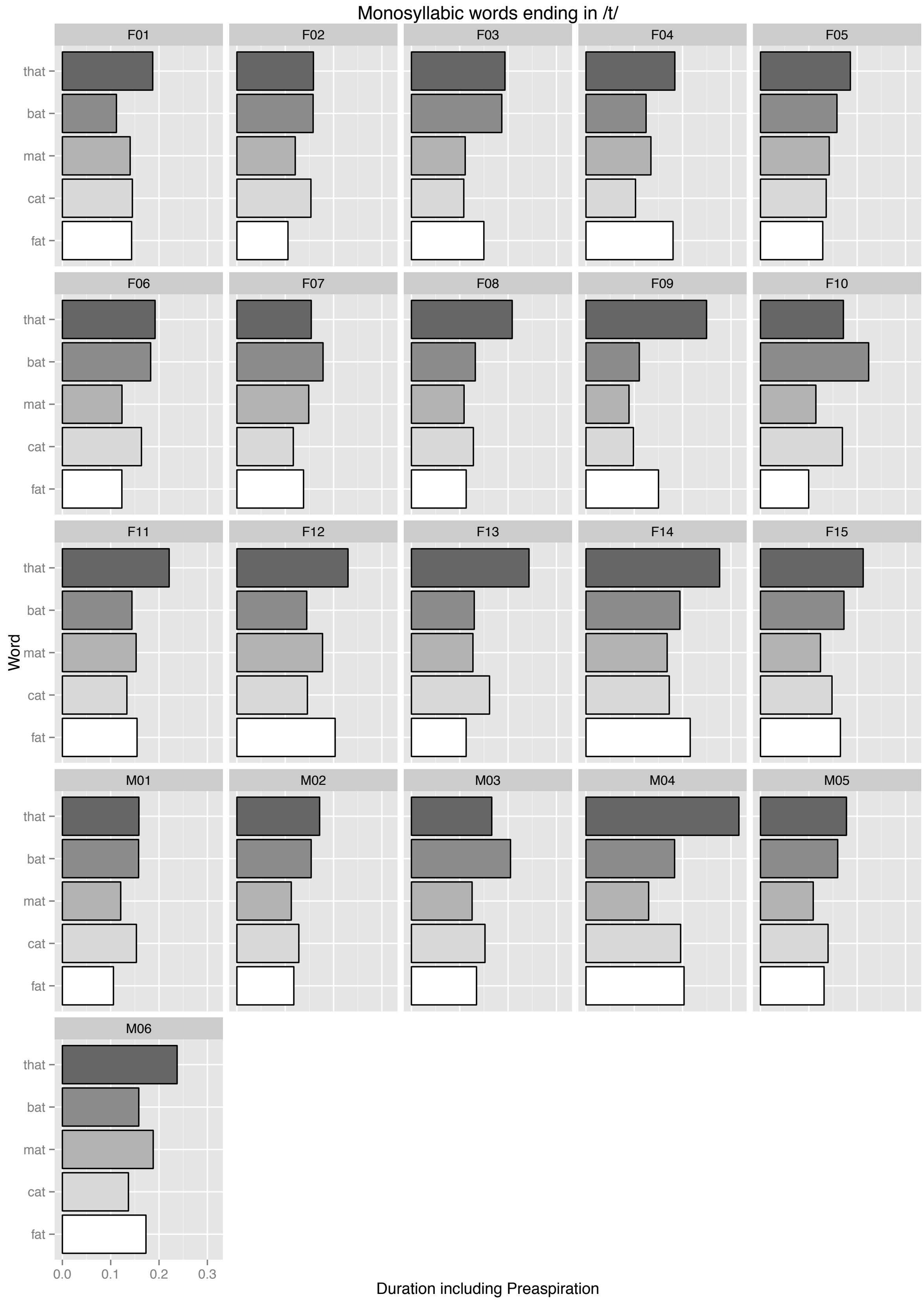

Figure 29: Vowel lengths in words ending in /t/ for each participant.

Figure 30: Vowel lengths in words ending in /d/ or /t/ for each participant.

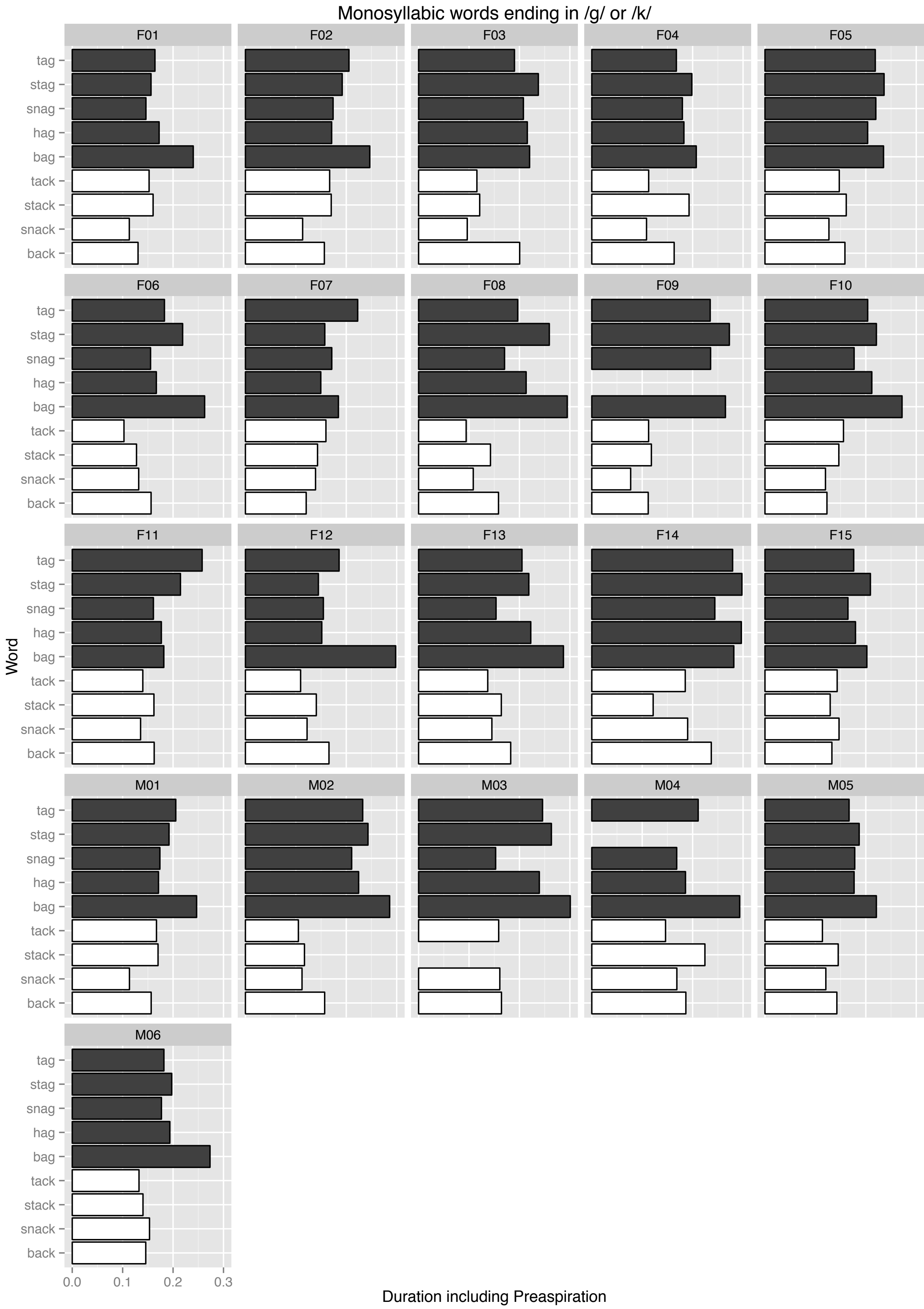

Figure 31: Vowel lengths in words ending in /g/ or /k/ for each participant.

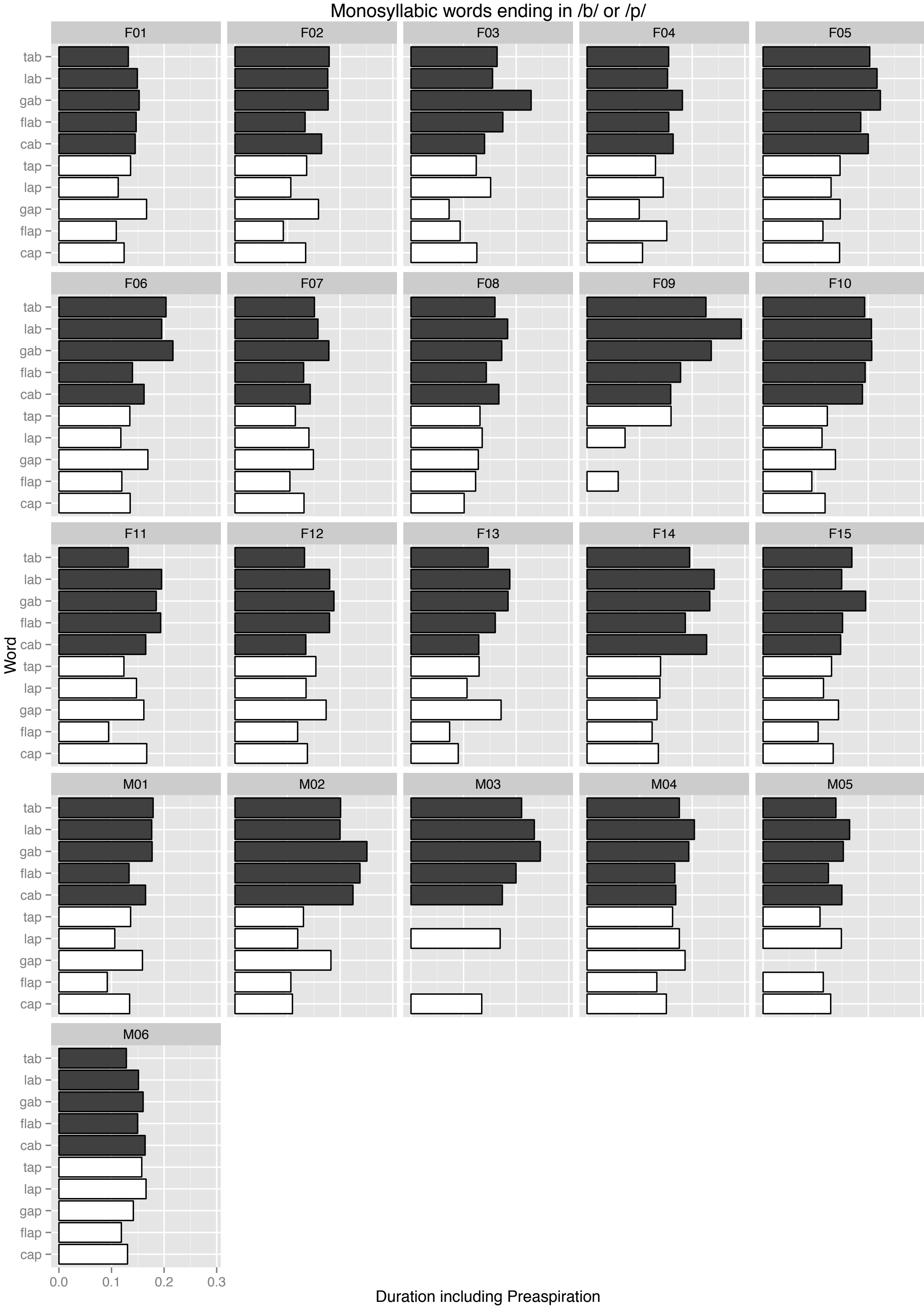

Figure 32: Vowel lengths in words ending in /b/ or /p/ for each participant.

Figure 33: Vowel lengths in words ending in nasals for each participant.

In the nasal patterns (Figure 33), it is observed that *Ann* is especially long in some speakers (F01, F03, F15, M03); this might be expected, given that *Ann* contains no preceding consonant and thus may compensatorily lengthen its vowel. *Man* (F02, F08, F09, F12, F15 M05) and *ban* (F02, F08, F09, F10, M05) also seem to be slightly longer than other pre-/n/ words. F14 and M02 exhibit a large amount of variation within their /m/ words, with both especially lengthening the two *jam* homophones. It does not look like there are large variations in the two /ŋ/ words tested aside from *hang* (excluded due to difficulties with 'h' words).

As mentioned above (Chapter 3), the voicing of the consonant following a vowel has an intrinsic effect on its duration This pre-fortis clipping creates an approximately 2:3 ratio of the duration of vowels before voiceless consonants compared with vowels before voiced consonants in English (Peterson & Lehiste 1960; Cruttenden 2001).

	Before voiced C	**Before nasal**	**Before voiceless C**	**Ratio voiced: voiceless**
Short vowels	0.172	0.133	0.103	1.67
/æ/	0.234	0.196	0.158	1.48
Long vowels	0.319	0.233	0.165	1.93
Diphthongs	0.357	0.265	0.178	2.01

Table 18: Vowel lengthening by environment (from Cruttenden 2001, based on Wiik 1965), with ratios added

Several collected tokens form pairs (e.g. *bad*/*bat*) that are identical save for the voicing of the segment following /æ/. In order to get another look at possible lengthening words, each subject's within-pair voiced word to voiceless word ratio was calculated and is plotted in Figure 34. The darkened area denotes ratios falling between 1 and 2; dots falling below 1 indicate that the member of the pair with a coda voiceless consonant was longer, while dots above 2 indicate that the voiced member of the pair was considerably longer than might be expected.

One advantage of this approach to visualising duration data is that everything is held constant except the voicing designation of the coda consonant, enabling a highly controlled look into whether certain words containing the voiced consonant are more or less lengthened compared with their voiceless counterpart. On the other hand, a disadvantage is that the ratio for a truly 'long' vowel in the voiced environment may be obscured by lengthening in the voiceless environment, as in the case of *back* lengthening by F03.

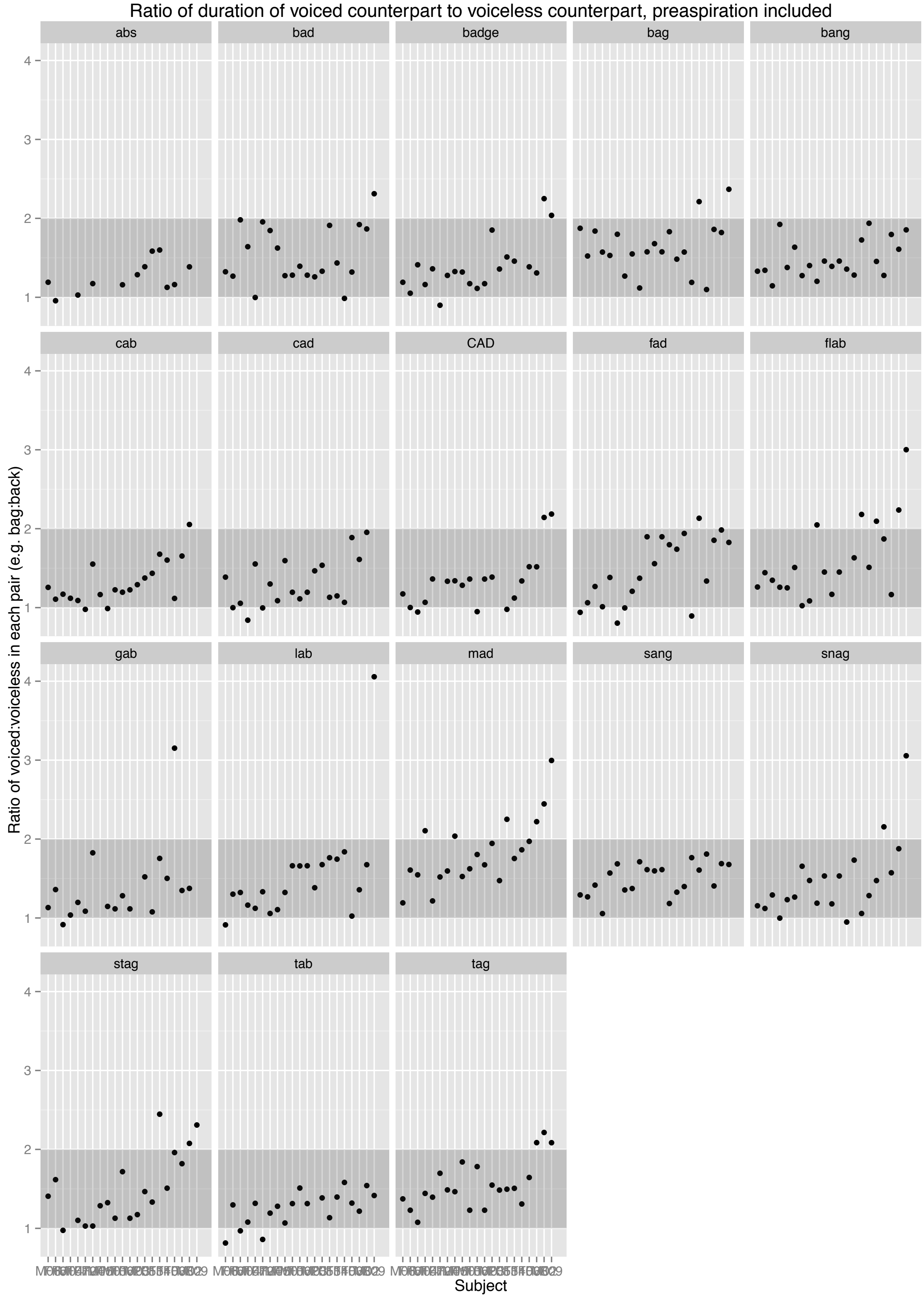

Figure 34: Within-pair voiced to voiceless ratios for each word; each dot is one subject's ratio for one pair.

Interestingly, *bad* – the prototypical lengthened word – shows comparatively little lengthening compared to *bat*: only F09 exhibits a ratio above 2, while two subjects' ratios hover below 1. On the other hand, six subjects had average durations for *mad* more than double the length of their *mat,* and no subjects showed ratios below 1. Other notable pairs include *flab/flap* (5 with ratios above 2); *stag/stack* (3 above 2); and *tag/tack* (3 above 2). In most cases, the largest ratios are seen for F09 (cf. Figures 30-31).

6. Discussion

6.1. Preaspiration

Previous studies have found preaspiration to be present in the Newcastle area (Foulkes, Docherty, & Watt 2001; Foulkes & Docherty 1999; Docherty & Foulkes 2000), Scottish Standard English (Gordeeva and Scobbie 2007, 2010, 2013), Middlesbrough (Jones & Llamas 2003), Liverpool (Watson 2007), Manchester (Hejná & Scanlon 2015), and throughout Wales (Morris 2010, Hejná 2015). Hejná (2014) reports that in these dialects, stressed short vowels can be preaspirated preceding the voiceless obstruents /p/, /t/, /k/, /f/, /θ/, /s/, /ʃ/, and /tʃ/. This appears to be a sociolinguistically conditioned phenomenon, with women and younger speakers leading in preaspiration.

Hejná (2014) suggests several intriguing historical possibilities for the preaspiration found in Wales and Northern England, including influence from the Celtic or Scandinavian languages. In Icelandic and Faroese, preaspiration has been normalised into the phonological system in reflexes of a set of historical Proto-Scandinavian geminate voiceless consonants /pp, tt, kk/; a significant amount of preaspiration also occurs in many dialects of Swedish and Norwegian (Helgason 2002). Contact with Scandinavian languages seems to have encouraged the development of preaspiration in some Sami languages as well as some varieties of Scottish Gaelic (Morris 2010). It is therefore conceivable that, since preaspiration in England has mainly been found in the North, it could be due to influence from historical Scandinavian settlement and language mixing (Hejná 2014). Preaspiration in Scotland could similarly be due to transfer from Gaelic. Morris (2010) finds that preaspiration is a widespread, though non-obligatory, realisation of voiceless stops in Northern Welsh, with female speakers leading its use. Preaspiration in speakers of Welsh English could thus be due to transfer effects from Welsh (Hejná 2014).

The fact that preaspiration has never before been reported in the accents of southern England makes it especially surprising that it exists to some extent in every speaker in this sample of Cambridge students. If preaspiration has indeed been present in Northern, Scottish, and Welsh dialects of English for longer than it has been in southern England, this raises the possibility that it is a recent change in which SSBE, the nation's standard variety, has begun to adopt a feature of less prestigious varieties. In quality, the TRAP vowel of SSBE has been found to have lowered and centred away from the historical RP [æ] and toward [a] (Wells

1982; Fabricius 2007; Kamata 2008). This is interesting in light of the historically northern pronunciation of TRAP/BATH as [a], but according to Fabricius, "it remains to be investigated… whether there is a likely external source such that we can document this as a result of *dialect contact*…" (2007: 22). If dialect contact with the North has indeed contributed to the centring of TRAP, it could be an equally possible explanation for the rise of preaspiration in SSBE. In an attitudinal survey of Oxford University students from southern England, Hiraga (2005) found that though the Yorkshire accent was rated below RP, Network American, New York City, and even Alabama English in terms of "status" (beating out only the Brummie accent of Birmingham), this northern variety was rated the highest out of all six in terms of "solidarity". If southerners thus perceive northern varieties to hold a certain degree of covert prestige, this would point toward an explanation for the spread of less standard northern features into their speech.

Hejná (2014) argues that preaspiration is especially interesting *vis à vis* glottalisation, which affects vowels preceding word-final voiceless stops. One Aberystwyth speaker analyzed by Hejná exhibited systematic preaspiration before word-medial voiceless stops (*lapper, batter, backer*) but glottalised systematically before those segments in word-final position (*bap, bat, back*). Though glottalisation was not specifically measured in Praat, this seems to be the case with most of the speakers in this sample of SSBE speakers. Whether the vowel was glottalised, slightly creaky, or simply modal, there was no evidence of breathy voice or preaspiration before word-final voiceless stops.

Preaspiration and glottalisation in this case may be analysed as poslexical rules that apply in a specific order, with glottalisation of word-final voiceless stops bleeding a preaspiration rule. Preaspiration may target a superset of the environments targeted by the glottalisation rule, but because glottalisation has already applied to final stop environments, preaspiration may be blocked:

	cat /kʰæt/	***cattle*** /kʰætl̩/	***cash*** /kʰæʃ/	***passion*** /pʰæʃn̩/
1. Glottalise before final stops	kʰæˀt	kʰætl̩	kʰæʃ	pʰæʃn̩
2. Preaspirate before voiceless obstruents	[kʰæˀt]	[kʰæʰtl̩]	[kʰæʰʃ]	[pʰæʰʃn̩]

When seen from the perspective of the TRAP-BATH split and with an eye toward describing a possible BAD-LAD split, the environments which condition preaspiration look similar to those which have historically conditioned /æ/-lengthening (Figures 9-10). It seems worth noting that none of the regional accents previously identified as containing preaspiration have the TRAP-BATH split. If preaspiration were confined only to the TRAP phoneme in any of these regional dialects or SSBE, it might raise the possibility that in certain environments, there exists an intermediary stage in vowel lengthening between a short vowel and a long vowel, in which the modal section of the vowel stays short but lengthening initially occurs via preaspiration. However, it seems that in the dialects in which preaspiration has been measured, it exists outside of just the TRAP phoneme (Hejná, personal communication). Further research into SSBE is needed to confirm that this is the case.

6.2. BAD-LAD split

The results of this experiment are relevant to theories of phonetic variation and synchronic/diachronic phonology, and raise two broad questions. Firstly, what can be defined as a 'long' /æ/, and do the patterns of variation observed in this data follow a gradient that matches with cross-vowel 'baseline' variation (Peterson & Lehiste 1960), or the implicational weighting hierarchies established by Harris (1986, 1989) or Labov (2007)? Secondly, at what level of phonology does /æ/ durational allophony operate, or in terms of Lexical Phonology, does it derive from lexical, 'extrinsic' postlexical, or 'intrinsic' postlexical rules (see Table 2; Kiparksy 1988)?

6.2.1. Phonetic conditioning of /æ/-lengthening

Intuitively categorising the /æ/ in a word as 'long' or 'short', as previous descriptions and studies have done (Chapter 3), is deceptively simple. Evaluating this putative dichotomy using acoustic measurements turns out to be much more difficult, especially given the often chaotic-seeming results at the token level (Chapter 5). Instead of trying to reduce this allophony to a binary categorical distinction, this experiment will first be analysed in terms of hierarchies of segments that inhibit or encourage lengthening.

The comparability of this experiment's 'cross-section' of lengthening behaviour with hierarchies constructed using binary categorisations cannot be taken for granted. However, Harris (1989) has suggested that /æ/-lengthening phenomena first arise through the phonologisation of 'intrinsic' and therefore gradient phonetic contrasts conditioned by co-articulatory constraints across consonantal contexts. Though he sees these 'intrinsic' phonetic contrasts as 'natural' in that they can be related to substantive aspects of articulatory dynamics, Harris (1986) is also careful to state that it is not the resulting rules themselves that are 'natural', but rather the historical changes of which they are synchronic reflexes. This theory of how synchronic variation is further explored in Section 6.2.2.

As noted in Chapter 2, the more general vowel-lengthening hierarchy established by Peterson & Lehiste (1960) contradicts those found by Harris (1986, 1989) and Labov (1971) for /æ/ specifically (Table 19). Overall, the vowel lengthening hierarchy found by Peterson & Lehiste (1960) can be expressed as follows:

voiced fricatives > nasals > voiced stops/affr. ≈ voiceless fricatives > voiceless stops/affr.

Harris' (1986, 1989) proposal, on the other hand, is:

voiceless fricatives > nasals > voiced stops/affr. > voiced fricatives > voiceless stops/affr.

This contrasts with the proposal by Labov (1971) for the Mid-Atlantic states' splits:

[-velar] nasals > voiceless fric. > [-velar] voiced stops > ʃ > g > voiced fric. > voiceless stops

P&L	z	ð	v	m	ŋ	n	ʃ	θ	g	d	b	s	f	dʒ	t	k	tʃ	p
Harris (RP)	f	θ	s	ʃ	m	n	ŋ	d	dʒ	b	g	v	z	ð	p	t	tʃ	k
Labov (US)	m	n	f	θ	s	d	b	ʃ	g	v	z	(ŋ)	p	t	k			

Table 19: Baseline hierarchy (from left to right, most to least encouraging of lengthening) of Peterson & Lehiste (1960), compared with the implicational weighting hierarchies suggested by Harris (1989) and Labov (1971).

As Harris (1986) points out, similarities between /æ/-lengthening systems could indicate reflexes of a common change that has diffused outwards from a single point of origin. In this case, it is conceivable that two slightly different primary /æ/-lengthening systems, represented by Labov's (1971) and Harris's (1989) hierarchies, took hold in the Mid-Atlantic American states and the south of England, respectively. Given their overall similarities in contrast to Peterson & Lehiste's (1960) 'default' vowel length condition – notably, a relatively high ranking for voiceless fricatives – these two systems may themselves have descended from a single older system.

In the present experiment, the set of monosyllabic words including preaspiration as a part of the vowel measurement yields the general implicational weighting (not counting /z/ and /v/):

voiceless fric. ≥ voiced stops/aff. ≥ nasals > voiceless stops/aff. ≥ nasal + voiceless stop

On the other hand, the monosyllabic set excluding preaspiration yields the hierarchy:

voiced stops/aff. ≥ nasals > voiceless stops/aff. ≥ nasal + voiceless stop ≥ voiceless fricatives

P&L	z	ð	v	m	ŋ	n	ʃ	θ	g	d	b	s	f	dʒ	t	k	tʃ	p
(+preasp)	z	s	f	ʃ	g	d	ŋ	m	v	n	dʒ	θs	b	t	k	tʃ	p	
(-preasp)	z	g	d	ŋ	m	n	dʒ	v	b	t	tʃ	k	f	s	ʃ	p	θs	

Table 20: Baseline hierarchy (from left to right, most to least encouraging of lengthening) of Peterson & Lehiste (1960), compared with the hierarchies suggested by this experiment's datasets including and excluding preaspiration in the measurement of vowel length.

This secondary /æ/-lengthening system diverges from Peterson & Lehiste's (1960) 'default' in some ways similar to the TRAP-BATH split hierarchies (Table 20). Including preaspiration, the hierarchy shows comparative lengthening of the voiceless fricatives, emphasised in the Harris model; the /θs/ of *maths* may not have as much of a lengthening effect as the other voiceless fricatives simply because it is part of a complex coda (see Chapter 5). Excluding preaspiration, the system bears a resemblance to Labov's model – and the General American pattern – in that the nasals rank highly compared to /v/, a voiced fricative. In opposition to Fudge's (1977) claim (Chapter 2), lengthening before /ŋ/ is overall no different than before /m/ or /n/. Again, as a caveat, the /z/ and /v/ patterns emerge from comparatively little data, so analyses involving the voiced fricatives are tentative.

It is suggested that the promotion in particular of nasals and voiceless fricatives over voiced fricatives may have two possible origins. It may reflect a development in post-TRAP-BATH split RP/SSBE that is simply common enough to have occurred twice independently. Supporting this theory are observations of CLOTH-lengthening, another common process by which dialects that already have a lengthened TRAP allophone begin to lengthen certain historically short-/ɒ/ words. In this case, the leading environments also seem to be voiceless fricatives and nasals (as in lengthened NYC *long, coffee, boss*) (Harris 1986; Labov 1981). Another possibility is that similarities between the primary and secondary /æ/-lengthening environments are due to a common history, with secondary lengthening representing a linguistic 'residue' from the TRAP-BATH split. If, as argued by Wells (1982), the TRAP-BATH split was at some point a quantity difference which only later developed a difference in quality, it is conceivable that some words or environments have continued to generate /æː/ while others fully changed over to the /ɑː/ class.

But secondary lengthening seems to have its own unique features, comparable to but quite different from the outcome of previous TRAP-BATH splits. It is especially notable that in both the including/excluding preaspiration datasets, /g/ and /d/ stand out for their overall lengthening. In another interesting corollary with CLOTH-lengthening, these happen to be environments where the NYC system has also lengthened (*dog, God,* but not *cob, job*). In contrast, /nt/ coda clusters discourage secondary /æ/-lengthening, even though they were favourable environments in the TRAP-BATH split (RP *grant*).

It would be assumed that a dialect that has not undergone noticeable lengthening in a short phoneme would exhibit gradient differences in duration comparable to other short vowels. It therefore remains unclear why lengthening in historically short /æ/ (and, as mentioned, /ɒ/) would follow a different weighting hierarchy than expected from Peterson & Lehiste's (1960) cross-vowel comparisons of co-articulatorily natural lengthening environments, and more in-depth research would be needed to understand these patterns.

But setting aside this concern, it proposed here that what makes secondary /æ/-lengthening noteworthy – in the sense that trained linguists like Blake (1985), Fudge (1977), Wells (1982), Jones (1972 [1918]), Cruttenden (2001), and Linguists #1 and #2 (see Chapter 3) have been able to pinpoint specific environments and words that have a 'long' /æ/ – may be a function of a perceptual ability to, first, intuitively account for 'inherent' lengthening by unconscious reference to a 'natural' hierarchy, and, second, recognise deviations from this norm as being somehow out of place. In this way, gradient duration allophony purely due to 'natural' factors may not receive any notice from speakers or listeners, since they can 'normalise' for this perceptually; it's only when durational differences, even if still gradient, cease to follow a hierarchy that people are used to and can reliably normalise against that words begin to sound comparatively 'long'.

In Tables 21 and 22, portions of Table 10 (Section 2.3) are reproduced with their segments reorganised into the hierarchies emergent from this experiment. The specific coda clusters /nd/, /nt/, /ŋk/, /mp/, and /st/ are added in. These have been omitted until now for simplicity's sake, but are relevant for making more detailed comparisons between primary and secondary /æ/-lengthening environments in SSBE. For instance, while a following /n/ alone (e.g. *plan*) was not a lengthening environment in England, nasal + stop clusters (*grand, grant*) contain the BATH vowel (see Chapter 2). /mp/ lengthened (*example*), but only in disyllables; it is thus not counted as a lengthening environment for the sake of comparison with the current

-preasp hierarchy	z	g	d	ŋ	m	n	dʒ	v	nd	b	t	nt	tʃ	k	f	ŋk	s	ʃ	p	mp	st	θ
RP (Jones)		±	±		±	±					±			±								
RP (Cruttenden)		+	+		±		+		±	+										±		
RP (Wells)	+		±		+																	
RP (Fudge)	±	±	±	-	±	±	±	±	±	±	-	-	-	-	-	-	-	-	-	-		-

Table 21: Previous BAD-LAD observations arranged along the lengthening hierarchy emergent from the dataset without preaspiration.

+preasp hierarchy	z	s	f	ʃ	g	d	st	ŋ	m	v	n	dʒ	nd	θ	b	t	nt	k	tʃ	ŋk	p	mp
RP (Jones)					±	±			±		±					±		±				
RP (Cruttenden)					+	+			±			+			+							
RP (Wells)	+					±			+													
RP (Fudge)	±	-	-	-	±	±	-	-	±	±	±	±	±	-	±	-	-	-	-	-	-	-

Table 22: Previous BAD-LAD observations arranged along the lengthening hierarchy emergent from the dataset with preaspiration.

monosyllabic hierarchies. The overlay of the TRAP-BATH colouring (red for environments that did not contribute words to the BATH class in RP/SSBE, and green for ones that did) emphasises that this new lengthening hierarchy is quite separate from that which governed primary /æ/-lengthening.

Assuming that preaspiration is a recent phenomenon in SSBE, we can use the hierarchy that does not count preaspiration as part of the vowel length to do a comparison. Starting with the segments that most heavily favour lengthening in this dataset, /z/, /g/, and /d/, we see that all sources agree on the presence of lengthening, at least in some words. /m/, /n/, /dʒ/, and /v/ are also high in the hierarchy and have been noted as lengthening environments. Intriguingly, /ŋ/ shows no overall difference compared with the other nasals, despite being ruled out as long by Fudge (1977) as well as Blake (1985) in Australia. /b/ was also mentioned as a lengthening environment by Cruttenden and Fudge, though the words tested in this experiment are markedly shorter before /b/ than before the other voiced stops. Though Cruttenden (2001: 111) claims that one potential minimal pair could be *champ* (champion) vs. *champ* (at the bit), the /mp/ words in this sample pattern towards the very bottom of the hierarchy.

It is tempting to consider the differences found between the present dataset excluding preaspiration and previous descriptions of the BAD-LAD split as the result of differing methodologies, and in particular the questionable accuracy of attempting to analyse one's own idiolect. Linguists may have a tendency to find patterns where they do not exist, and the two intuition-based studies surveyed here contain caveats suggesting that their strict categorical approach was not as self-evident as it may have seemed:

> Even after the distinction had been pointed out to me, I had some difficulty in accepting that it was phonemic in my idiolect and it was only after hearing Charles Ferguson speak on the subject at Monash in 1981 that I became convinced that a phonemic opposition between æ and æ: was to be found in my own speech and in the pronunciation of my native Melbourne speech-mates. (Blake 1985: 6-7).

> The task of determining whether the vowel of a given word is [æ] or [æ:] is not always an easy one. The influence of sentence factors is often difficult to separate from the inherent quantity of the vowel, especially in monosyllables, and there is in fact a residue of cases which I have not been able to assign to one category or the other. (Fudge 1977: 56).

Assuming, though, that /ŋ/ is truly a more favourable lengthening environment now than it was in mid-20th century RP, this change can be explained through analogical levelling.

Whatever rule it was that initially lengthened certain pre-nasal words now applies equally to velar nasals. Cruttenden's (2001) suggestion of pre-/mp/ splitting, however, may be merely an error.

The dataset including preaspiration also sheds interesting light on how voiceless fricatives, implicated heavily in the operation of the TRAP-BATH split, may over time make their way to the top of the lengthening hierarchy. Though they lie in the middle range of Peterson & Lehiste's (1960) cross-vowel hierarchy, co-articulatory constraints separate from those normally operating upon vowel duration can encourage preaspiration preceding voiceless fricatives. Over time, if this preaspiration is reanalysed by learners as being part of the vowel, a pattern of longer /æ/ before voiceless fricatives could become phonologised as an extrinsic source of allophony.

6.2.2. Synchronic phonology, diachronic trajectory

Labov (1981) states that in contrast to neogrammarian vowel changes, which tend to operate gradually within subsystems and with few lexical exceptions, lexical diffusion is most often found in changes across subsystems, particularly lengthenings and shortenings of vowels. Elsewhere, Labov (1994) has outlined a 'low exit principle' operating in vowel shifts that allows low vowels to 'exit' the short subsystem and enter into the long subsystem by lengthening and then changing in quality, rising up the front or back of the vowel space. This principle accounts for several shifts over the history of English, including the lengthening and raising of FACE in Late Middle English as well as the various changes first in quantity and then in quality that have pushed BATH to [ɑː] in RP and have raised it toward [ɛᵊ] in North American dialects. Observing a possible BAD-LAD split therefore allows unique insights into the micro-operation of the low exit principle, and as such secondary lengthening must be located within theories of diachronic as well as synchronic language change.

We return to Table 2 (reproduced here as Table 23) to consider the synchronic operation of secondary /æ/-lengthening, in hopes of situating it within Lexical Phonology's framework of historic change – if indeed it does represent a change.

Firstly, it can be demonstrated that the BAD-LAD split does not involve the creation of a new phonemic category, nor a novel allegiance to another pre-existing category (the top level in Table 23). In the TRAP-BATH split in RP, lengthened BATH at some point joined and augmented a pre-existing (though impoverished) class of PALM and later START words. North

American varieties such as NYC that exhibit highly complex primary /æ/-lengthening systems are borderline cases: raised long-/æ/ tokens have the potential to merge with the vowel in *yeah, idea*, and in non-rhotic speakers, *bared* and/or *beard*. Wells (1982) describes this as a merger, suggesting that NYC BATH has shifted in quality enough to augment another phonemic class (as in the British BATH/PALM/START case), but Kiparsky and Harris argue that a single /æ/ phoneme still underlies both allophones. Clearly nothing so extreme is currently happening with secondary /æ/-lengthening, so in Lexical Phonology this must still be allophony, not a phonemic split.

	North England	Gen Am	NYC/Phila	RP/Aus		NCS
phonemic inventory	/a/	/æ/	/æ/	/æ/	/ɑː/ (RP) /aː/ (Aus)	/æh/
lexical rules			lengthen before certain tautosyllabic segments, subject to morphological boundaries and various lexical exceptions	BAD-LAD split?		
postlexical rules – extrinsic allophony		lengthen all /æ/ before nasals				
postlexical rules – 'intrinsic' allophony	gradient phonetic conditioning based on voicing, manner, etc. of following segment	gradient raising of lengthened allophones based on manner of following segment	gradient raising of lengthened allophones based on voicing, manner, etc. of following segment, plus sociolinguistic conditioning	gradient phonetic conditioning based on voicing, manner, etc. of following segment		gradient raising of lengthened allophones based on voicing, manner, etc. of following segment

Table 23: Reproduction of Table 2 (Chapter 2). Phonological rules governing /æ/ lengthening.

Secondary /æ/-lengthening also does not originate from purely 'natural' gradient co-articulatory effects (the bottom level of Table 23). Section 6.2.1 demonstrates why some level of the grammar besides 'intrinsic' constraints must be at work: neither of the including/excluding preaspiration hierarchies emergent from this data follow the cross-vowel patterns outlined in Peterson & Lehiste's (1960) research on co-articulatory effects on duration. Indeed, the primary /æ/-lengthening systems put forth by Harris (1986, 1989) and Labov (1971) also violate several 'natural' conditions, a seemingly major flaw in their model of extrinsic phonological contrasts emerging over time from the build-up of slight exaggerations of intrinsic postlexical rules.

Table 23 therefore indicates that secondary /æ/-lengthening lies somewhere in between lexical and 'extrinsic' postlexical rules in operating on the TRAP phoneme. Understanding how this sub-phonemic variation patterns has implications for Lexical Phonology's treatment of /æ/-lengthening processes in general:

> According to the theory of Lexical Phonology, any rule that undergoes lexicalization as a result of analogical levelling is granted access to all aspects of lexical structure which were previously hidden from it when it operated post-lexically. One such effect is the ability to sustain lexical exceptions. So once lexicalized, a given change is free to become subject to lexical diffusion. In fact, as Kiparsky points out (1988: 399), the theory of Lexical Phonology makes the apparently correct prediction that ONLY contrasts which are present in the lexical segment inventory (the output of lexical phonological rules) are susceptible to lexical diffusion. As far as we know, 'allophonic' contrasts, which are processed post-lexically, are never involved in lexically-selective change (Harris 1989: 51).

Kiparsky (1988) argues that lexical diffusion and regular, neogrammarian-type sound change are the result of two different types of phonological rules: lexical diffusion is a property of lexical rules, while neogrammarian change occurs via postlexical rules. Lexical rules may have lexical exceptions, while postlexical rules may not. Labov (1981) outlined a dichotomy of features of the two types of change, used here as diagnostics for characterising the BAD-LAD split (Table 24).

	'Neogrammarian' change	Lexical diffusion
Discrete	no	yes
Phonetic conditioning	fine	rough
Lexical exceptions	no	yes
Grammatical conditioning	no	yes
Social affect	yes	no
Predictable	yes	no
Learnable	yes	no
Categorised	no	yes
Dictionary entries	1	2

Table 24: Labov (1981)

On the one hand, the secondary /æ/ lengthening found in this study seems to fit the pattern of a neogrammarian change, evidence which would suggest it operates as a postlexical rule. It does not operate by replacing one discrete phoneme with another, and therefore almost certainly does not create two 'dictionary' entries. Kiparsky (1988) points out that attested examples of lexical diffusion involve a redistribution of phonemes among lexical items and do not create new phonological contrasts; in other words, they "invariably involve *neutralization* processes, i.e. processes whose output can be lexicalized" (399). In the case of the BAD-LAD split, longer variants have not (yet) been relexicalised as belonging to a new, pre-existing phoneme in the way that BATH joined PALM in RP or even the way that BATH joined SQUARE in NYC. The conditioning of lengthening rather exhibits a gradient across coda segments depending on voicing and manner of articulation. The lack of differences between mono- and bi-morphemic *adder* and noun vs. verb *can* (Figure 27), among other homophonous pairs, suggests that it is not conditioned by morphology or lexical characteristics in the grammar. Furthermore, though this thesis has not touched upon sociolinguistic factors, Fudge (1977) reported a social evaluation he associated with shortening otherwise 'long' words (see Section 7.).

On the other hand, in some ways the BAD-LAD split behaves more like lexical diffusion, which would suggest operation as a lexical rule. Though it is difficult to interpret the word-level results of the present experiment, they suggest that some final-/d/ and final-/g/ words like *bag*, *bad, mad,* and *sad* may be especially long for some speakers and are therefore lexically selective.

In Table 24, 'Learnability' refers to the ability of adult learners to acquire a 'perfect' pattern: an example of a non-learnable pattern would be the TRAP-BATH split in RP, the 'perfect' acquisition of which would be extremely difficult for a second-language or second-dialect speaker (Labov 1981). It is unclear whether the BAD-LAD split would count as 'learnable', but if the high variability between subjects is any indication, perhaps the answer is 'no'. It is also difficult to discern whether short and long /a/ are categorised separately: though the results of this thesis cast doubt upon the notion that TRAP words can be neatly split into 'long' and 'short', previous idiolectal treatments of secondary lengthening have insisted that such a distinction exists.

The results of this experiment therefore highlight Lexical Phonology's theoretical inability to account for allophonic contrasts that show signs of lexically-specific patterning. According to Kiparsky (1988), the characteristics identified by Labov (1981) are not the result of two types of sound change, but rather the preconditions for such changes: perhaps the fact that secondary /æ/-lengthening does not neatly follow all the preconditions for a single type of change indicates that it is not a change after all, but is rather a stable pattern of variation. But admitting this possibility brings us no closer to finding where in the synchronic grammar the lengthening operates, and doing so may require the re-evaluation of Lexical Phonology's model of the embedding and production of allophony.

7. Future Directions for Research

Several factors, such as the need to select a finite number of target words in the main experiment and a limited dissertation word count, have restricted this investigation to an overview of the main phonetic and phonological factors governing the synchronic and diachronic patterning of secondary /æ/-lengthening in SSBE. Naturally, the next step will be to carry out a full analysis of the multisyllabic words as was done for the monosyllabic ones: this will put to the test a fuller set of previous assertions that have not been investigated by experimental means. In addition, a comparison of these SSBE results with those of Piercy's (2010) measurements of the expanding TRAP-BATH split in Dorset could also be fruitful; by recruiting only SSBE speakers with a fully complete TRAP-BATH split, this thesis has avoided addressing the complexities of idiolectal interactions between incomplete primary /æ/-lengthening and possible secondary lengthening. There remain many other factors that deserve exploration in future treatments of this data as well as other experimental investigations going forward.

7.1. Acoustic data processing

Data was collected for several words which were not included in this analysis due to difficulties in consistently finding where a consonantal onset ended and the /æ/ vowel began. All words in which the vowel was immediately preceded by /h/, /w/, or /r/ were thus excluded. If a protocol were developed for consistently and accurately segmenting these words, they could be included in future analyses, allowing a more detailed look into the patterning of strong preterites (*drank*, *sprang*, *swam*), adjectives (*drab*, *drably*), and lexical/function word pairs (*have*/*have*, *has*/*has*).

This thesis has presented only the initial analyses of duration. One of the next steps in fully exploiting this data would be to analyse not just the length but also the quality of reflexes of short /æ/. A number of recent studies (Fabricius 2007; Kamata 2008) have reported shifting of this vowel in an apparent rotation of TRAP and STRUT. Tokens could be compared within speakers to see whether certain phonological environments lead the lowering and centralising of /æ/ toward [a], and the dataset as a whole could be normalised so as to compare F1/F2 values between speakers.

7.2. Ideological and semantic factors

Fudge (1977) suggested that long /æ:/ correlates with informality and short /æ/ with formality, raising the possibility that the operation of the BAD-LAD split may involve social evaluation and is thus conditioned by factors of linguistic ideology. He observed that when he tried to pronounce 'long' words with a short [æ], "they are felt (by me) to give a 'prissy' impression" (Fudge 1977: 57). If this were an ongoing change in which younger generations of speakers are exposed to an older model of speech that contained more short /æ/ reflexes in places where they might use long /æ:/, it would be tempting to explain the formal/prissy impression of short /æ/ as a result of it being sociolinguistically indexed with older speech. However, the fact that secondary /æ/-lengthening has been noted since the beginning of the 20th century casts doubt upon this source of allophone-specific ideological valuation.

Intriguingly, Ferguson (1972) noted that Philadelphians have a similar awareness that the short /æ/ allophone is in some way superior to the lengthened one (which he labelled /ǣ/, probably representing [ɛ^{ə}] or [æ^{ə}]), just as Labov (2006) found negative reactions to the raised sound in New York. Speakers who normally used the long vowel in a particular word seemed to regard pronunciations of those words with a short vowel as "affected or bookish". Indeed, he even mentions

> …a widespread value series (descending order): a, æː, æ, ǣ, æy in American English. If a speaker normally uses one of these vowels in a particular lexical item he tends to find speakers who use a vowel above it in the series as affected or over-formal and speakers who use a vowel below it in the series as uneducated or substandard (Ferguson 1972: 266).

In Philadelphia, short variants that seem to be exceptions to the more general lengthening pattern are often "book words" (*asp, bade, lath, damsel*) not often used in conversation and which tend to be learned at school. In addition, he observes that some speakers have minimal pairs between lengthened *mad* (angry) and short *mad* (crazy) as well as between lengthened *damn* (expletive) and *damn* (formal reading in church).

This formality-based explanation does not seem to hold in many cases; there seems to be no ideological reason why *pad* might be shorter than *bad*. In the idiolects of Linguists #1 and #2 (Chapter 3), *lad* was characterised as short, with the speakers both noting that *lad* seems to be a more 'northern' word. This possible effect of regional association – with the implication being that a more 'northern' pronunciation of TRAP/BATH sounds to SSBE speakers like a comparatively ‘short’ vowel – is only applicable to a small number of words, so does not explain the variation as a whole.

Fudge (1977: 65) also asserted that long /æ/ seemed to show “a positive correlation with the semantic feature of ‘expressiveness’”, which does not fully correlate with but only tends toward aspects of phonological structuring. This might explain Jones’ (1972 [1918]) observation that *back* and *that* lengthen, as well as the lengthening seen in the *that* of some participants in the present study.

This experiment tested only a single type of rather formal speech, as participants were reading sentences off of a screen in a recording booth. An initial attempt to model lexeme-specific lengthening that appears to target more ‘familiar’ words does not show a significant effect of frequency (Chapter 5). However, further research is clearly needed to test effects of situational and lexeme-specific formality and expressiveness, in addition to other possible semantic or ideological factors.

7.3. Preaspiration

Finding preaspiration was unexpected, and thus this experiment was not designed with it in mind. The segmentation of recordings in Praat could therefore be re-done using alternate methods of measuring preaspiration as well as glottalisation. In Hejná’s (2014, 2015) method of marking preaspiration, sections of breathy voice are marked separately from ‘true’ preaspiration and counted as part of the vowel, with the rest counting as part of the consonant. Since this analysis counted both breathy voice and preaspiration as part of the vowel (following Morris 2010), different patterns may emerge from looking at a more detailed exploration of voice quality between participants and phonological environments.

The presence of preaspiration in this sample of young SSBE speakers at Cambridge should also encourage further research investigating southern British dialects. Investigations specifically targeting preaspiration, such as those carried out by Hejná (2014, 2015) in Wales, are necessary going forward. In addition, it would be very interesting to look *backward* in SSBE to see if the results of this thesis can be observed in previously collected data. The prevalence of preaspiration in nearly all speakers in this sample is most striking because it has never before been reported in this community. The DyViS database (Nolan et al. 2009), with style-controlled recordings for 100 SSBE-speaking Cambridge University students, would be a good place to start with re-analysis of older data given the similarities between its subject pool and that of the present thesis.

8. Conclusion

Lengthening of the low short vowel has occurred numerous times in the history of English: the FACE vowel lengthened and subsequently shifted as part of the 15th-16th century Great Vowel Shift, and BATH lengthened and shifted in the TRAP-BATH split of many Modern English dialects. The observation that [æ] is noticeably longer in a subset of words in RP and SSBE is therefore of great interest to the study of the recurrent diachronic patterns apparent in the history of the English low vowel space (cf. Gburek 1985; Labov 1994, 2007). Fudge (1977) details his own intuitions of this secondary /æ/-lengthening, but concludes that "what general principles there may be can only be established by detailed study of a large number of idiolects" (Fudge 1977: 55), acknowledging that an experimental study of this phenomenon would require both the preparation of a body of data targeting appropriate words and a group of informants speaking similar varieties of English. This thesis answers his call for further research, reporting the first experimental acoustic analysis the BAD-LAD split in SSBE.

Beyond just describing the patterns of secondary /æ/-lengthening in terms of postvocalic consonantal segments, this thesis also situates the results of the present experiment within the previous literature on co-articulatory phonetic factors in vowel lengthening as well as the framework of Lexical Phonology (Harris 1986, 1989; Kiparsky 1988). Through comparing differences in primary /æ/-lengthening, Harris (1989: 48) asserts that it is possible to identify "a recurrent pattern of implicational weighting based primarily on values for voicing and manner of articulation" which govern the diachronic evolution of /æ/-lengthening. The results of this thesis, however, challenge the ability of Lexical Phonology to fully account for the synchronic operation of the BAD-LAD split, which may operate as an allophonic contrast processed as a postlexical rule while also exhibiting word-specific variation.

Unexpectedly, this study also finds preaspiration in certain phonological environments across the sample of SSBE speakers. Future research into this phenomenon, which has been noted in other parts of the British Isles but never before in SSBE, is necessary to verify whether this is indeed a widespread change affecting English in the southeast of England. It would be interesting to investigate how and why it has suddenly taken hold, and what role, if any, it plays in the sort of durational allophony studied in this thesis.

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Appendix A: Words targeted in experiment

abs
add
am
Ann
ant
apps
ash
ass
back
bad
badge
bag
ban
band
bang
bank
banned
bat
batch
bland
cab
CAD
cad
camp
can (aux)
can (N)
canning
cap
cash
cat
chav
CLAS
dam
damn
damp
drab
drank
fad
fat
flab
flap
gab
gaffe
gap
gas
gash
glad
hack
had
hag
ham
hand
hang
has (aux)
has (V)
hat
have
have (V)
jam (car)
jam (food)
jazz
lab
lad
lam
lamb
lamp
land
lap
mad
man
mass (church)
mass (measure)
massed
mat
maths
pad
Pam
plan
ram
RAM
SAD
sad
Sam
sang
sank
sash
scam
snack
snag
spam
sprang
stack
stag
stand
stank
swam
tab
tack
tag
tap
that
adder (snake)
adder (person)
amber
ample
angle
ankle
anxious
ashen
badly
banger
banker
basil
began
camel
cancel
candle
cattle
channel
dammit
dazzle
drably
family
fashion
flannel
gabbing
gammon
gapping
gavel
gladden
gladly
handle
hangar
hanger
madden
Maddie
madly
mammal
Manning
manning
mantle
Matty
paddle
passion
planning
sadden
saddle
salmon
sandal
snacking
snagging
tacking
tagging
tassel

Anchor vowels:

bait
mall
gut
school
hall
class
snored
cut
cord
bite
fall
board
fool
hate
cup
height
pass
sheet
pool
feet
mast
fight
beet
can't
fate

Appendix B: Sentences read aloud in experiment (in order of appearance)

If you want to go fishing, you need to bring **bait**.
Though I asked for marmalade, in fact he gave me **jam**.
Instead of breaking apart, in fact the gel had **massed**.
She's not meek, in fact she's full of **passion**.
Though I was dreading the lecture, in fact it wasn't **bad**.
Brits call it a shopping centre, but Americans call it a **mall**.
It's not on my knees, in fact it's on my **lap**.
Don't put it in the hearth, put it on the **mantle**.[1]
He didn't hurt his leg, in fact he hurt his **ankle**.
I didn't order tuna, in fact I ordered **salmon**.
Though he thought the plan would go smoothly, in fact it hit a **snag**.
He didn't hit me with a shoe, he hit me with a **sandal**.
Before you start your project, you need to have a **plan**.
She didn't lose her scarf, in fact she lost her **hat**.
I'm not sure, but I feel it in my **gut**.
The drinks were good, but the food tasted **bad**.
Since they didn't need lots of cookies, I only made a **batch**.
Though he says that I'm not, in fact I always **am**.
It's not a hospital, it's a **school**.
I didn't say that he was sane, I said that he was **mad**.
It wasn't just a cut, in fact it was a **gash**.
She doesn't sing solo, she just sings in a **band**.
He's not that far, he's just down the **hall**.
She doesn't want to show it, but I think she feels **sad**.
She says I haven't asked, in fact I really **have**.
A small child is around, you need to not say "**dammit**".
Americans call it gridlock, but Brits call it a **jam**.
They don't call it a lesson, they call it a **class**.
She says the food was good, but in fact it was **bad**.
The cat isn't skinny, in fact it looks quite **fat**.
If you work with airline baggage, you must be good at **tagging**.
John keeps his cash under the mattress, instead of in a **bank**.
I couldn't sleep, since my roommate **snored**.
Brian said the plan was sound, but I thought it was **mad**.
While giving out the prizes, the mayor wore a **sash**.
Since Susan did the bottling, Rebecca did the **canning**.
It didn't smell good, it fact it really **stank**.
If you're not careful, you're going to get **cut**.
The farmer owned some animals, in fact he had some **cattle**.
The professor is at the Centre of Latin American Studies, but students call it **CLAS**.
To close the envelope, you have to lick the **flap**.
She's a typical politician, with the gift of the **gab**.
The door doesn't have a knob, in fact it has a **handle**.
You can use a wire, or a **cord**.
Though he's nearly blind, in fact the dog can **paddle**.

---

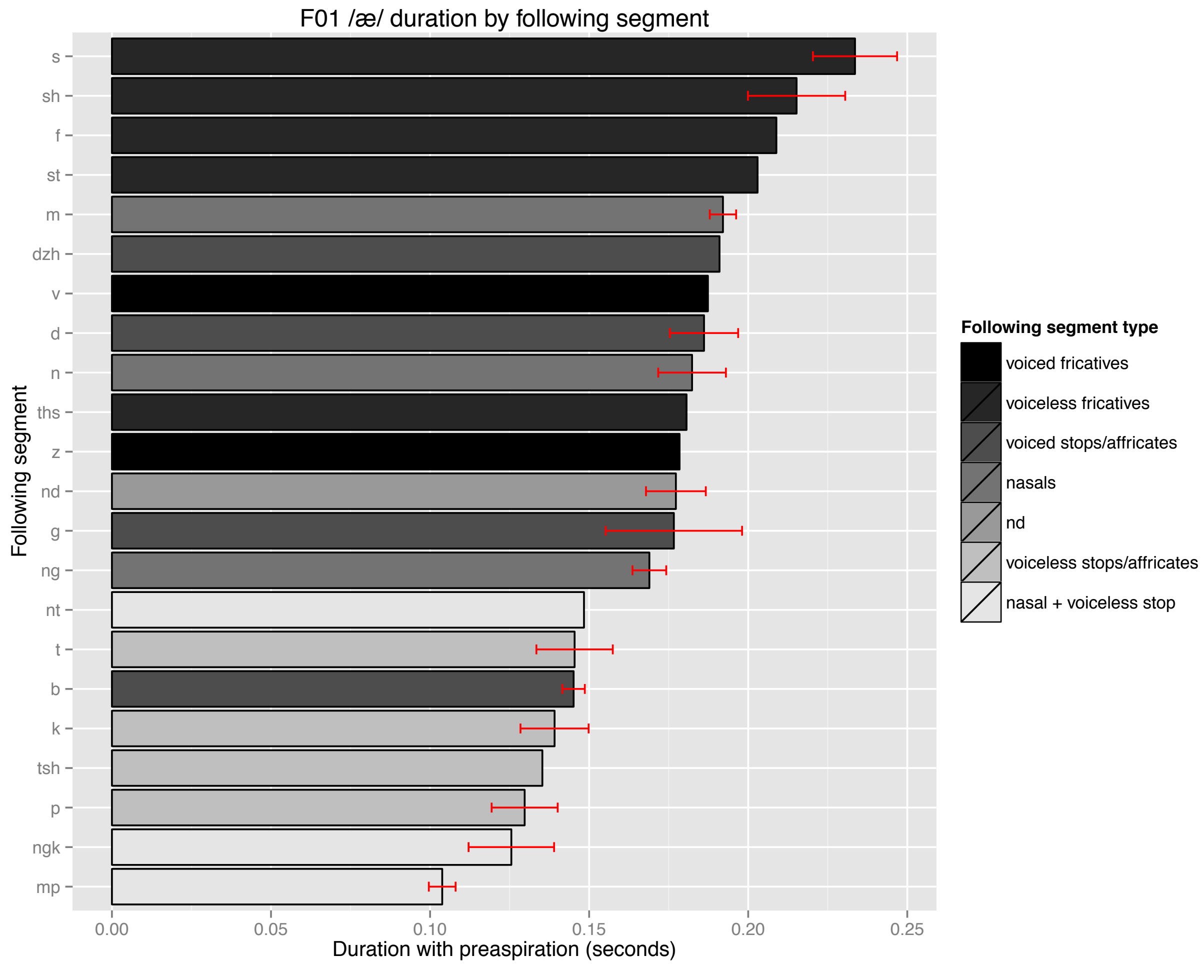
[1] This was an error; in doing utterance rate calculations, this clause was counted as containing four, rather than five, syllables preceding the stressed syllable of *mantle*.

To open the drink, you have to lift the **tab**.
To ride a horse, you have to use a **saddle**.
Since the policeman is undercover, he doesn't wear a **badge**.
I don't see a goat, in fact I see a **ram**.
He didn't write on his arm, but he wrote on his **hand**.
Go and pet the dog, he really won't **bite**.
He wasn't disappointed, in fact he seemed quite **glad**.
Braces don't prevent cavities, in fact they counter **gapping**.
They didn't just like each other, they fell in love quite **madly**.
Though I thought Nadine would care, she doesn't give a **damn**.
Christmas treats are great, but now I've got some **flab**.
I didn't get a ticket, in fact I got a **tag**.
She finished her work, so you know she was **glad**.
Don't wear that, you know it's out of **fashion**.
Walk carefully, or else you'll **fall**.
My computer was getting slow, so I installed more **RAM**.
To open the bottle, you have to twist the **cap**.
The offer isn't real, in fact it's just a **scam**.
Write on the table, not on the **board**.
His name is Matthew, but we just call him **Matty**.
It wasn't a board, in fact it was a **pad**.
I can pay you £20, in fact that's all I **have**.
The plane isn't on the runway, in fact it's in the **hangar**.
I thought the food would be good, but in fact it was **bland**.
It isn't on the floor, in fact it's on the **mat**.
Though we thought there would be coal, in fact we saw just **ash**.
He's not clever, he's a **fool**.
He didn't build his biceps, in fact he built his **abs**.
To silence the court, the judge could use his **gavel**.
There's no room to sit, so I guess we'll just **stand**.
The researcher isn't in the field, in fact she's in the **lab**.
Get me something I love, not something I **hate**.
Buildings are planned using Computer Aided Design, but builders call it **CAD**.
I didn't get the rosemary, in fact I got the **basil**.
The painting shouldn't rest against the wall, but rather it should **hang**.
I didn't hear a woman, in fact I heard a **man**.
I didn't want a bowl, I wanted a **cup**.
My father got an iPhone, in fact he likes his **apps**.
He loves to do maths, so we call him an **adder**.
At the end of the night, he has to call a **cab**.
He didn't have a llama, in fact he had a **camel**.
That's not a lasting trend, in fact it's just a **fad**.
Don't measure the width, measure the **height**.
When we saw the boy, we thought he looked quite **sad**.
The curtains don't hang colourfully, in fact they hang quite **drably**.
She can't have liked the food, if it tasted like **that**.
She didn't order steak, in fact she ordered **gammon**.
Though I thought Marie would fail, in fact she got a **pass**.
She looked angry, but in fact she was **glad**.
The old woman was not very nice, in fact she was a **hag**.

It’s wrong to measure volume, you have to measure **mass**.
She didn’t just shout, in fact she almost **sang**.
Don’t write on the board, write on the **sheet**.
I didn’t say the play was good, in fact the play was **bad**.
He didn’t seem calm, in fact he acted **anxious**.
When they let him have a pet, he wants to get a **mammal**.
The professor wasn’t just strange, in fact he seemed quite **mad**.
Zippers are fast to close, but buttons keep from **snagging**.
He didn’t go with Sandra, you know he went with **Ann**.
When Sylvester bought a donkey, his wife called it an **ass**.
Since the imports are unsafe, you know we need a **ban**.
I went to their house, and they even have a **pool**.
Though I thought he hadn’t done it, in fact he really **had**.
Though he thinks I can’t cook, in fact I really **can**.
I don’t like my college, but the funding is **ample**.
He didn’t see the front, in fact he saw the **back**.
He didn’t turn it down, he accepted it **gladly**.
I’d drive you back home, but you know I just **drank**.
We didn’t eat the pasta, in fact we ate the **ham**.
The salesman wasn’t genuine, in fact he was a **hack**.
He thinks he sees a girl, but in fact it’s a **lad**.
I didn’t wear any nylon, in fact I wore some **flannel**.
As soon as we arrived, the lecturer **began**.
I didn’t go to James, in fact I went to **Maddie**.
Though I get a lot of email, I know it’s mostly **spam**.
The French measure in metres, but Brits measure in **feet**.
The door didn’t shut softly, in fact it made a **bang**.
You shouldn’t subtract, in fact you should **add**.
The drink’s not in a bottle, in fact it’s in a **can**.
I didn’t pay by credit card, in fact I paid with **cash**.
She’s very talkative, in fact she can’t stop **gabbing**.
It can’t be a sailboat, it doesn’t have a **mast**.
It’s not a heater, but in fact it’s a **lamp**.
Instead of folding the shirt, you put it on a **hanger**.
I didn’t have a box, in fact I had a **bag**.
The play wasn’t meant to amuse, in fact it had to **sadden**.
To get the water, you have to use the **tap**.
They were far out at sea, so they didn’t see **land**.
To Americans it’s a sausage, but Brits call it a **banger**.
I didn’t go with Martin, you know I went with **Sam**.
She doesn’t study physics, in fact she studies **maths**.
She didn’t see her friends, in fact she saw her **family**.
The beavers didn’t build a bridge, in fact they built a **dam**.
Stop making so much noise, I hate it when you **fight**.
Winter depression can be Seasonal Affective Disorder, but doctors call it **SAD**.
I thought the bench was dry, but in fact it was **damp**.
That’s not a radish, that’s a **beet**.
She isn’t allowed, I know that she’s been **banned**.
My mum bought flowers for the parlour, she hates to see it **drab**.
They didn’t wait for the guests to arrive, in fact they started **snacking**.

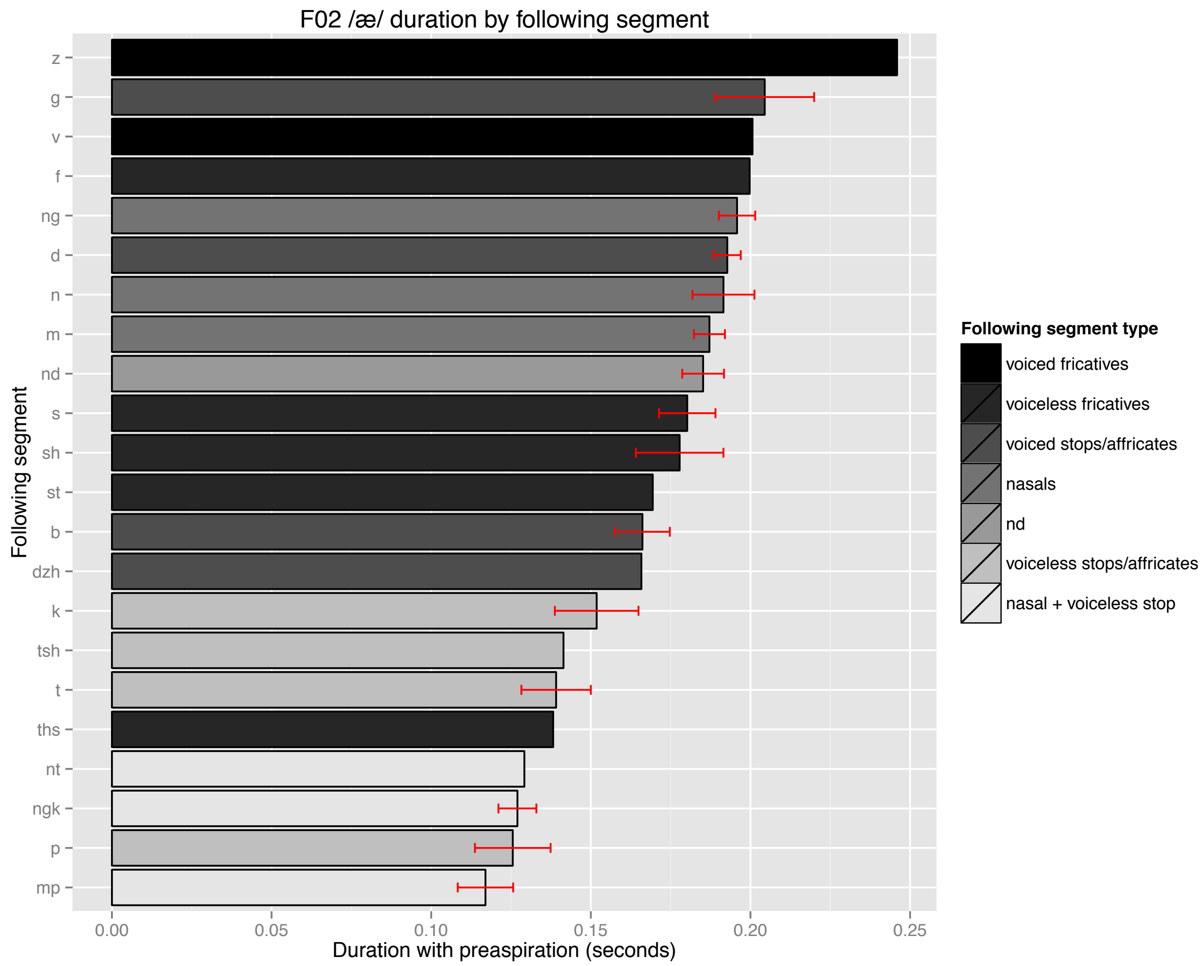
I thought it would float, but it actually **sank**.
I don’t want a torch, in fact I want a **candle**.
When we arrived on time, the lecturer was **glad**.
That jewellery isn’t gold, in fact it’s made of **amber**.
He said that I can, but I actually **can’t**.
When you go mountain climbing, you should first make a **camp**.
When she saw what he was wearing, Elaine called him a **chav**.
He didn’t say that he was happy, he said that he was **sad**.
To get to France, you go across the **Channel**.
She doesn’t want a dog, in fact she wants a **cat**.
She didn’t see a calf, in fact she saw a **lamb**.
When I talked with him, it was clear he was **mad**.
Though he tried to sound practiced, the speaker made a **gaffe**.
I didn’t go to Rita, in fact I went to **Pam**.
If you’re too ill to go, you know you ought to **cancel**.
I don’t just want the medal, in fact I want it **badly**.
He says he hasn’t seen it, in fact he really **has**.
Every Tube rider knows, you have to mind the **gap**.
I didn’t have a meal, in fact I had a **snack**.
When you watch his expression, you see his face go **ashen**.
Since the police are trying to find him, he’s living on the **lam**.
The jar doesn’t hold a liquid, in fact it holds a **gas**.
Their name wasn’t Smith, but in fact it was **Manning**.
I might try to look happy, but in fact I feel **sad**.
The church isn’t holding a wedding, in fact there’s now a **mass**.
Since Lorna did the hammering, Melissa did the **tacking**.
Arthur didn’t row there, in fact I think he **swam**.
The propaganda was so infuriating, in fact it had to **madden**.
He didn’t just jump up, in fact he almost **sprang**.
He doesn’t want a cobra, in fact he wants an **adder**.
He didn’t pull the rope, in fact he pulled the **tassel**.
Don’t throw them in a pile, you need to make a **stack**.
I didn’t see a termite, in fact I saw an **ant**.
I don’t see a bird, in fact I see a **bat**.
The presentation didn’t aim to inform, it simply aimed to **dazzle**.
Though she expected to have more food, in fact that’s all she **has**.
The film was so uplifting, in fact it had to **gladden**.
It’s not in the ship in the harbour, it’s in the one he’s **manning**.
I didn’t see an elk, in fact I saw a **stag**.
You don’t need an accountant, in fact you need a **banker**.
I didn’t use a nail, in fact I used a **tack**.
Sheldon is a model gentleman, he’s nothing like a **cad**.
When the nail was hammered in, it stuck out at an **angle**.
He wasn’t responsible for the whole project, but only for the **planning**.
She didn’t want classical music at her party, in fact she wanted **jazz**.
It wasn’t planned, it was **fate**.

Appendix C: Individual systems of /æ/ duration by following segment, including preaspiration in the measurement of vowel length



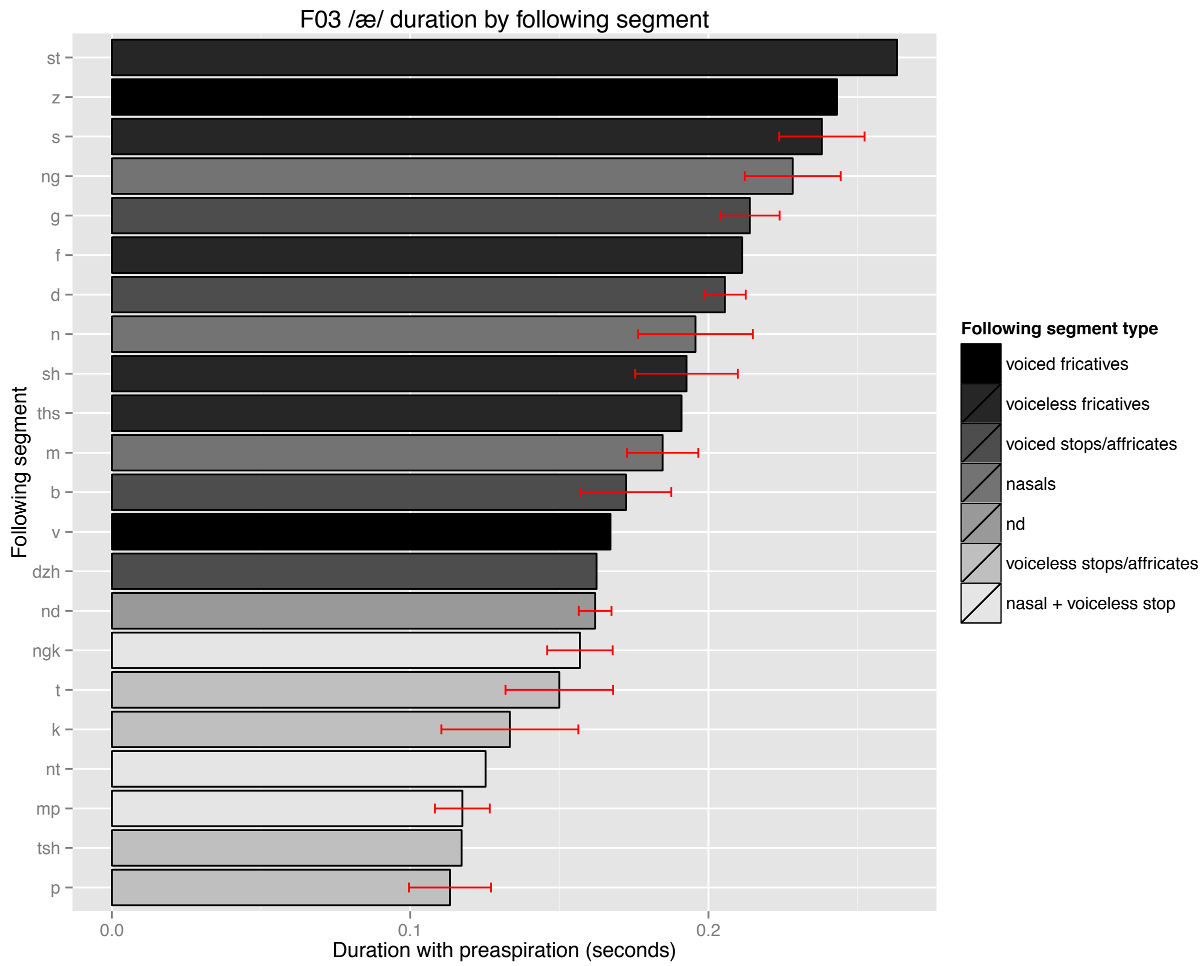
F01, a 19-year-old from Sevenoaks (Kent), exhibits the following approximate patterning of environments favouring lengthening:

d ≥ g > b
t ≥ k ≥ p
nt > ŋk > mp
m ≥ n ≥ ŋ
s ≥ ʃ = f = st ≥ θs



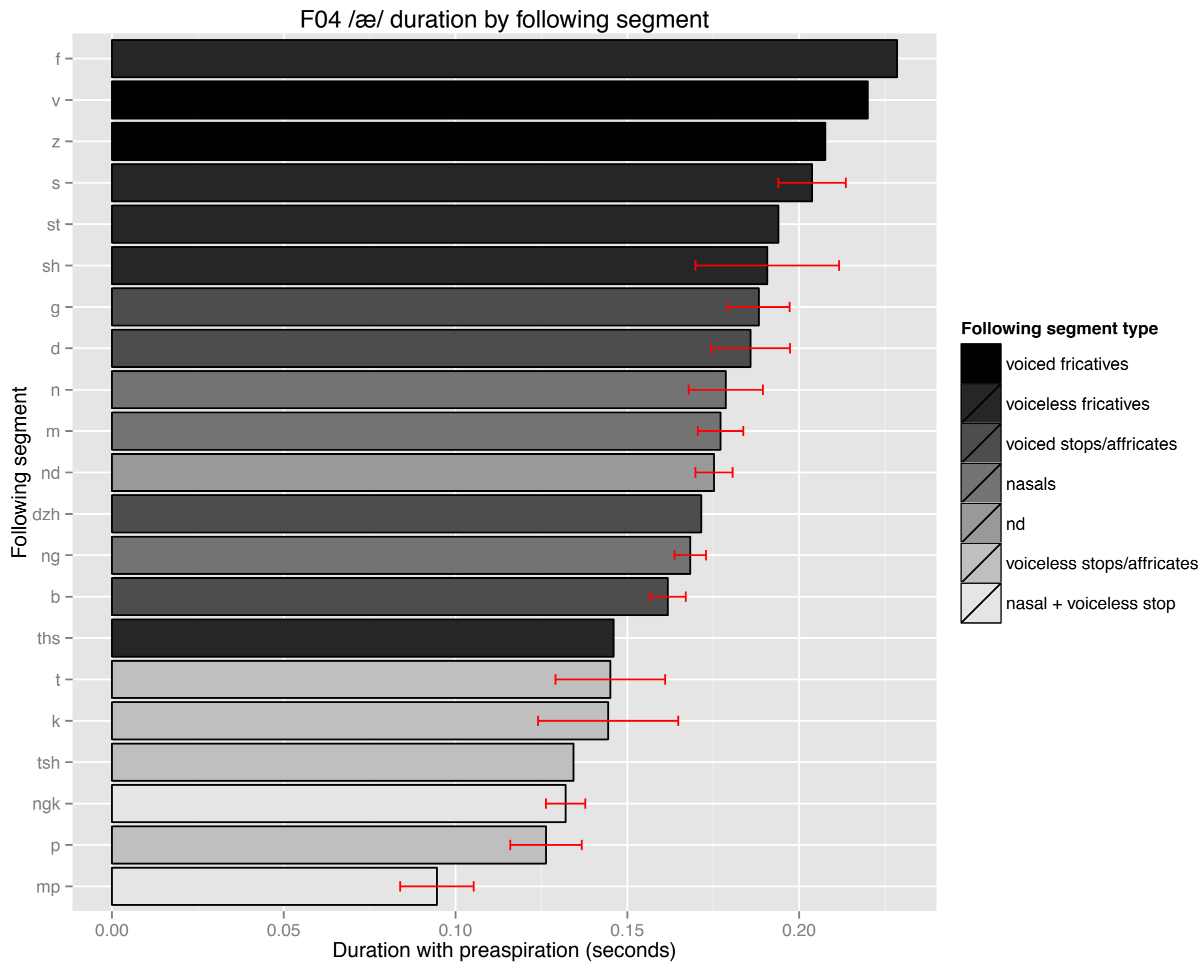
F02, a 19-year-old from Bury St Edmunds, exhibits the following approximate patterning of environments favouring lengthening:

g ≥ d > b
k ≥ t ≥ p
nt = ŋk ≥ mp
ŋ ≥ n ≥ m
f ≥ s = ʃ = st ≥ θs



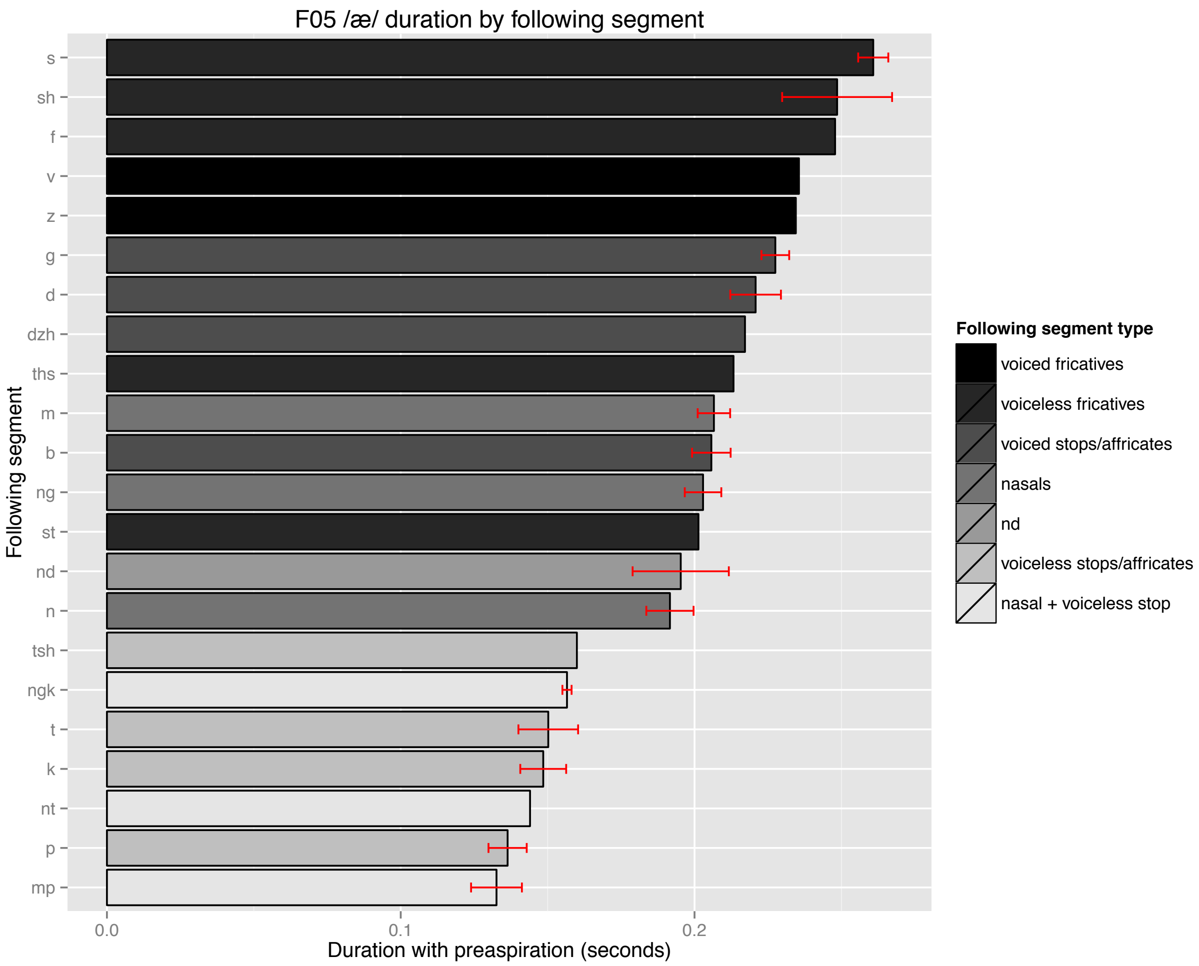
F03, a 21-year-old from East Sussex, exhibits the following approximate patterning of environments favouring lengthening:

g ≥ d > b
t ≥ k ≥ p
ŋk > nt ≥ mp
ŋ ≥ n ≥ m
st ≥ s ≥ f ≥ ʃ = θs



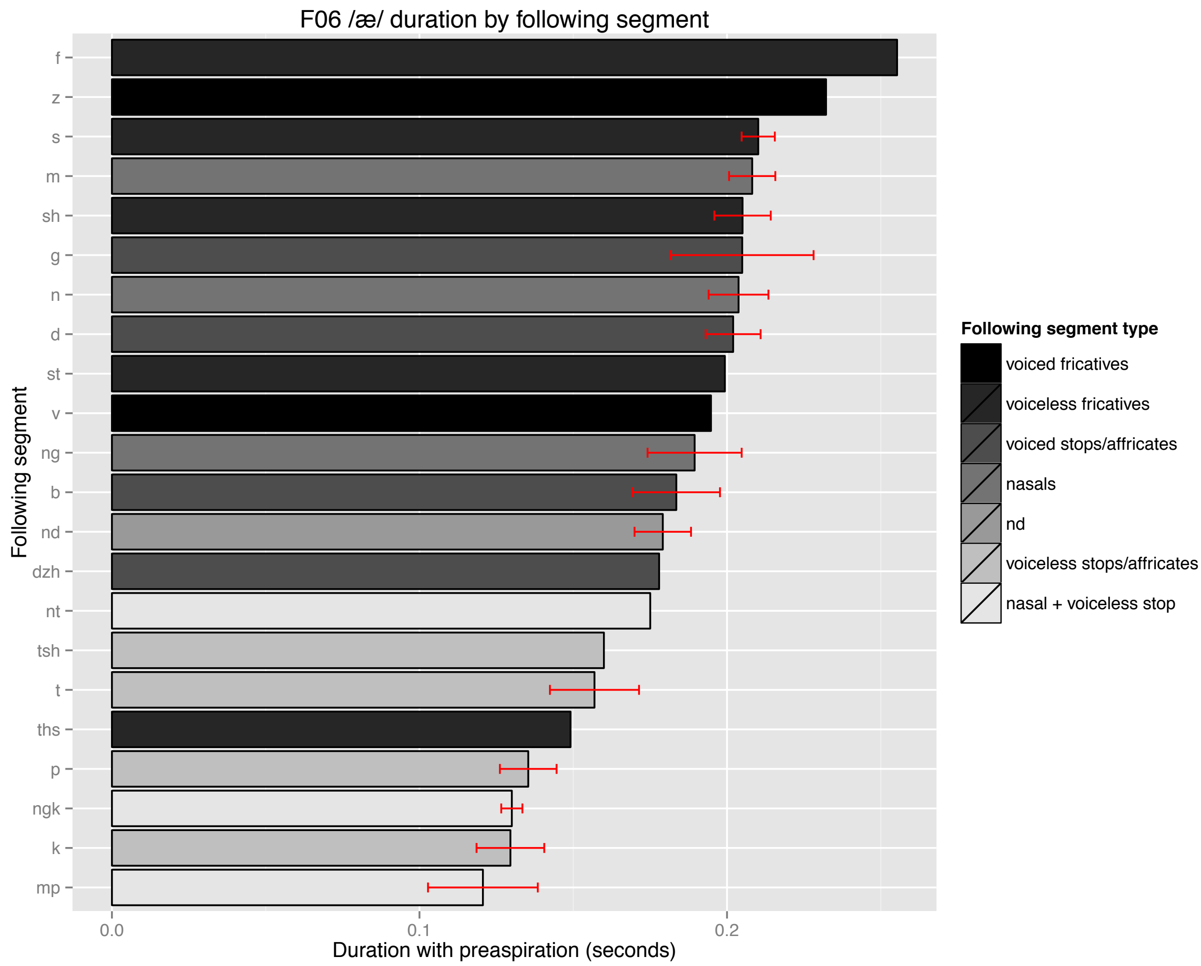
F04, a 22-year-old from Hastings, exhibits the following approximate patterning of environments favouring lengthening:

g = d > b
t = k ≥ p
ŋk > mp
n = m ≥ ŋ
f ≥ s = st = ʃ > θs



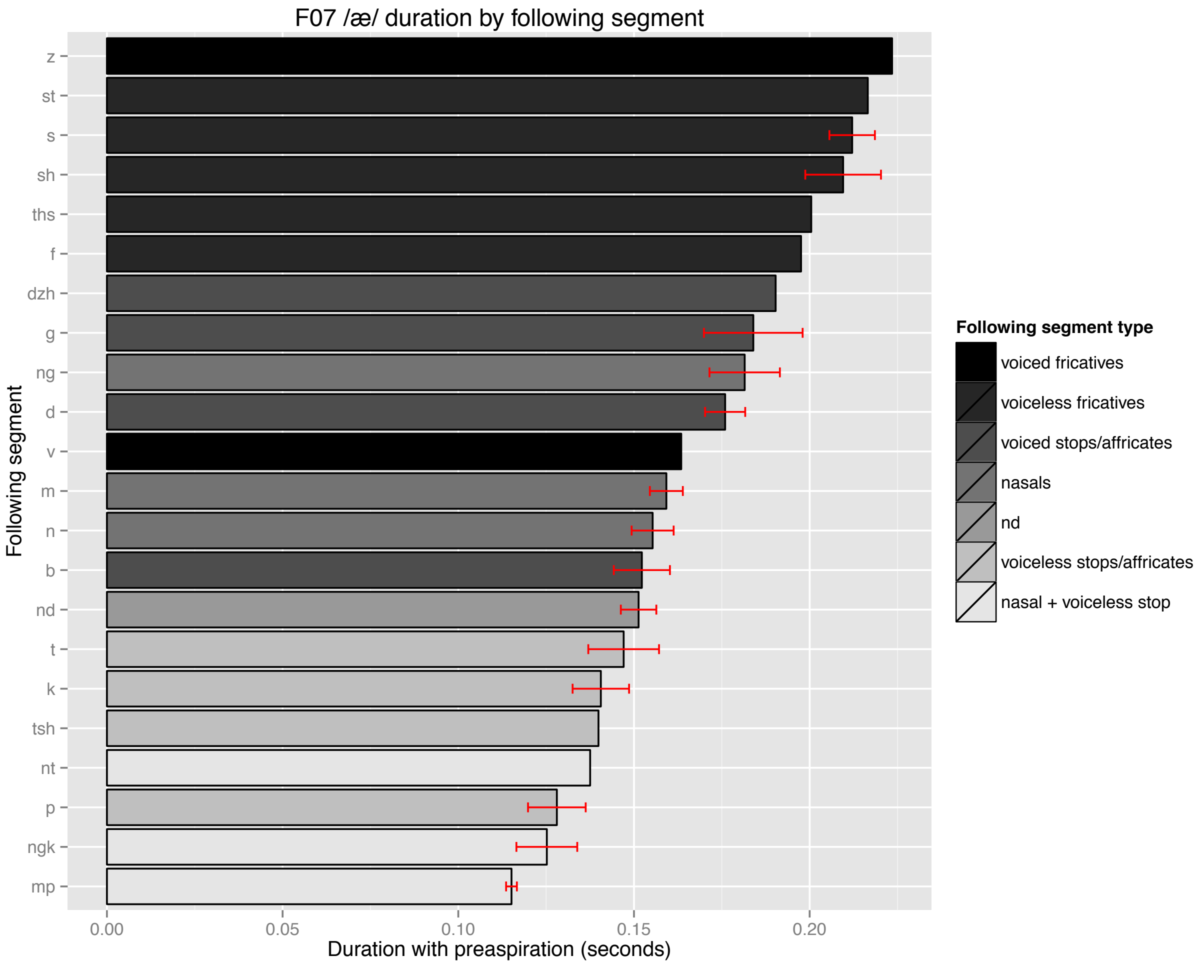
F05, a 20-year-old from Oxford, exhibits the following approximate patterning of environments favouring lengthening:

g = d ≥ b
t = k ≥ p
ŋk ≥ nt ≥ mp
m = ŋ ≥ n
s = ʃ = f ≥ θs ≥ st



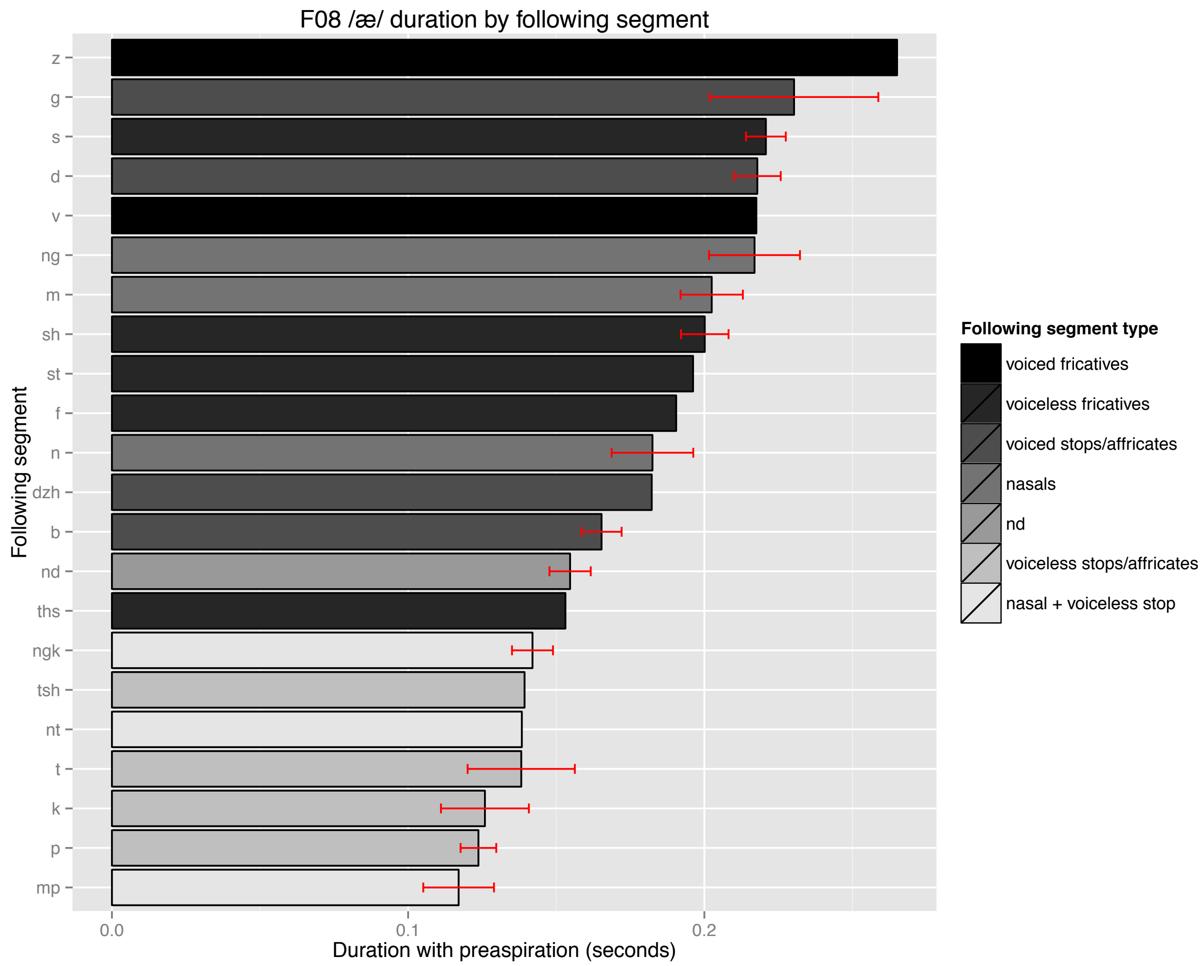
F06, a 20-year-old from London, exhibits the following approximate patterning of environments favouring lengthening:

g = d ≥ b
t ≥ p = k
nt ≥ ŋk = mp
m = n ≥ ŋ
f ≥ s = ʃ = st ≥ θs



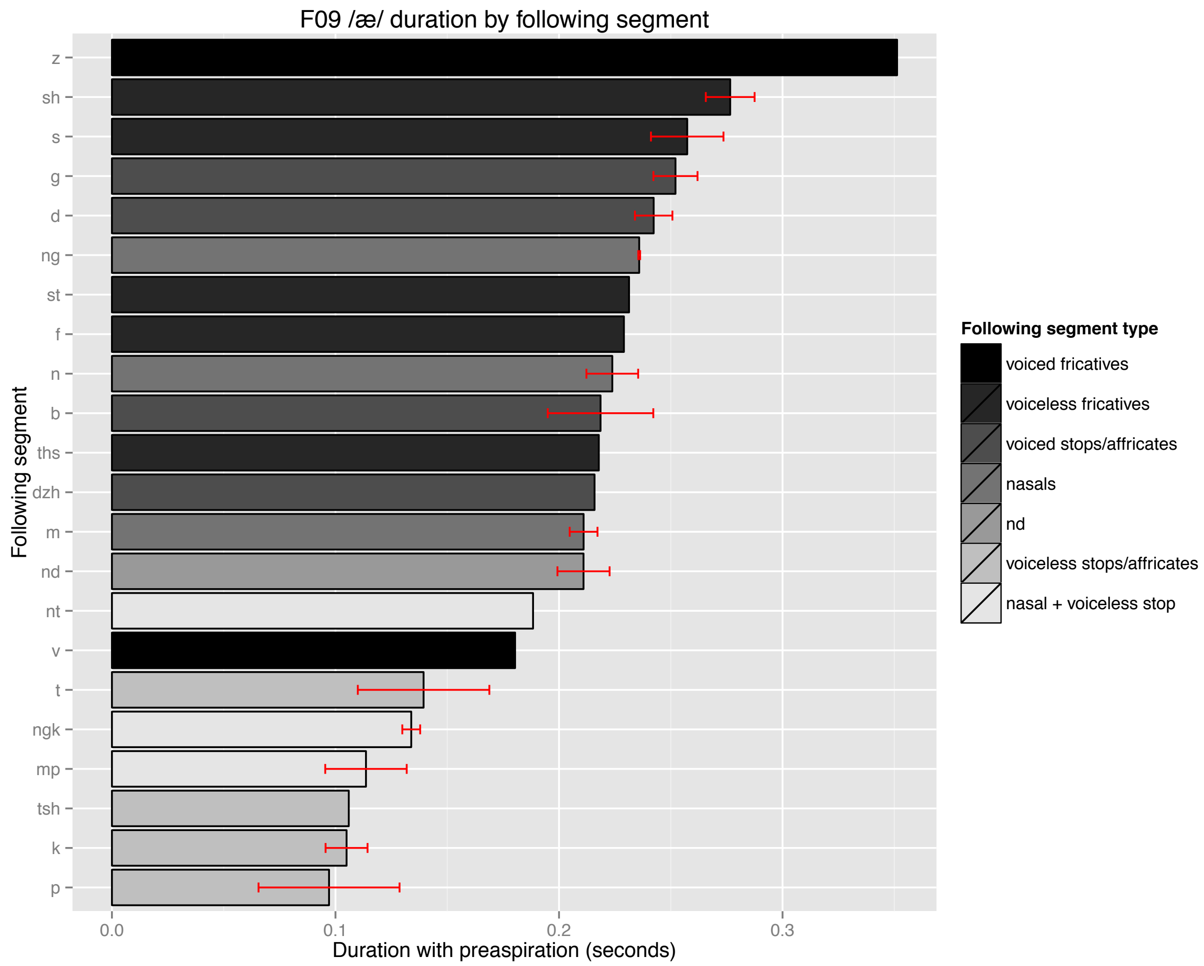
F07, a 24-year-old from Cambridge, exhibits the following approximate patterning of environments favouring lengthening:

g = d > b
t = k ≥ p
nt ≥ ŋk > mp
ŋ > m = n
st = s = ʃ = θs = f



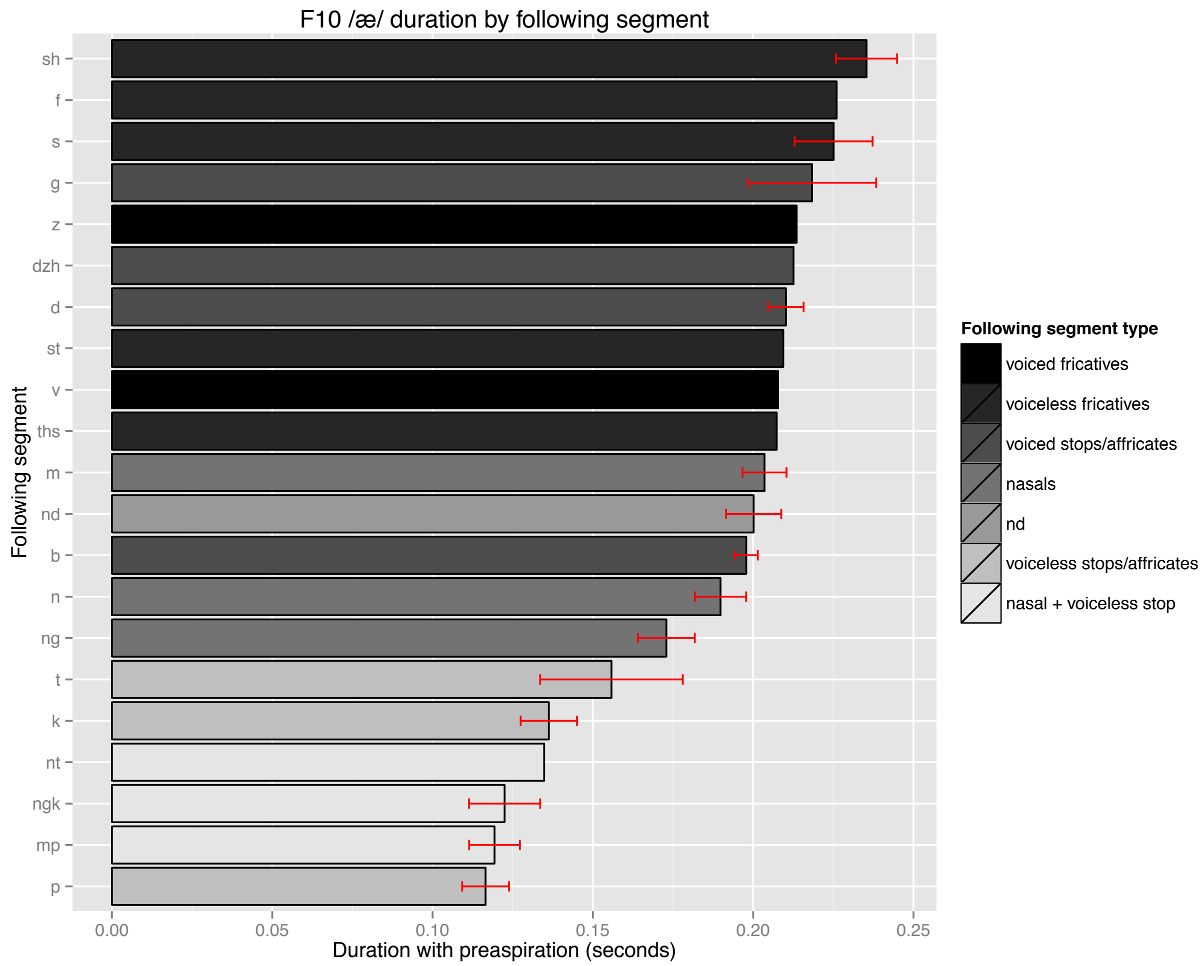
F08, a 19-year-old from Somerset, exhibits the following approximate patterning of environments favouring lengthening:

g = d > b
t = k = p
ŋk = nt ≥ mp
ŋ ≥ m ≥ n
s ≥ ʃ = st = f ≥ θs



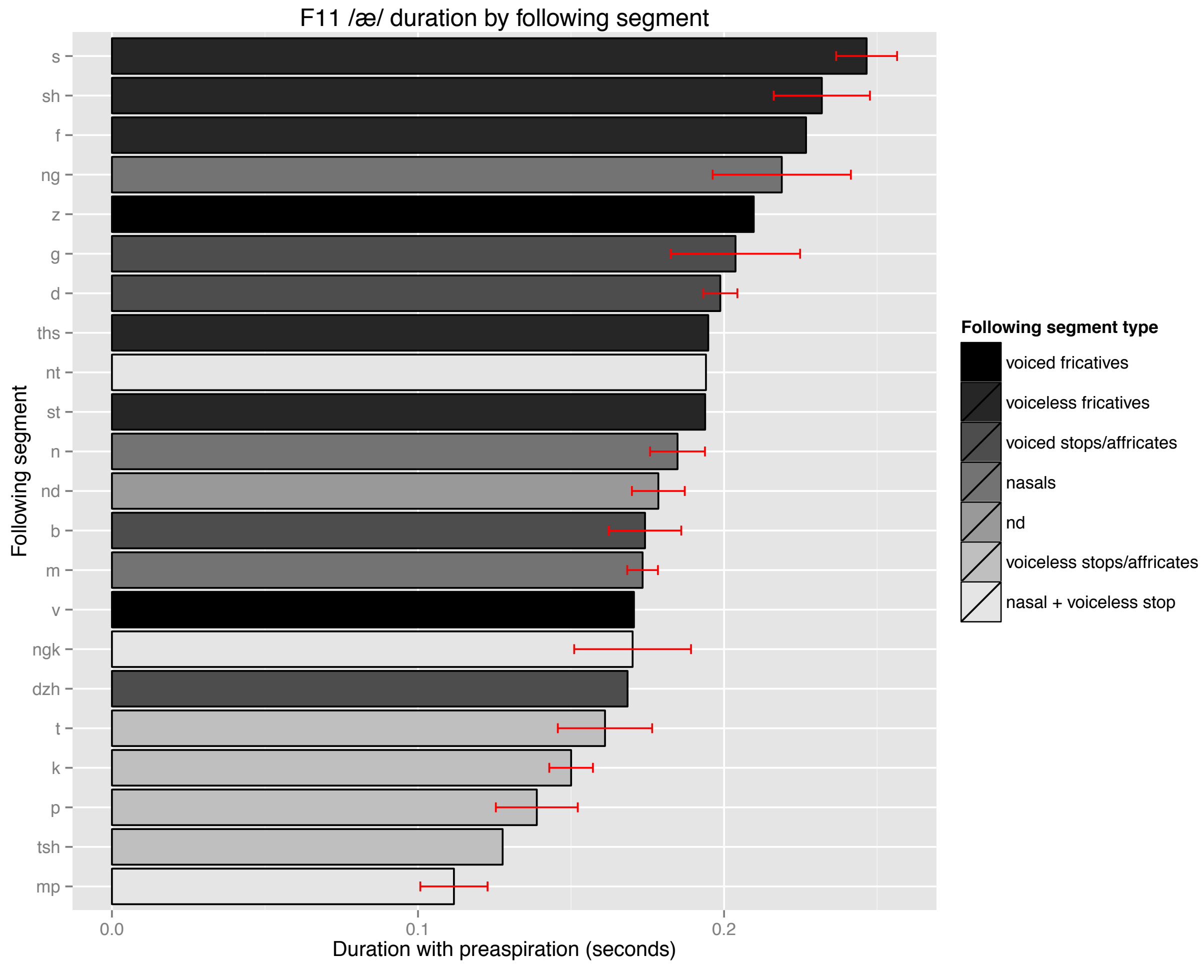
F09, a 24-year-old from Leicester, exhibits the following approximate patterning of environments favouring lengthening:

g = d ≥ b
t ≥ k = p
nt ≥ ŋk ≥ mp
ŋ ≥ n ≥ m
ʃ ≥ s ≥ st = f = θs



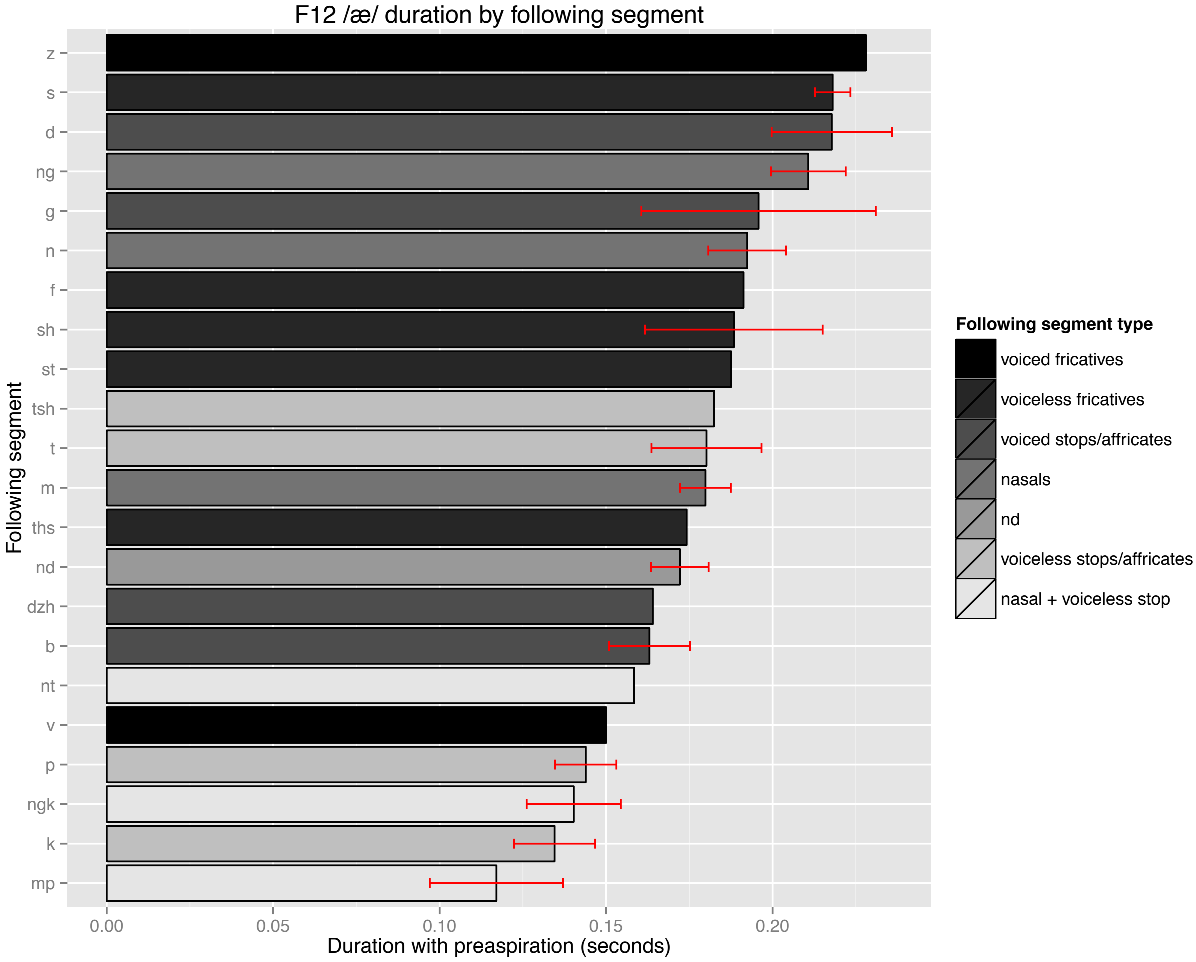
F10, a 23-year-old from Cambridge, exhibits the following approximate patterning of environments favouring lengthening:

g = d ≥ b
t ≥ k > p
nt ≥ ŋk = mp
m ≥ n ≥ ŋ
ʃ ≥ f = s ≥ st = θs



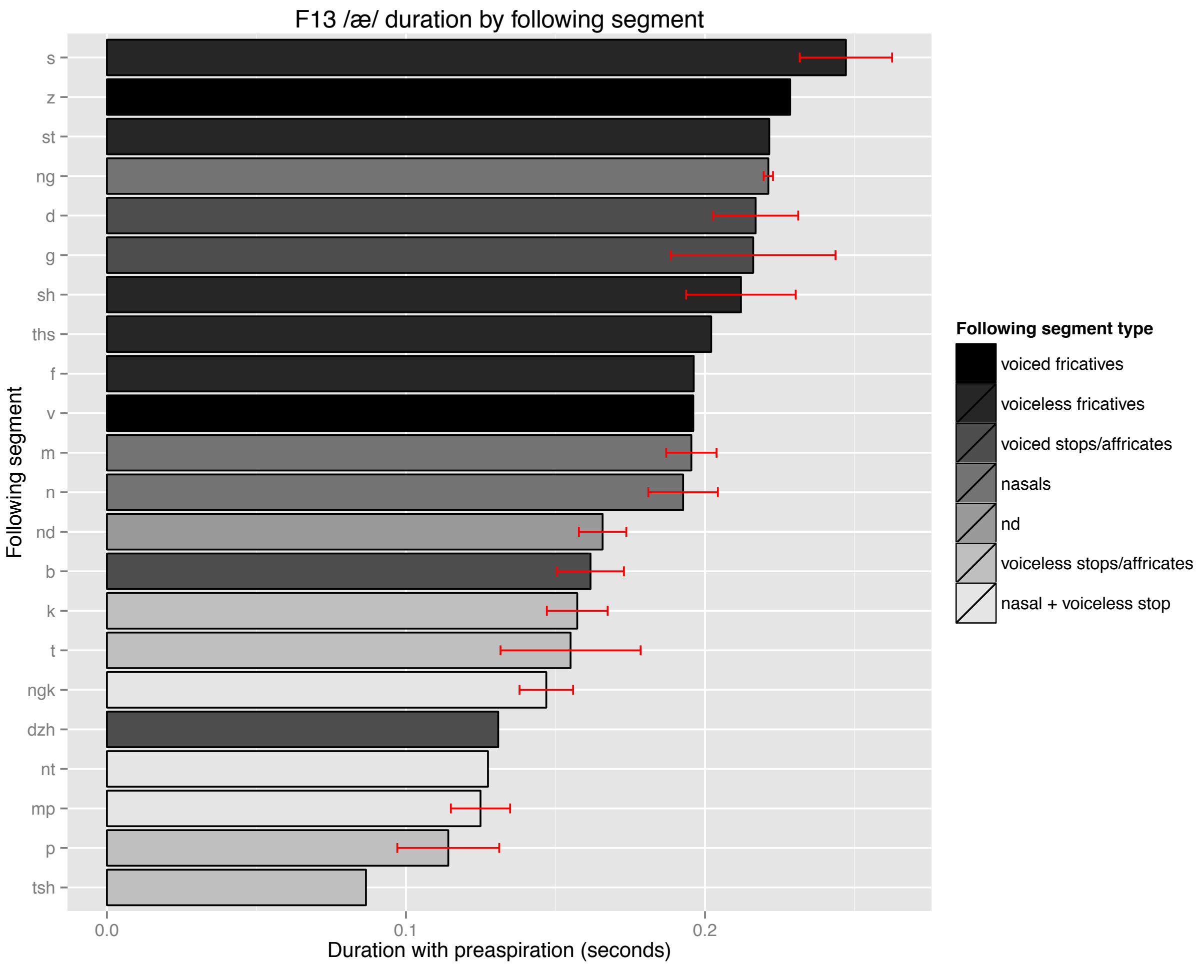
F11, a 21-year-old from Surrey, exhibits the following approximate patterning of environments favouring lengthening:

g = d ≥ b
t ≥ k ≥ p
nt ≥ ŋk > mp
ŋ > n ≥ m
s ≥ ʃ = f ≥ θs = st



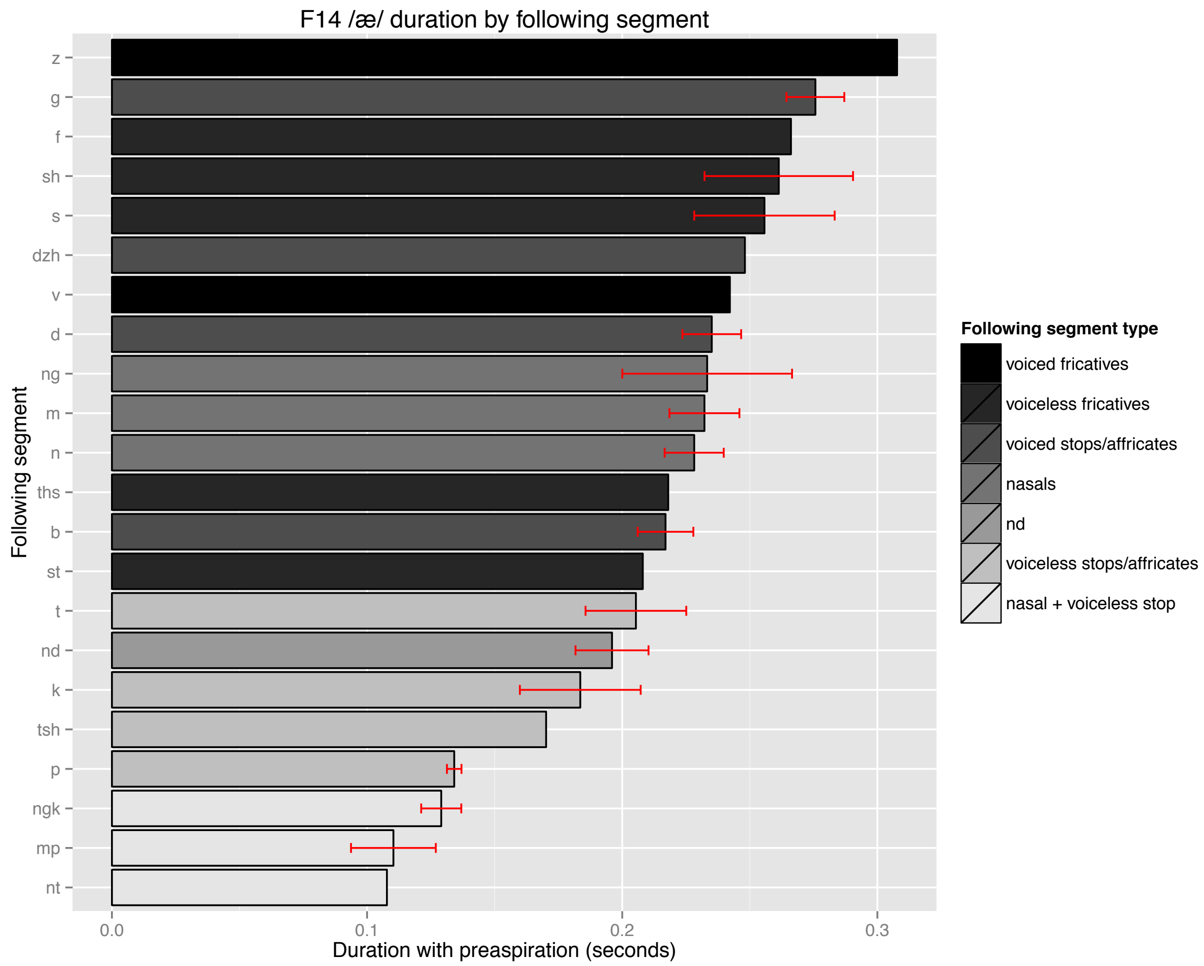
F12, an 18-year-old from Oxford, exhibits the following approximate patterning of environments favouring lengthening:

d = g ≥ b
t > p = k
nt ≥ ŋk ≥ mp
ŋ ≥ n ≥ m
s ≥ f = ʃ = st = θs



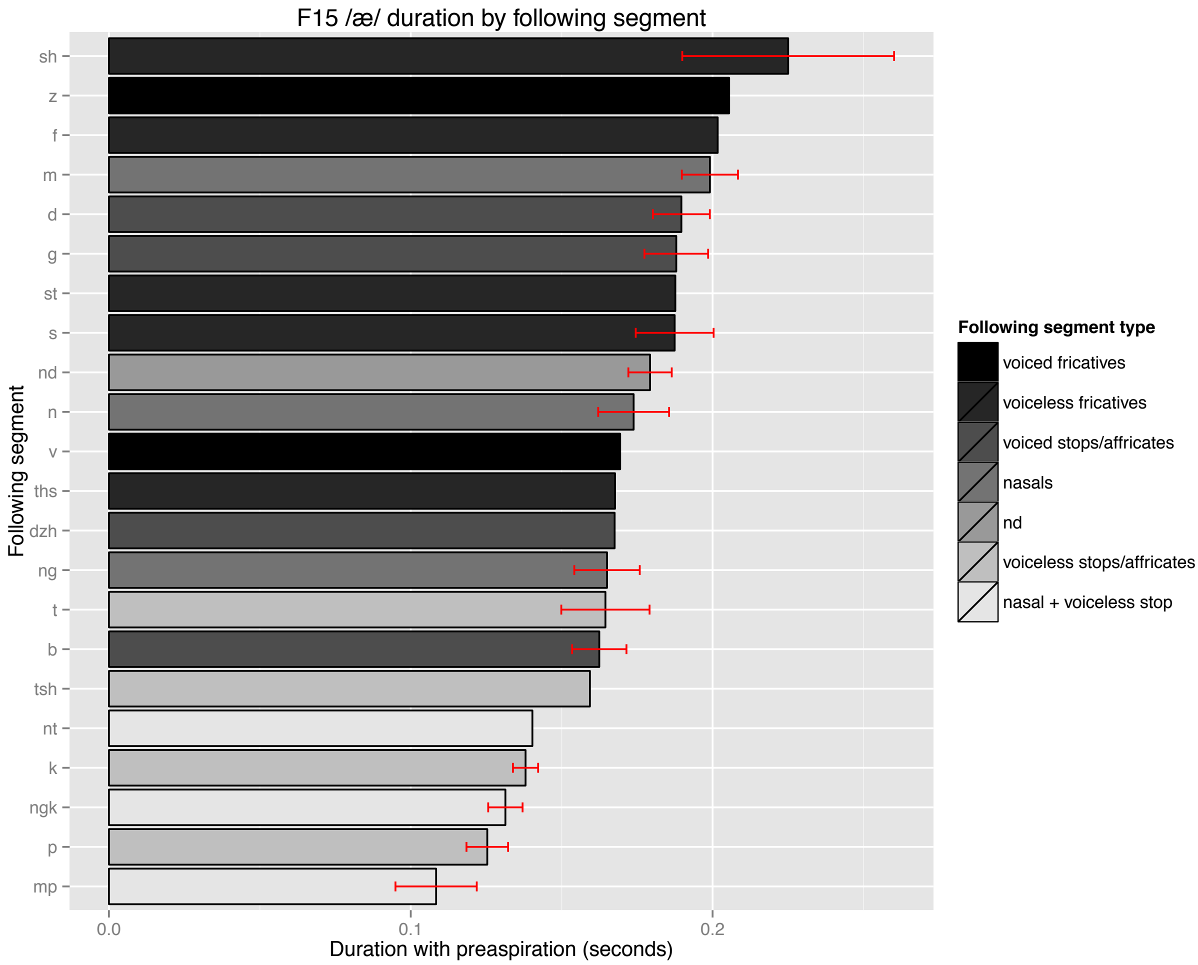
F13, a 21-year-old from London, exhibits the following approximate patterning of environments favouring lengthening:

d = g > b
k = t > p
ŋk ≥ nt = mp
ŋ > m = n
s ≥ st = ʃ = θs = f



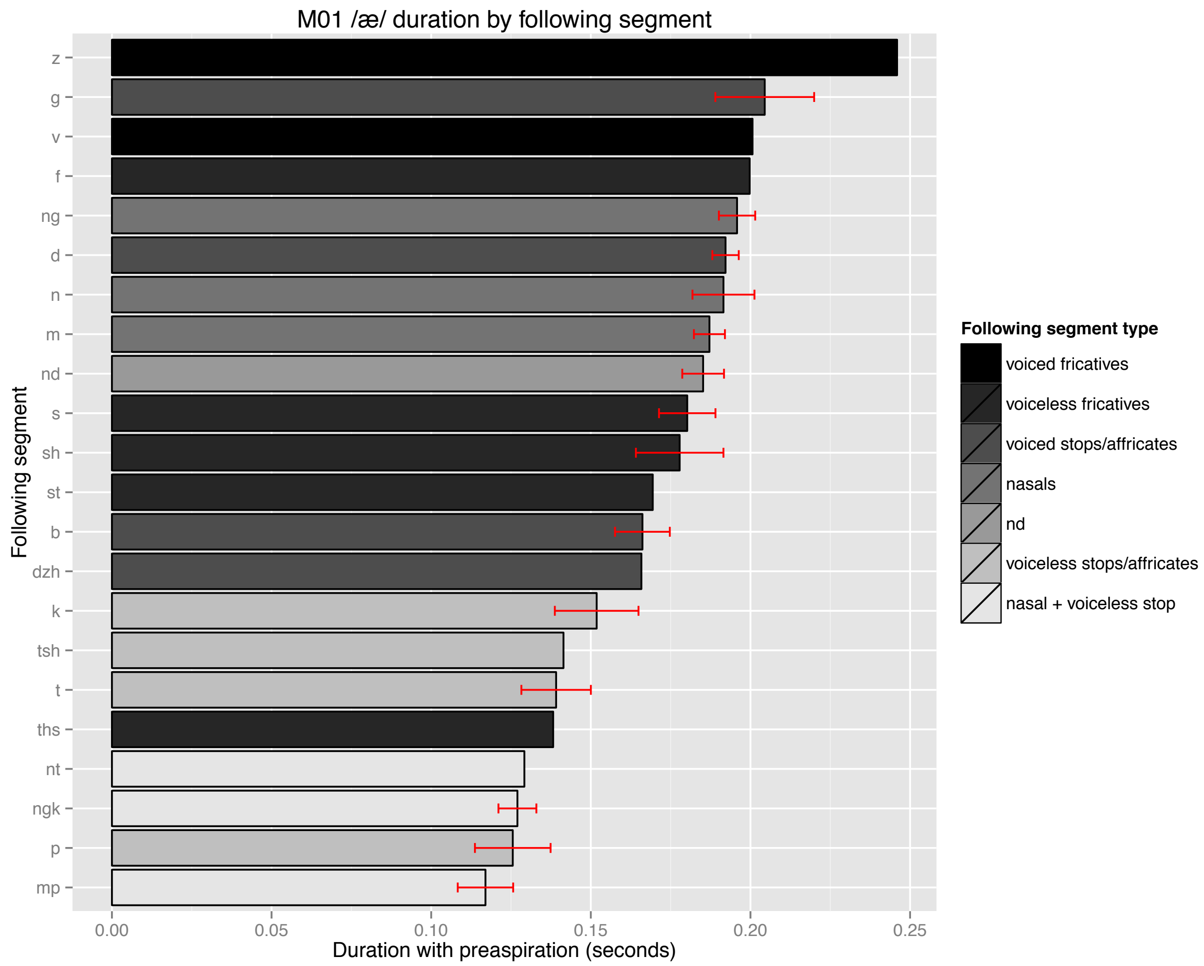
F14, a 23-year-old from London, exhibits the following approximate patterning of environments favouring lengthening:

g > d ≥ b
t ≥ k > p
ŋk ≥ mp = nt
ŋ = m = n
f = ʃ = s ≥ θs = st



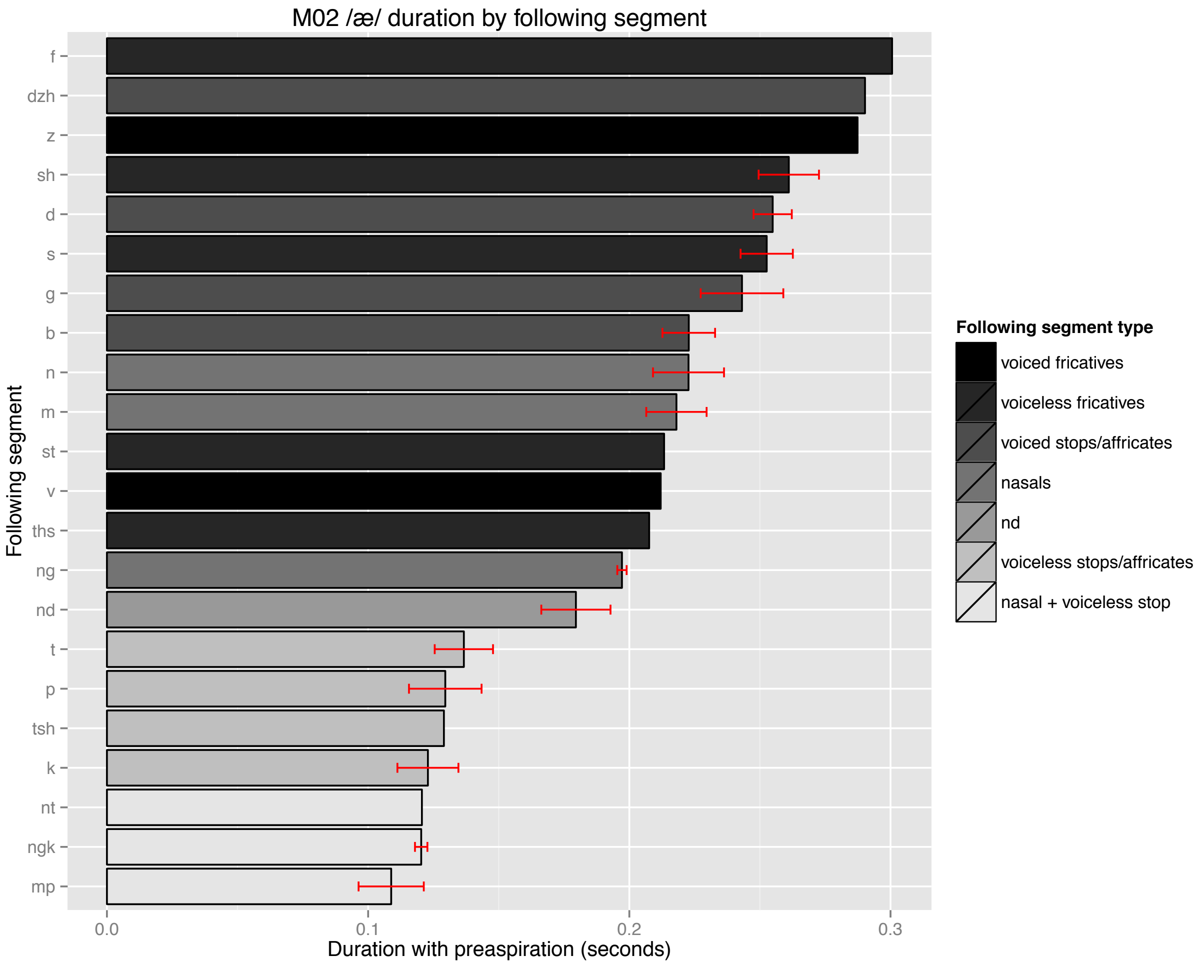
F15, a 20-year-old from Margate, exhibits the following approximate patterning of environments favouring lengthening:

d = g > b
t > k > p
nt ≥ ŋk > mp
m ≥ n = ŋ
ʃ ≥ f ≥ st = s ≥ θs



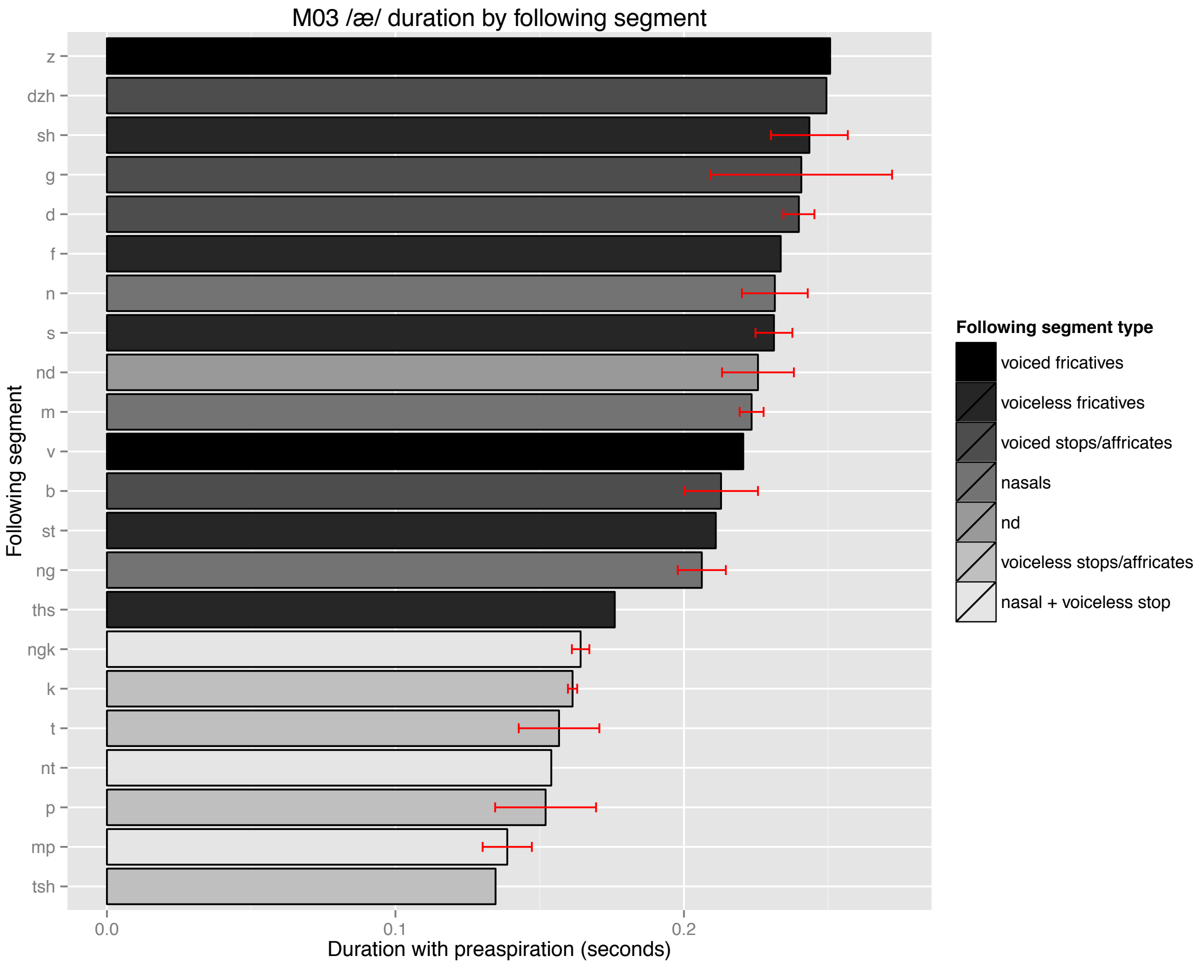
M01, a 19-year-old from London, exhibits the following approximate patterning of environments favouring lengthening:

g = d > b
k ≥ t ≥ p
nt = ŋk ≥ mp
ŋ = n = m
f ≥ s = ʃ = st ≥ θs



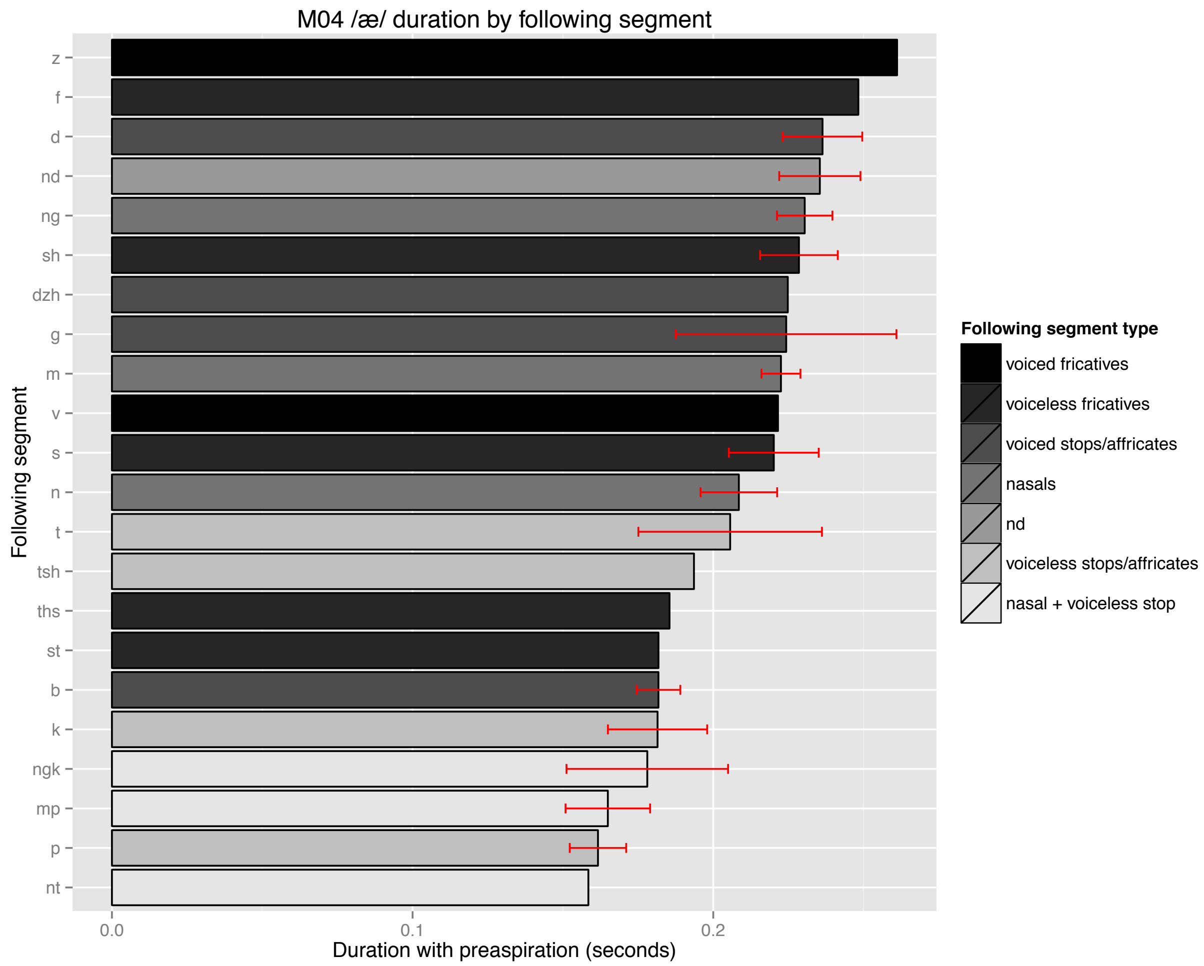
M02, an 18-year-old from Crowborough, exhibits the following approximate patterning of environments favouring lengthening:

d = g ≥ b
t = p = k
nt = ŋk ≥ mp
n = m > ŋ
f ≥ ʃ = s ≥ st = θs



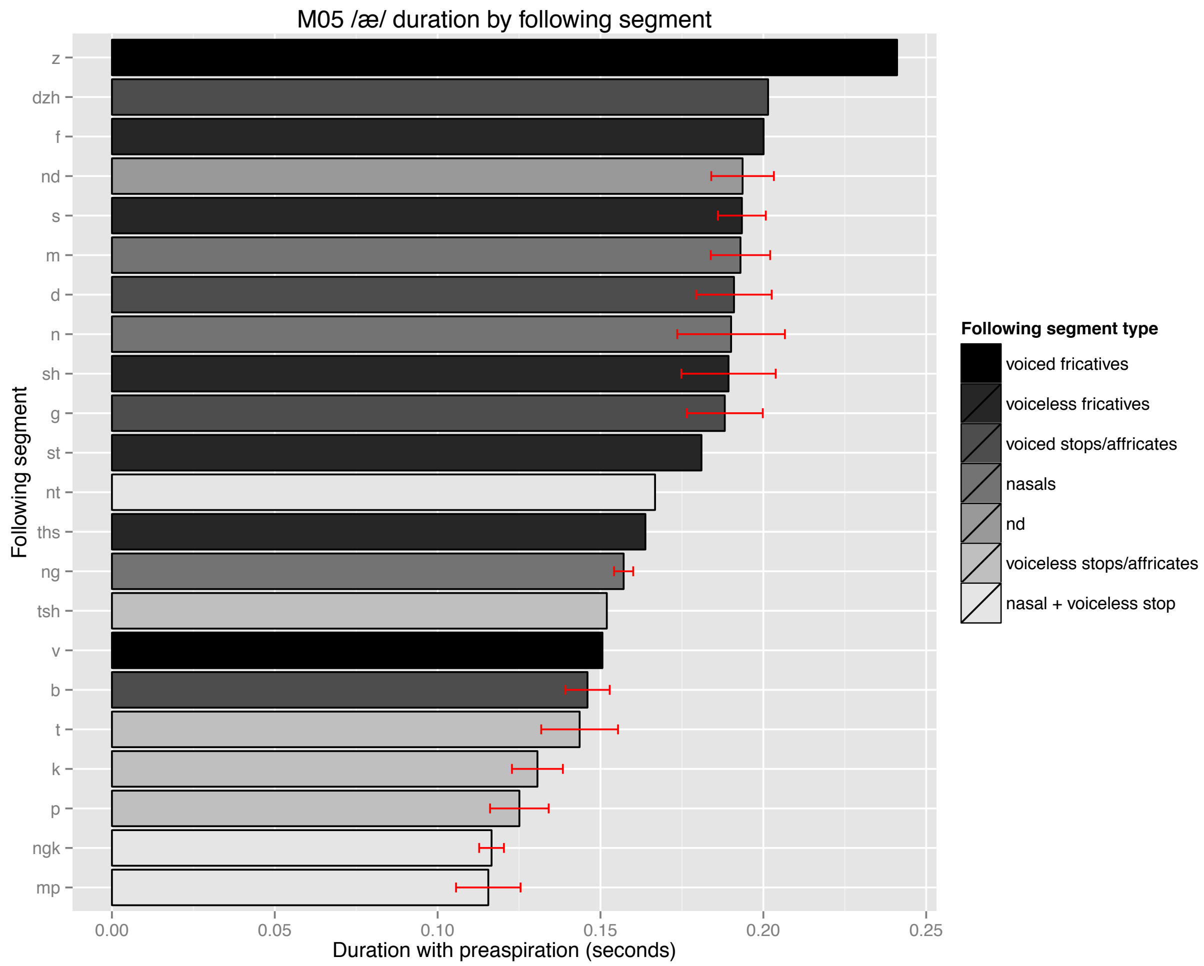
M03, a 20-year-old from Watford, exhibits the following approximate patterning of environments favouring lengthening:

g = d ≥ b
k = t = p
ŋk ≥ nt ≥ mp
n ≥ m > ŋ
ʃ ≥ f = s ≥ st ≥ θs



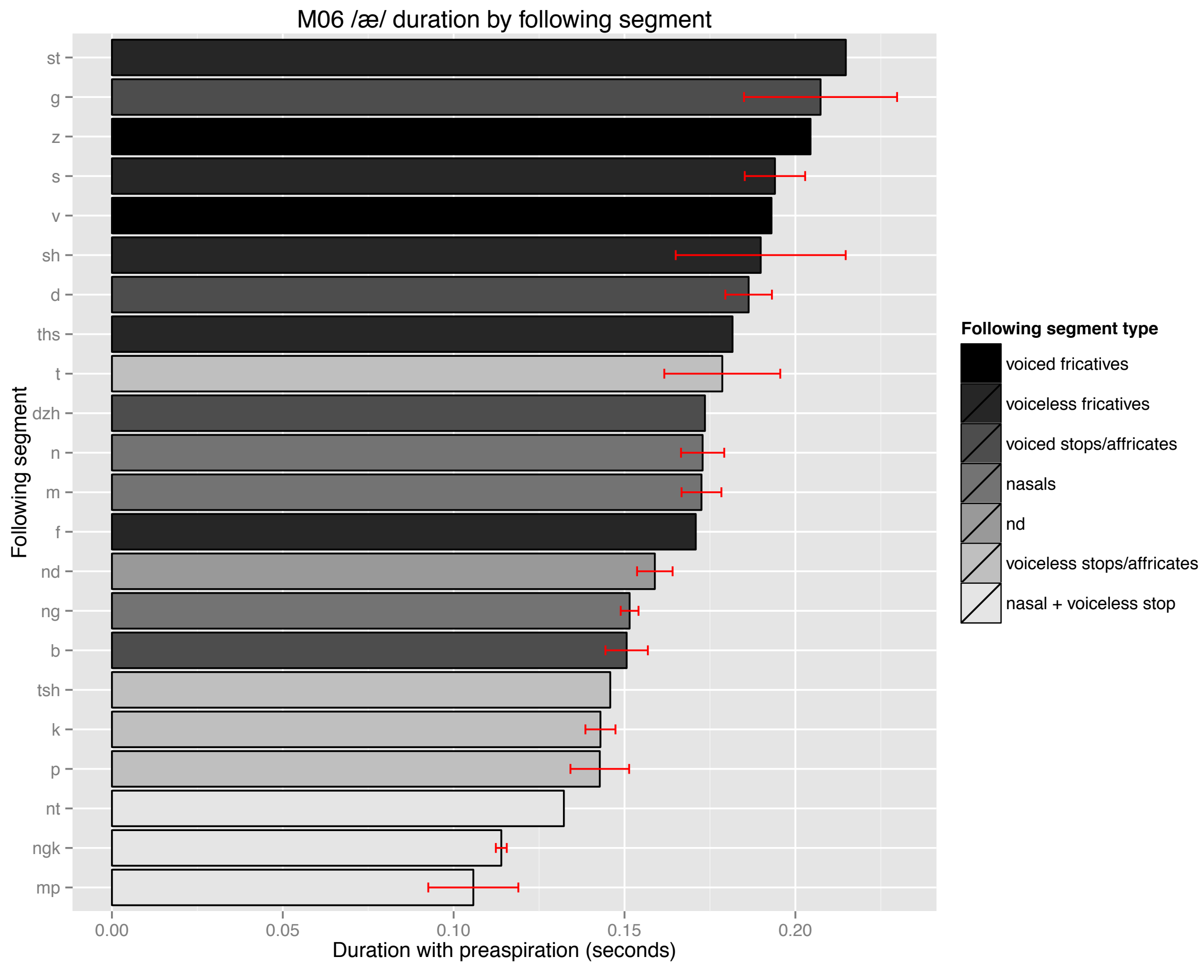
M04, an 18-year-old from Denham, exhibits the following approximate patterning of environments favouring lengthening:

d = g ≥ b
t ≥ k ≥ p
ŋk = mp = nt
ŋ ≥ m ≥ n
f ≥ ʃ = s ≥ θs = st



M05, a 24-year-old from Surrey, exhibits the following approximate patterning of environments favouring lengthening:

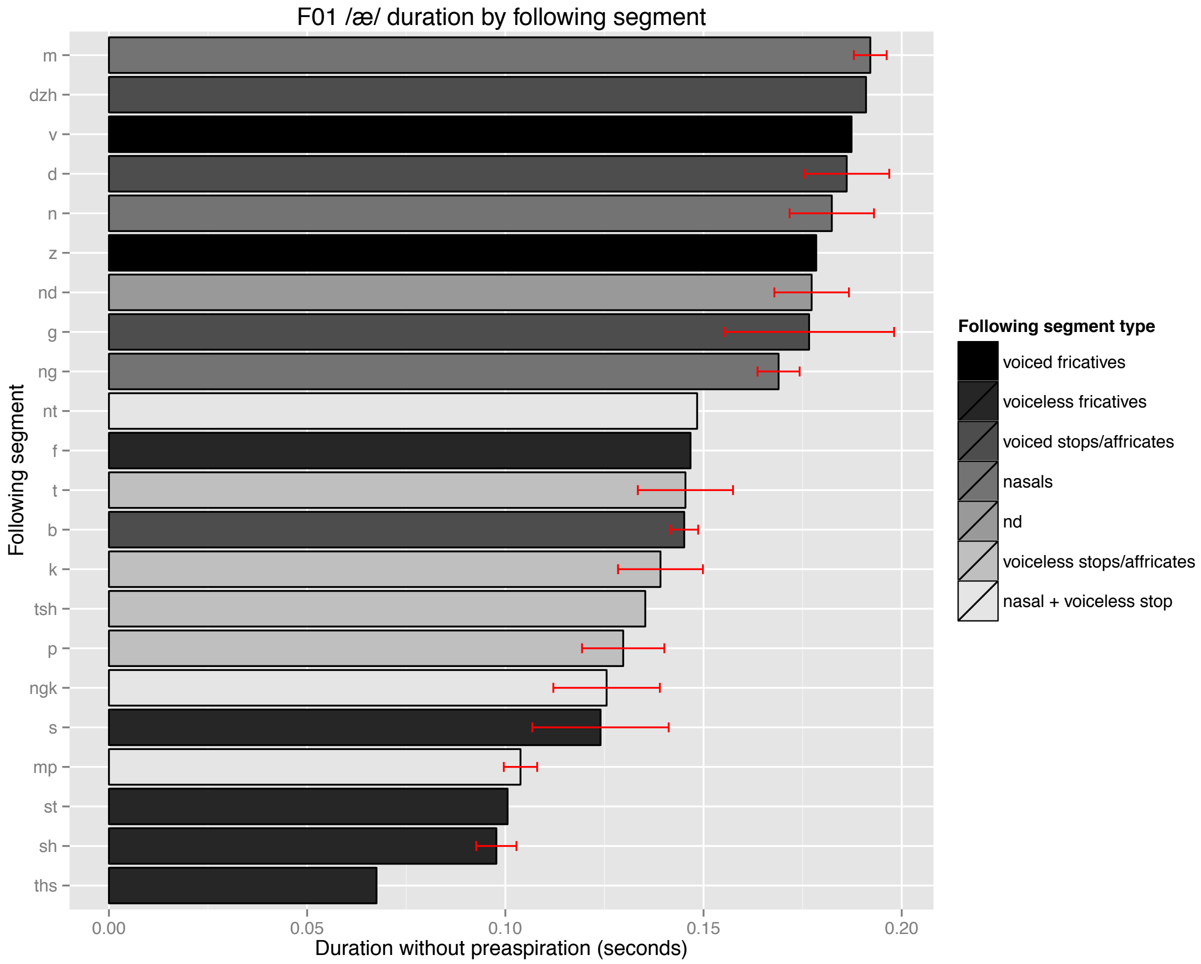
d = g > b
t ≥ k = p
nt ≥ ŋk = mp
m = n > ŋ
f = s = ʃ = st ≥ θs

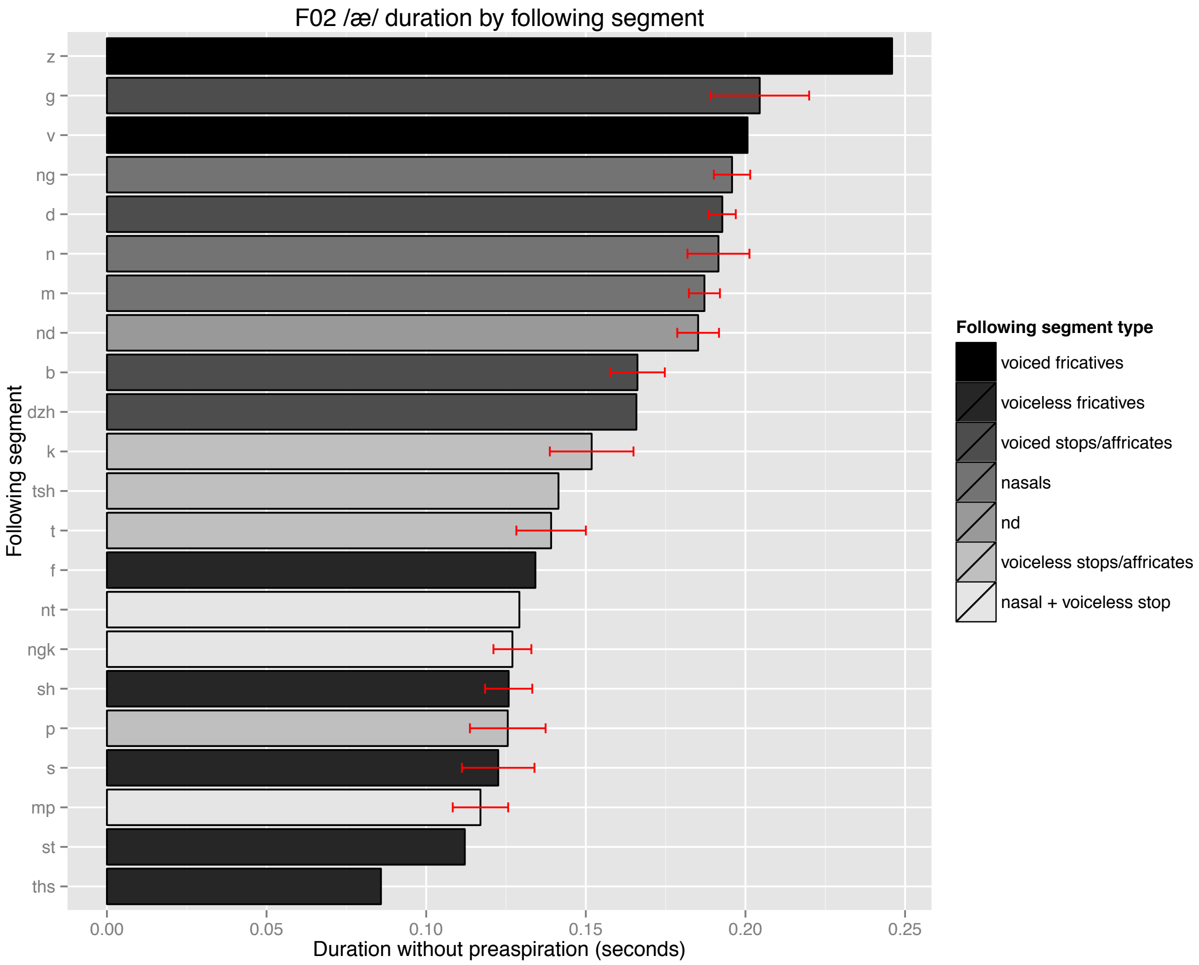


M06, a 23-year-old from Radlett, exhibits the following approximate patterning of environments favouring lengthening:

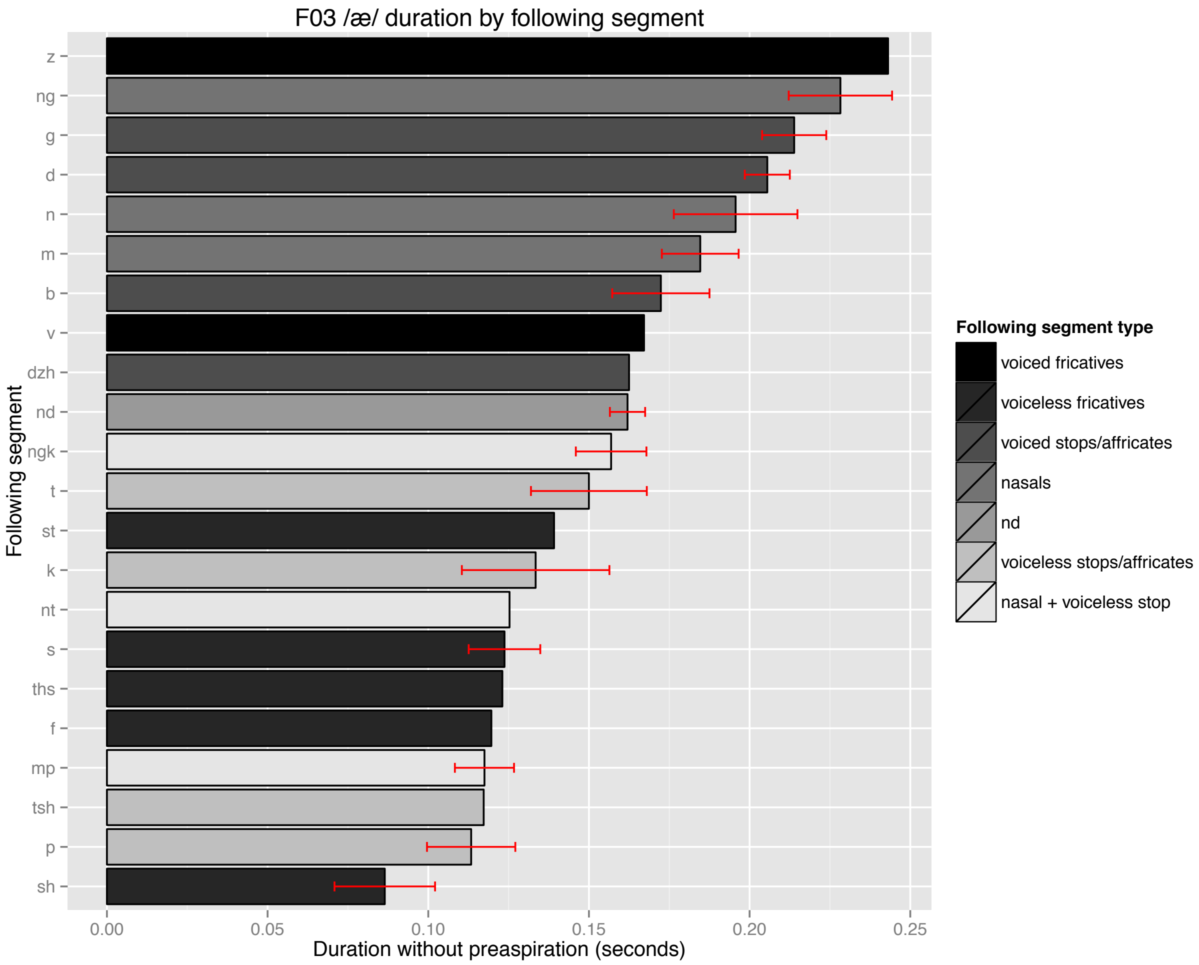
g ≥ d > b
t > k = p
nt ≥ ŋk = mp
n = m > ŋ
st ≥ s = ʃ = θs ≥ f

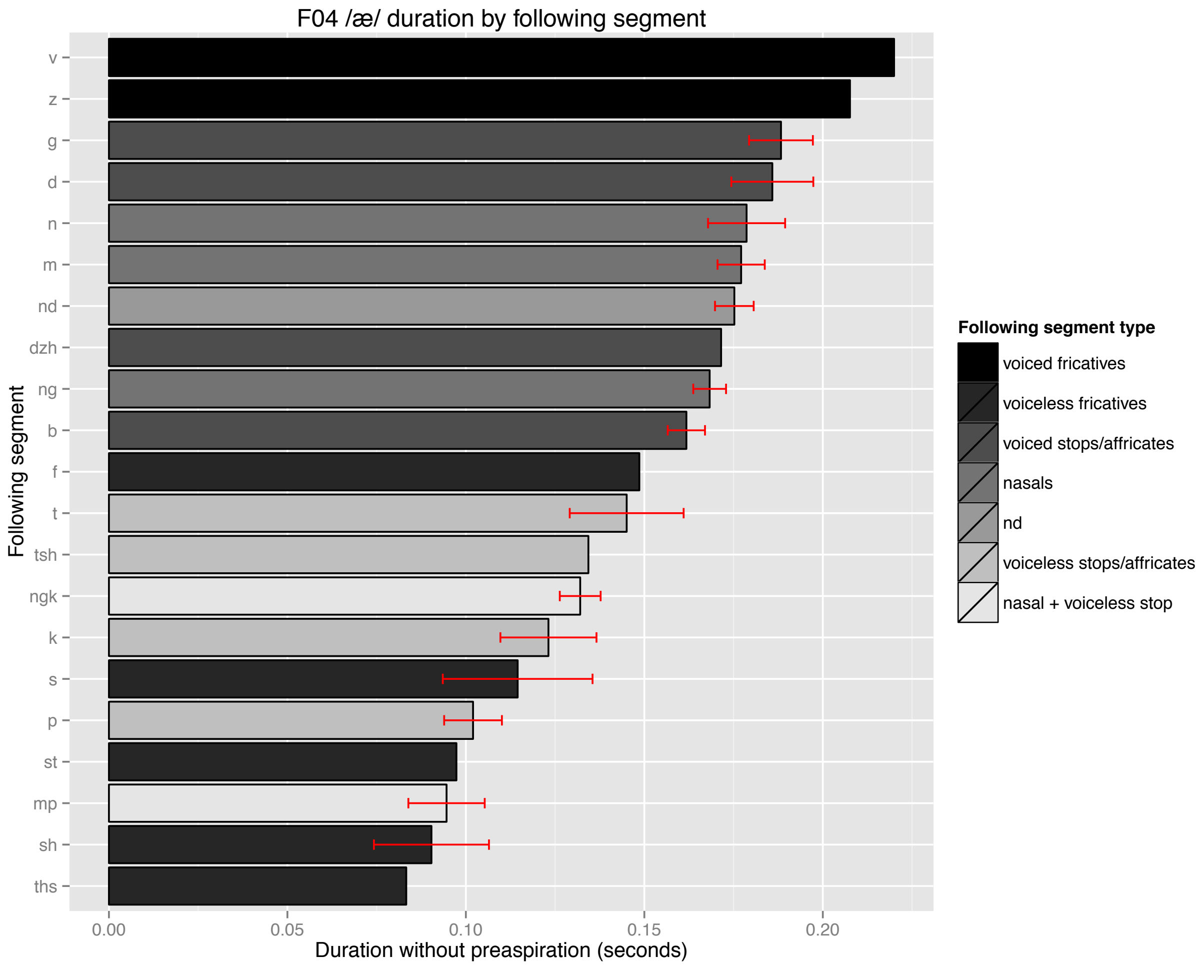
Appendix D: Individual systems of /æ/ duration by following segment, excluding preaspiration in the measurement of vowel length



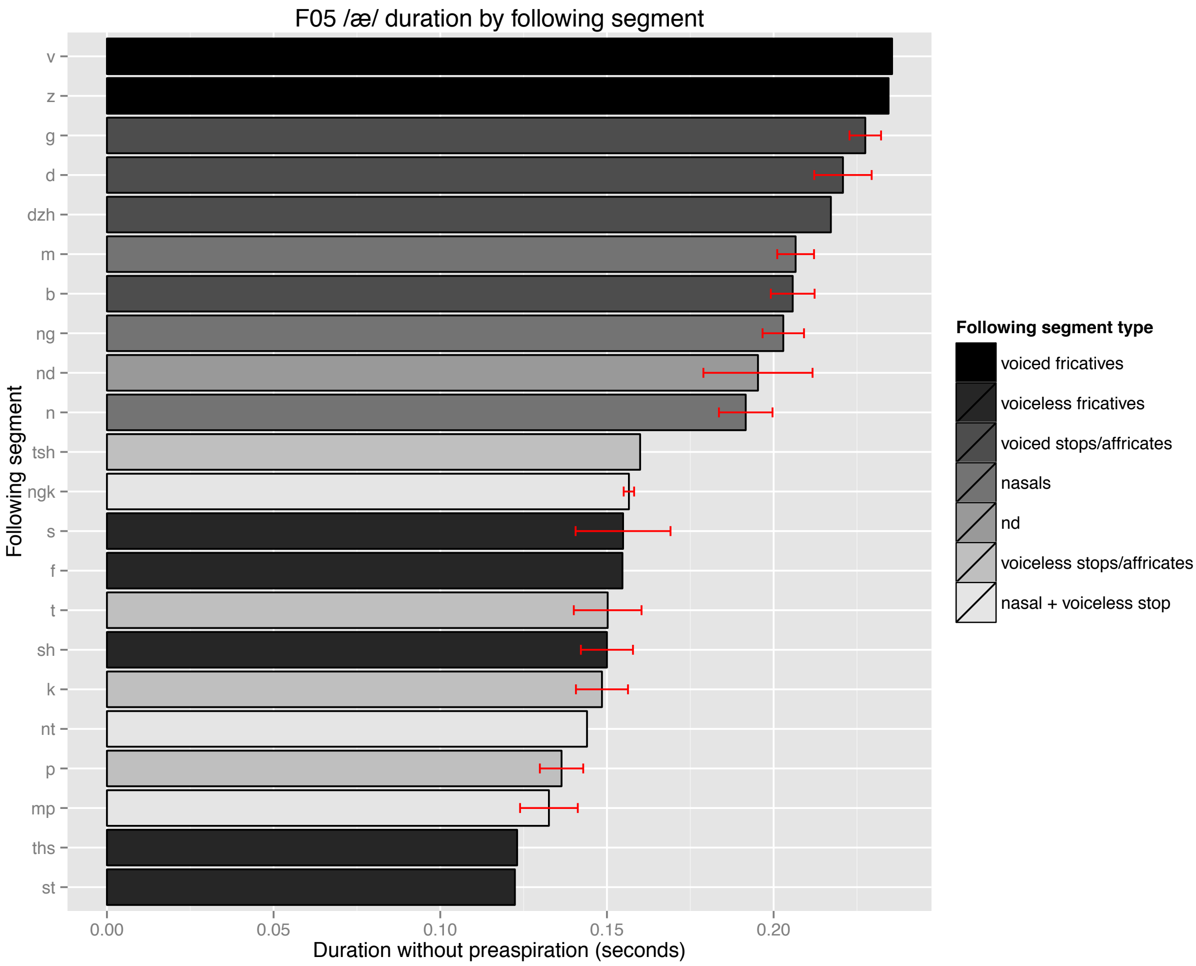


F02 /æ/ duration by following segment
z
g
v
ng
d
n
m
nd
b
dzh
k
tsh
t
f
nt
ngk
sh
p
s
mp
st
ths
Following segment
0.00
0.05
0.10
0.15
0.20
0.25
Duration without preaspiration (seconds)
Following segment type
voiced fricatives
voiceless fricatives
voiced stops/affricates
nasals
nd
voiceless stops/affricates
nasal + voiceless stop

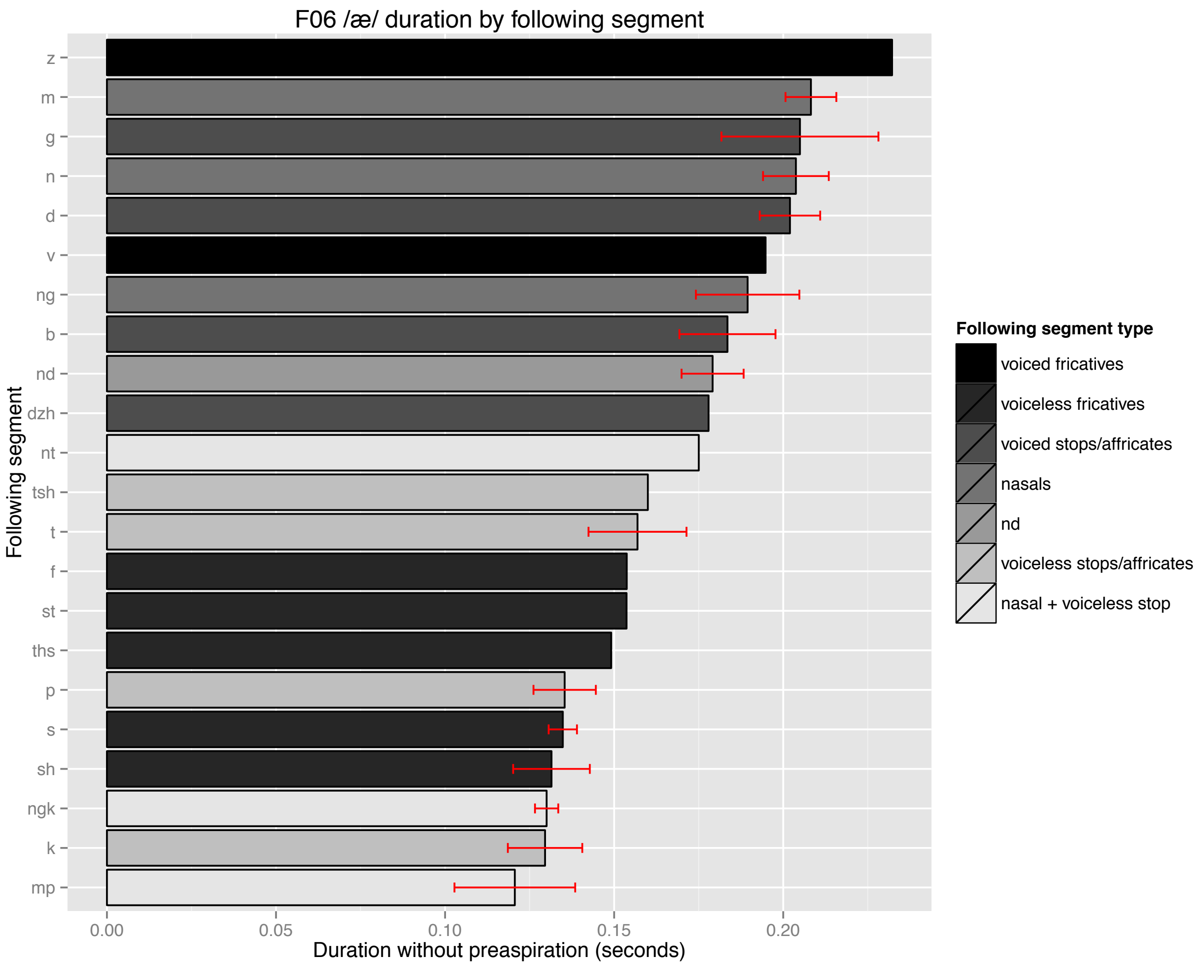

F03 /æ/ duration by following segment
Following segment
z
ng
g
d
n
m
b
v
dzh
nd
ngk
t
st
k
nt
s
ths
f
mp
tsh
p
sh
0.00
0.05
0.10
0.15
0.20
0.25
Duration without preaspiration (seconds)
Following segment type
voiced fricatives
voiceless fricatives
voiced stops/affricates
nasals
nd
voiceless stops/affricates
nasal + voiceless stop

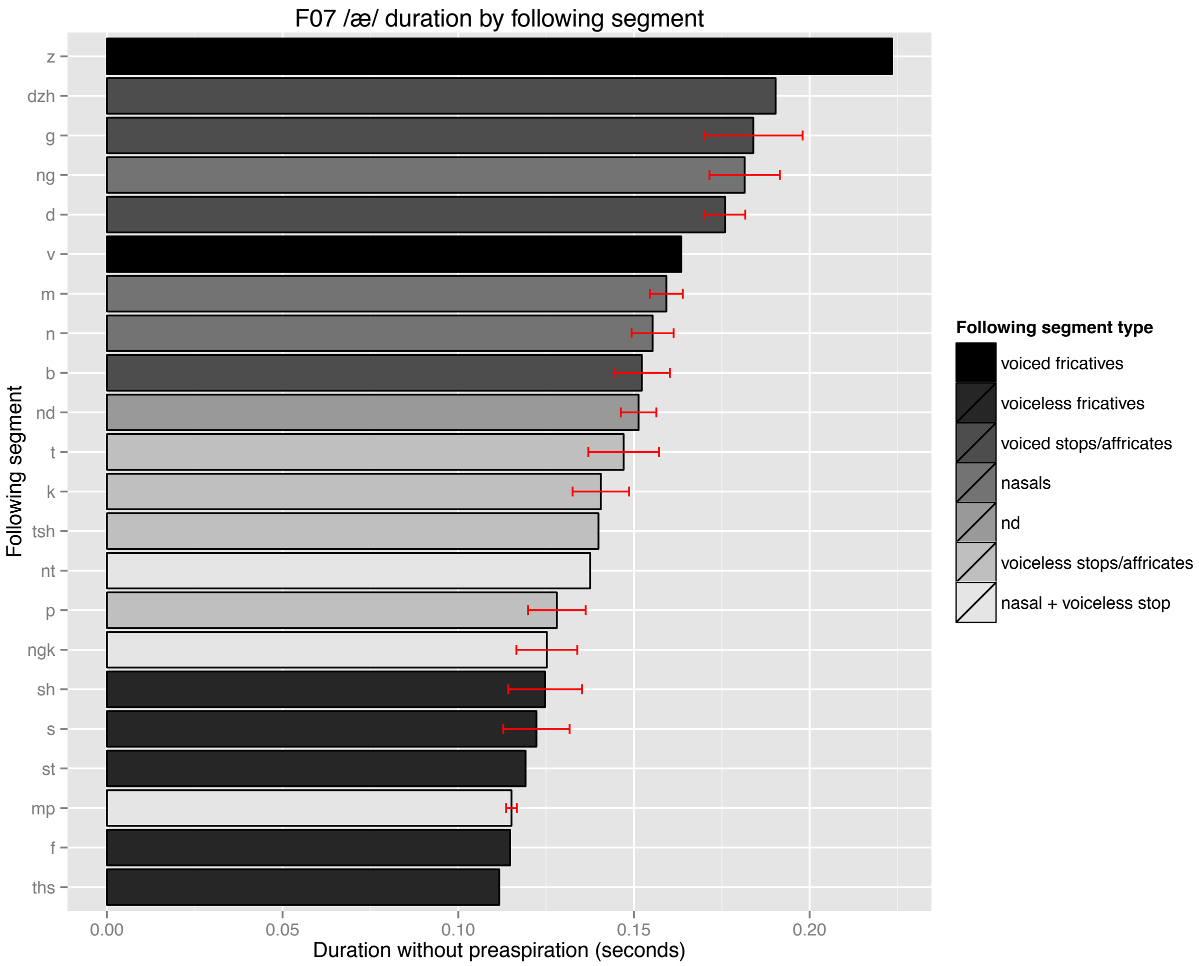


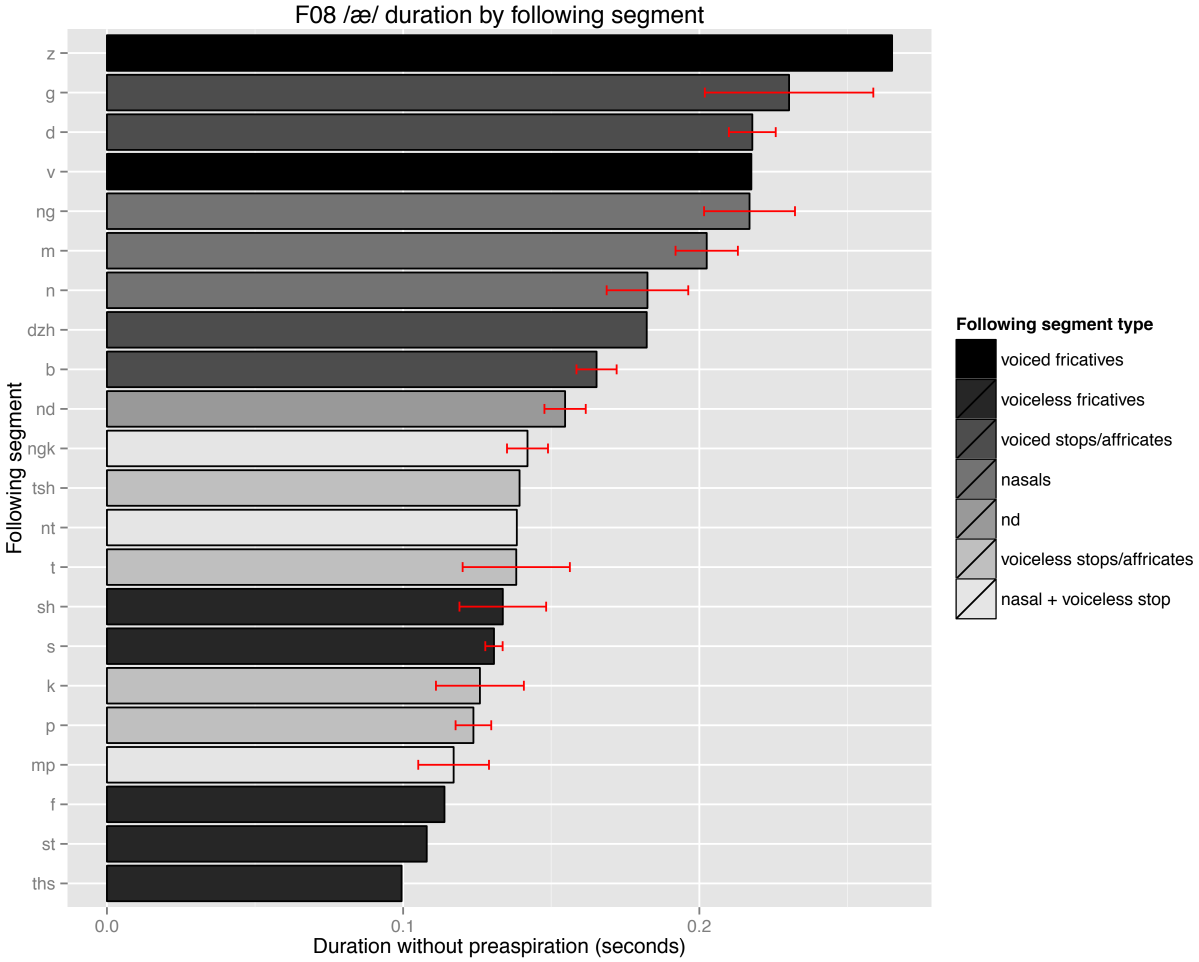
F04 /æ/ duration by following segment
v
z
g
d
n
m
nd
dzh
ng
b
f
t
tsh
ngk
k
s
p
st
mp
sh
ths
Following segment
0.00
0.05
0.10
0.15
0.20
Duration without preaspiration (seconds)
Following segment type
voiced fricatives
voiceless fricatives
voiced stops/affricates
nasals
nd
voiceless stops/affricates
nasal + voiceless stop

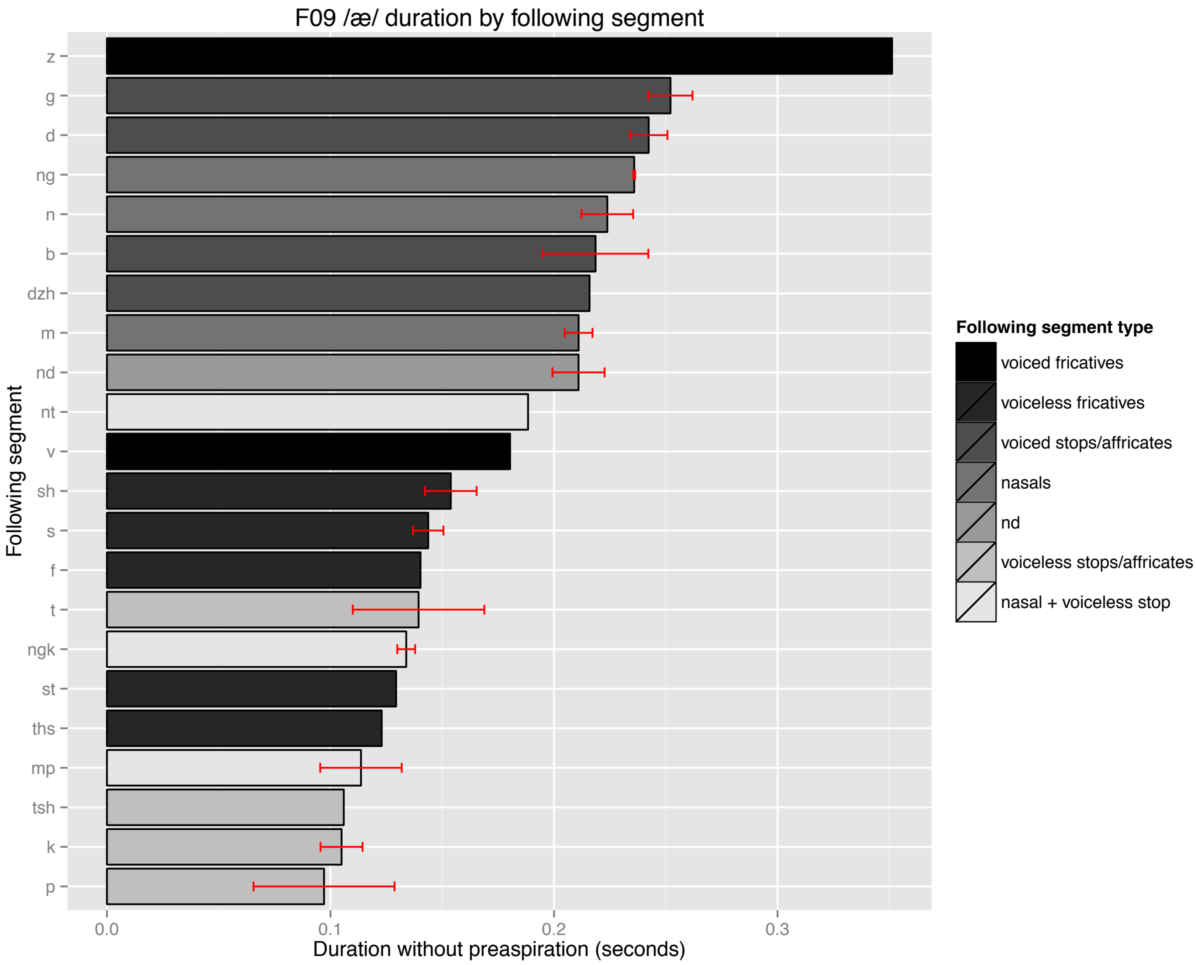


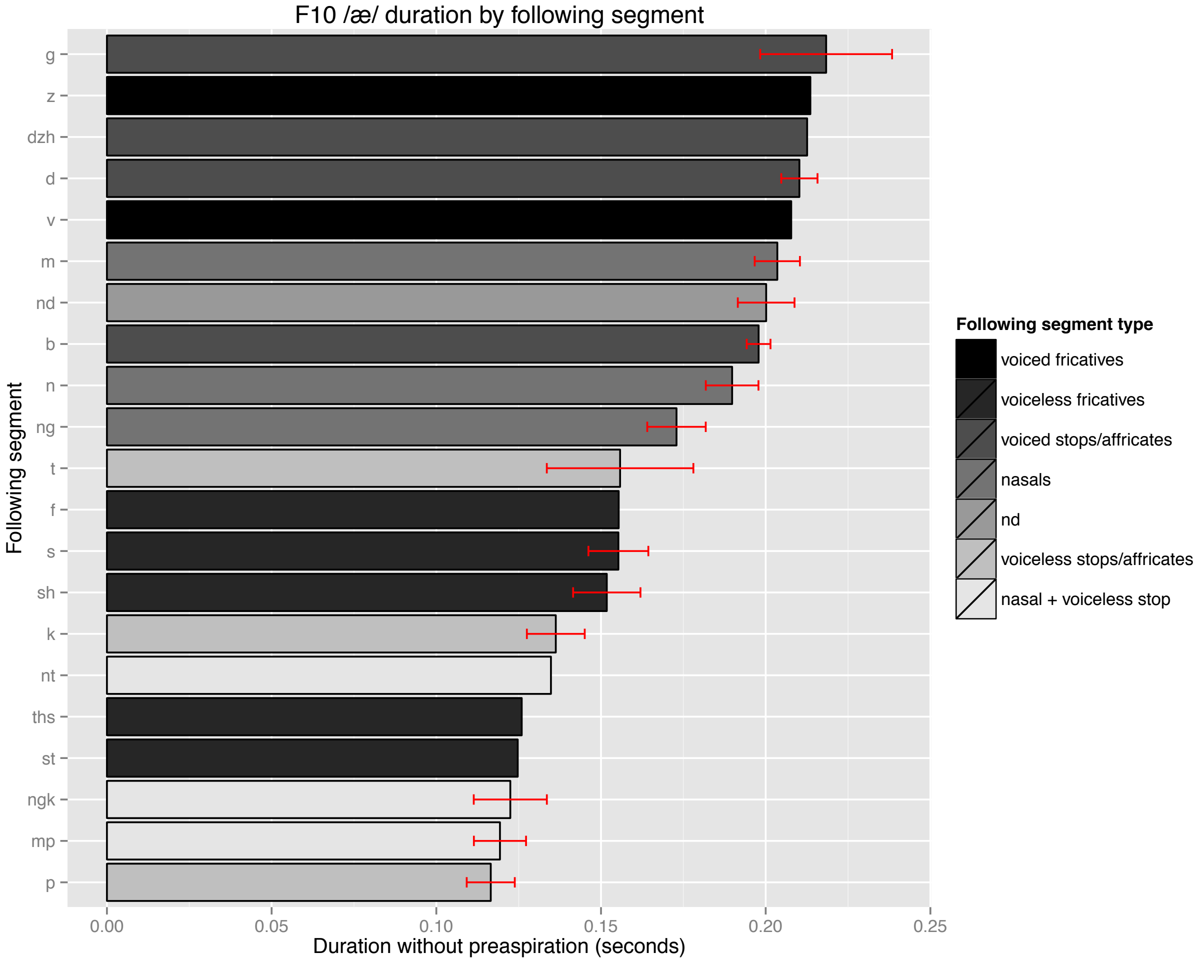
F05 /æ/ duration by following segment
v
z
g
d
dzh
m
b
ng
nd
n
tsh
ngk
s
f
t
sh
k
nt
p
mp
ths
st
Following segment
0.00
0.05
0.10
0.15
0.20
Duration without preaspiration (seconds)
Following segment type
voiced fricatives
voiceless fricatives
voiced stops/affricates
nasals
nd
voiceless stops/affricates
nasal + voiceless stop


F06 /æ/ duration by following segment
z
m
g
n
d
v
ng
b
nd
dzh
nt
tsh
t
f
st
ths
p
s
sh
ngk
k
mp
Following segment
0.00
0.05
0.10
0.15
0.20
Duration without preaspiration (seconds)
Following segment type
voiced fricatives
voiceless fricatives
voiced stops/affricates
nasals
nd
voiceless stops/affricates
nasal + voiceless stop

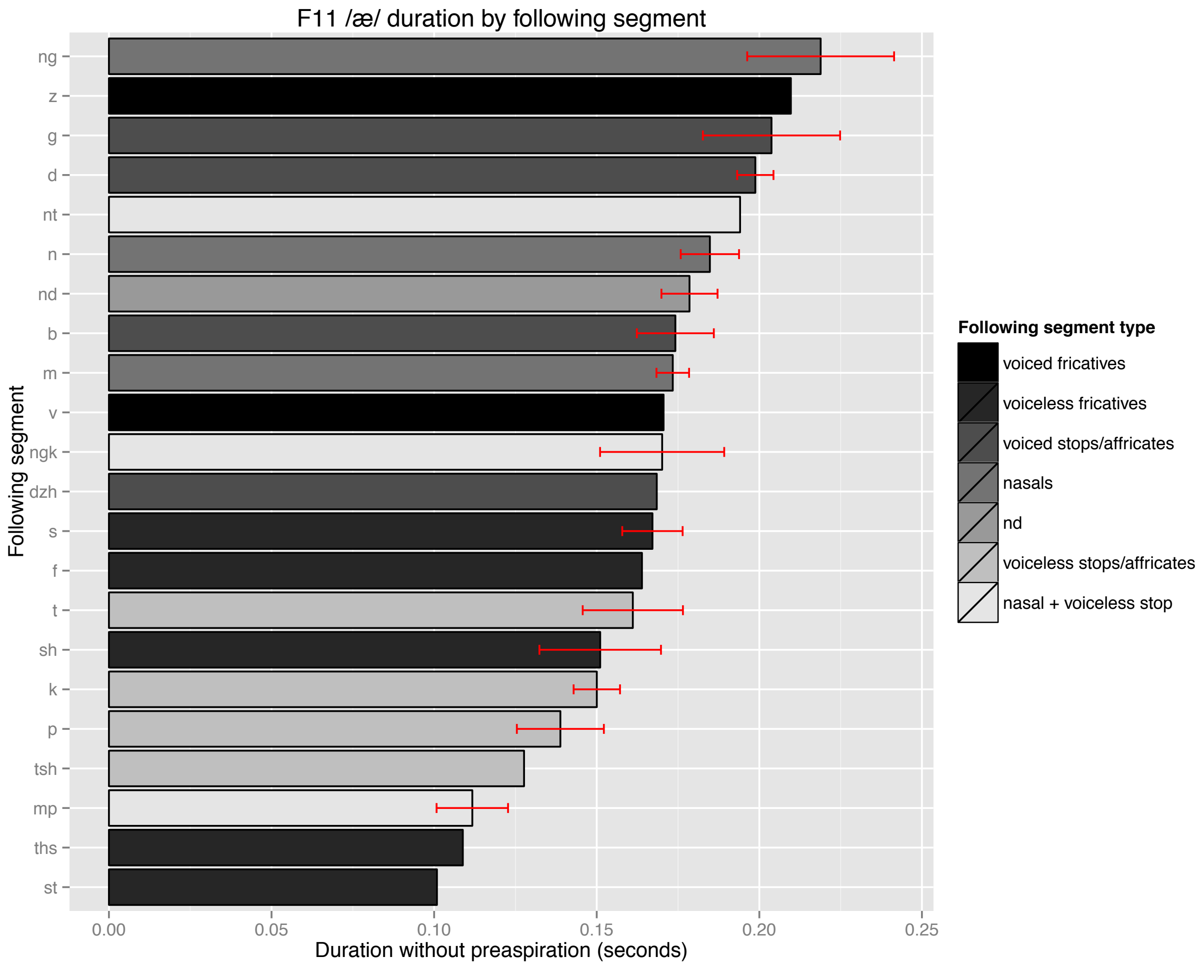

F07 /æ/ duration by following segment
z
dzh
g
ng
d
v
m
n
b
nd
t
k
tsh
nt
p
ngk
sh
s
st
mp
f
ths
Following segment
0.00
0.05
0.10
0.15
0.20
Duration without preaspiration (seconds)
Following segment type
voiced fricatives
voiceless fricatives
voiced stops/affricates
nasals
nd
voiceless stops/affricates
nasal + voiceless stop


F08 /æ/ duration by following segment
z
g
d
v
ng
m
n
dzh
b
nd
ngk
tsh
nt
t
sh
s
k
p
mp
f
st
ths
Following segment
0.0
0.1
0.2
Duration without preaspiration (seconds)
Following segment type
voiced fricatives
voiceless fricatives
voiced stops/affricates
nasals
nd
voiceless stops/affricates
nasal + voiceless stop

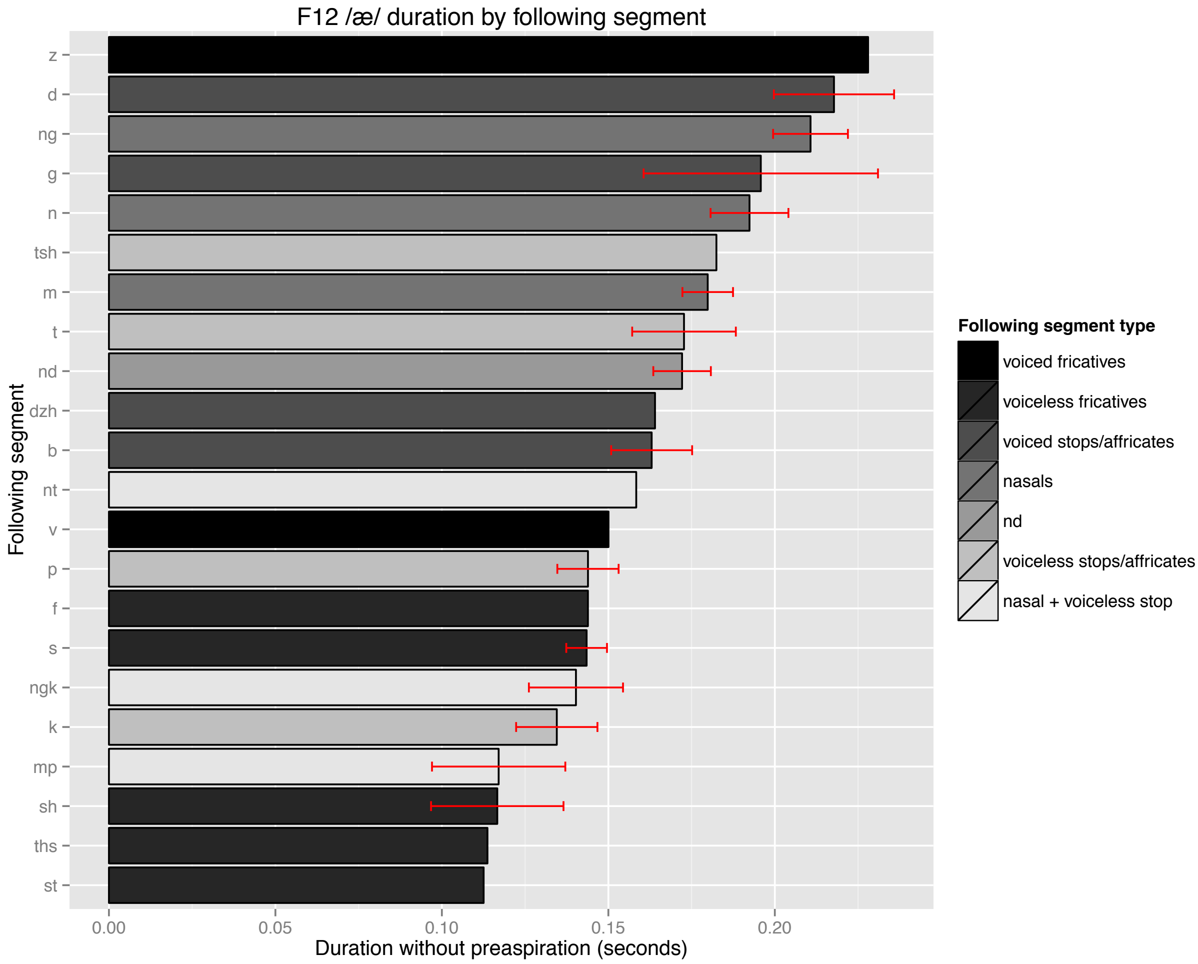

F09 /æ/ duration by following segment
Following segment
z
g
d
ng
n
b
dzh
m
nd
nt
v
sh
s
f
t
ngk
st
ths
mp
tsh
k
p
0.0
0.1
0.2
0.3
Duration without preaspiration (seconds)
Following segment type
voiced fricatives
voiceless fricatives
voiced stops/affricates
nasals
nd
voiceless stops/affricates
nasal + voiceless stop

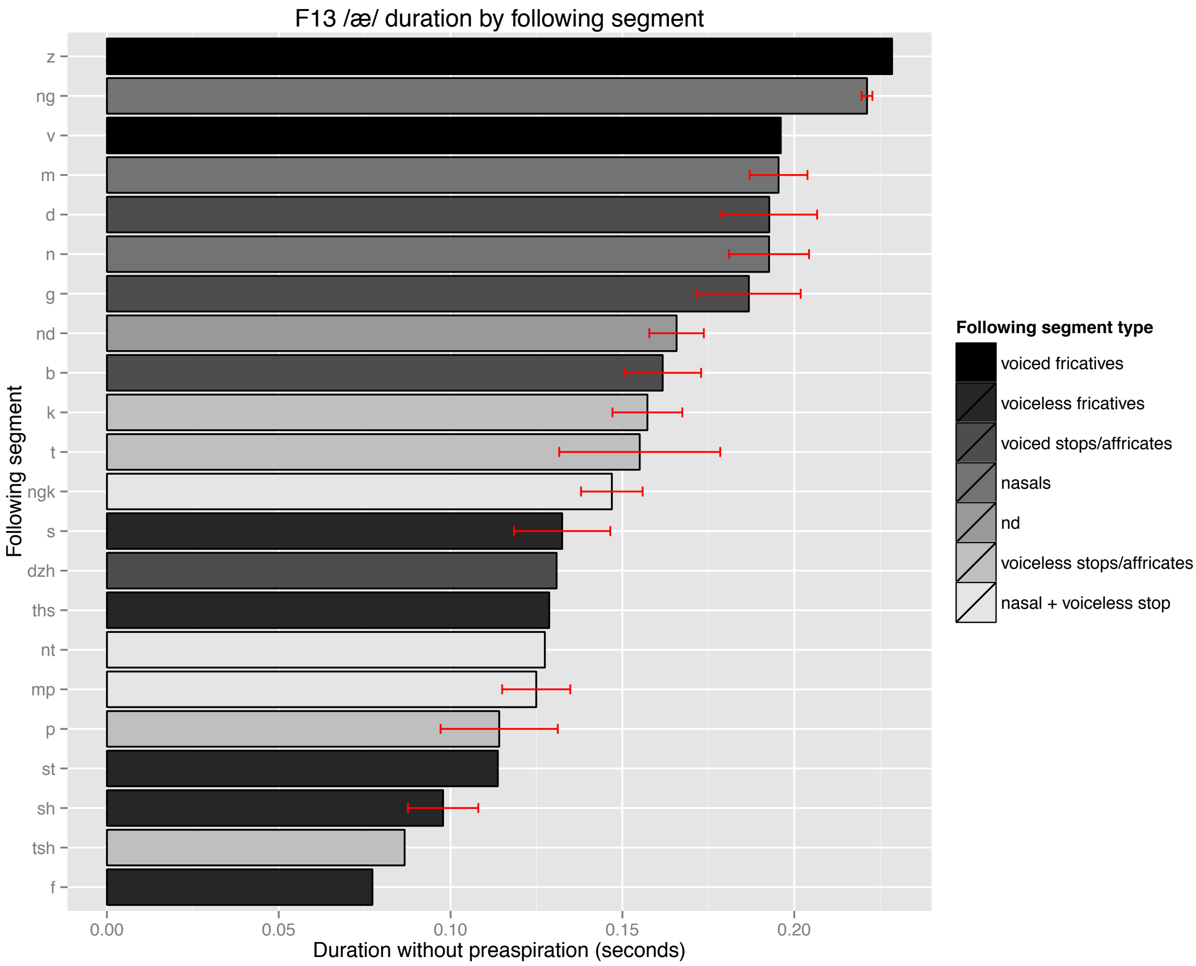


F10 /æ/ duration by following segment
g
z
dzh
d
v
m
nd
b
n
ng
t
f
s
sh
k
nt
ths
st
ngk
mp
p
Following segment
0.00
0.05
0.10
0.15
0.20
0.25
Duration without preaspiration (seconds)
Following segment type
voiced fricatives
voiceless fricatives
voiced stops/affricates
nasals
nd
voiceless stops/affricates
nasal + voiceless stop

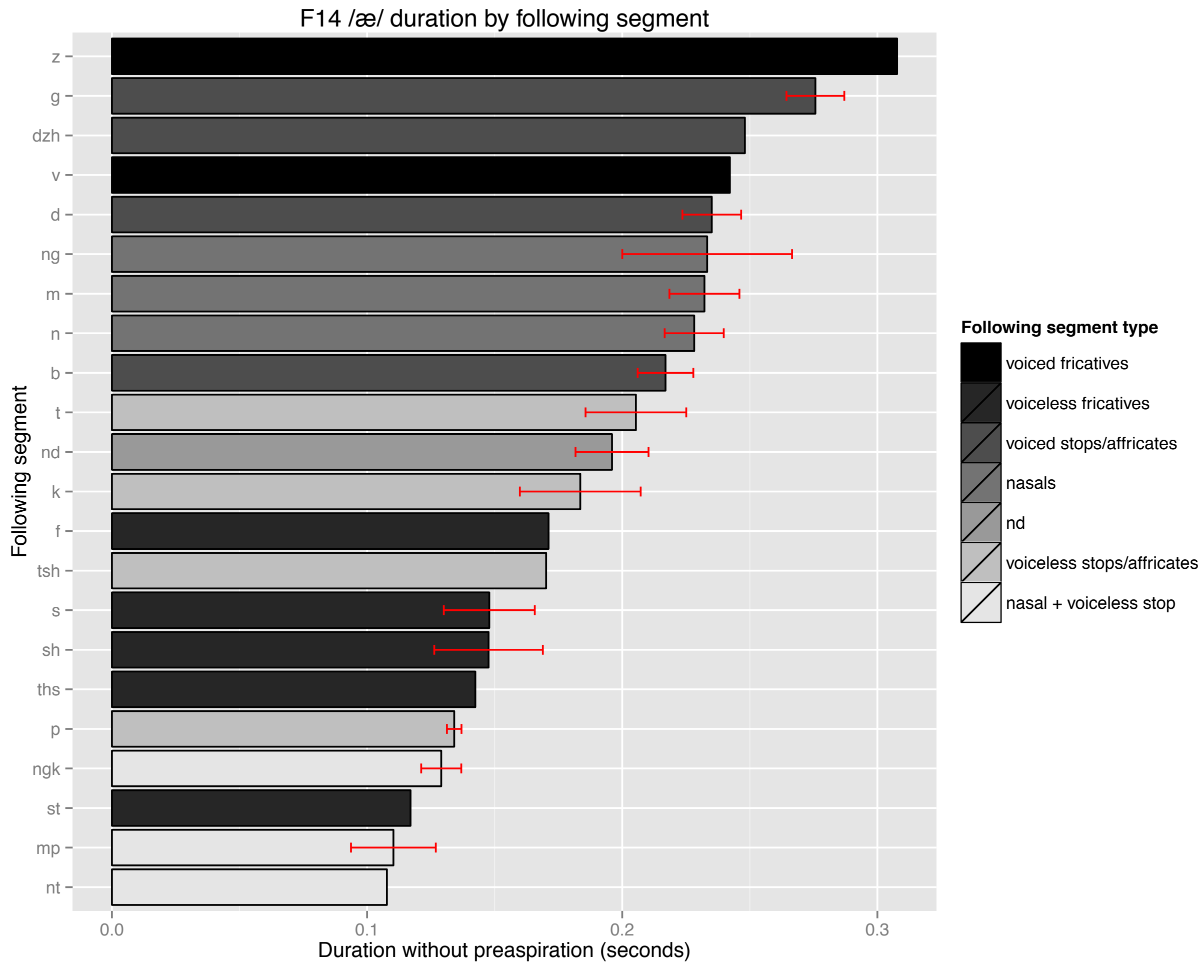


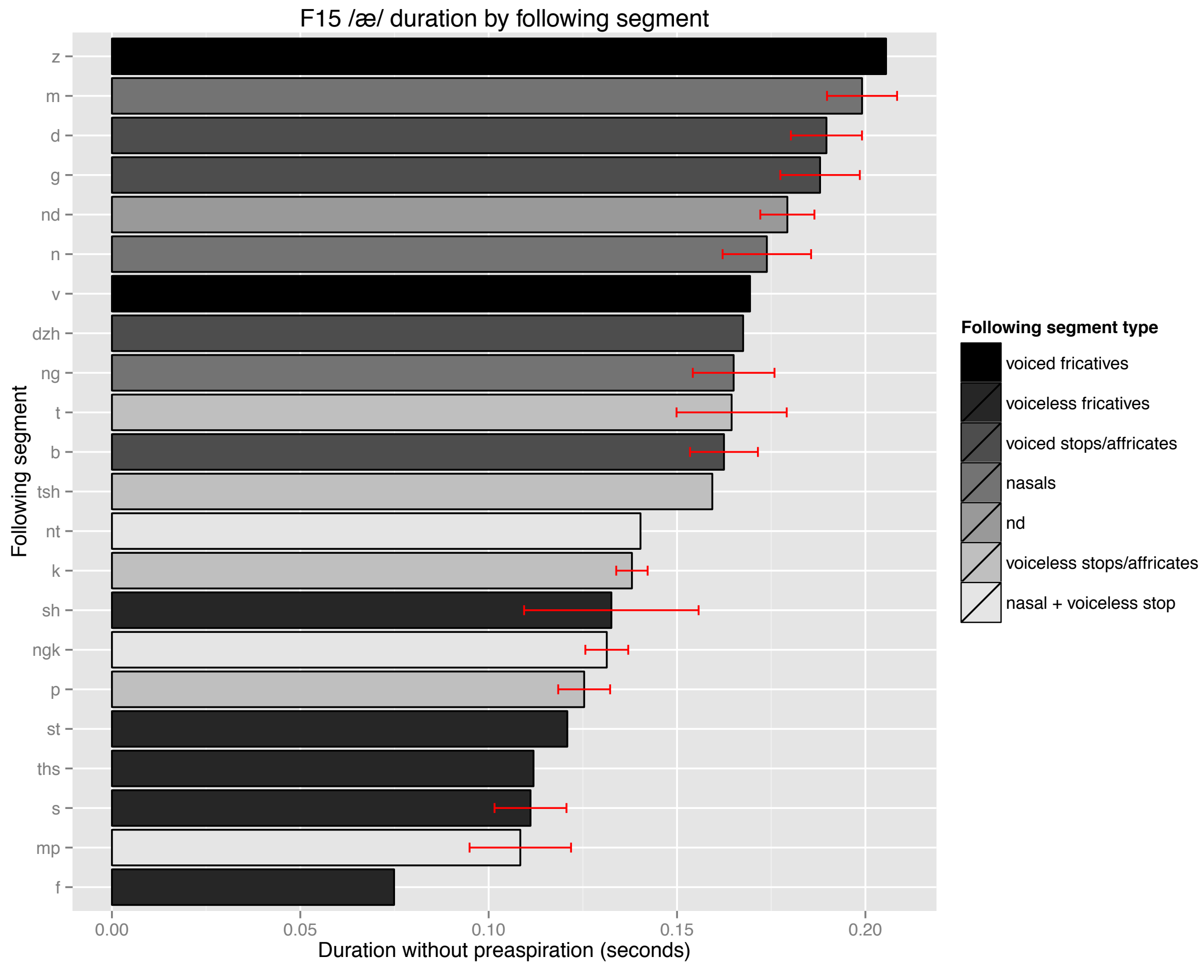
F11 /æ/ duration by following segment
ng
z
g
d
nt
n
nd
b
m
v
ngk
dzh
s
f
t
sh
k
p
tsh
mp
ths
st
Following segment
0.00
0.05
0.10
0.15
0.20
0.25
Duration without preaspiration (seconds)
Following segment type
voiced fricatives
voiceless fricatives
voiced stops/affricates
nasals
nd
voiceless stops/affricates
nasal + voiceless stop

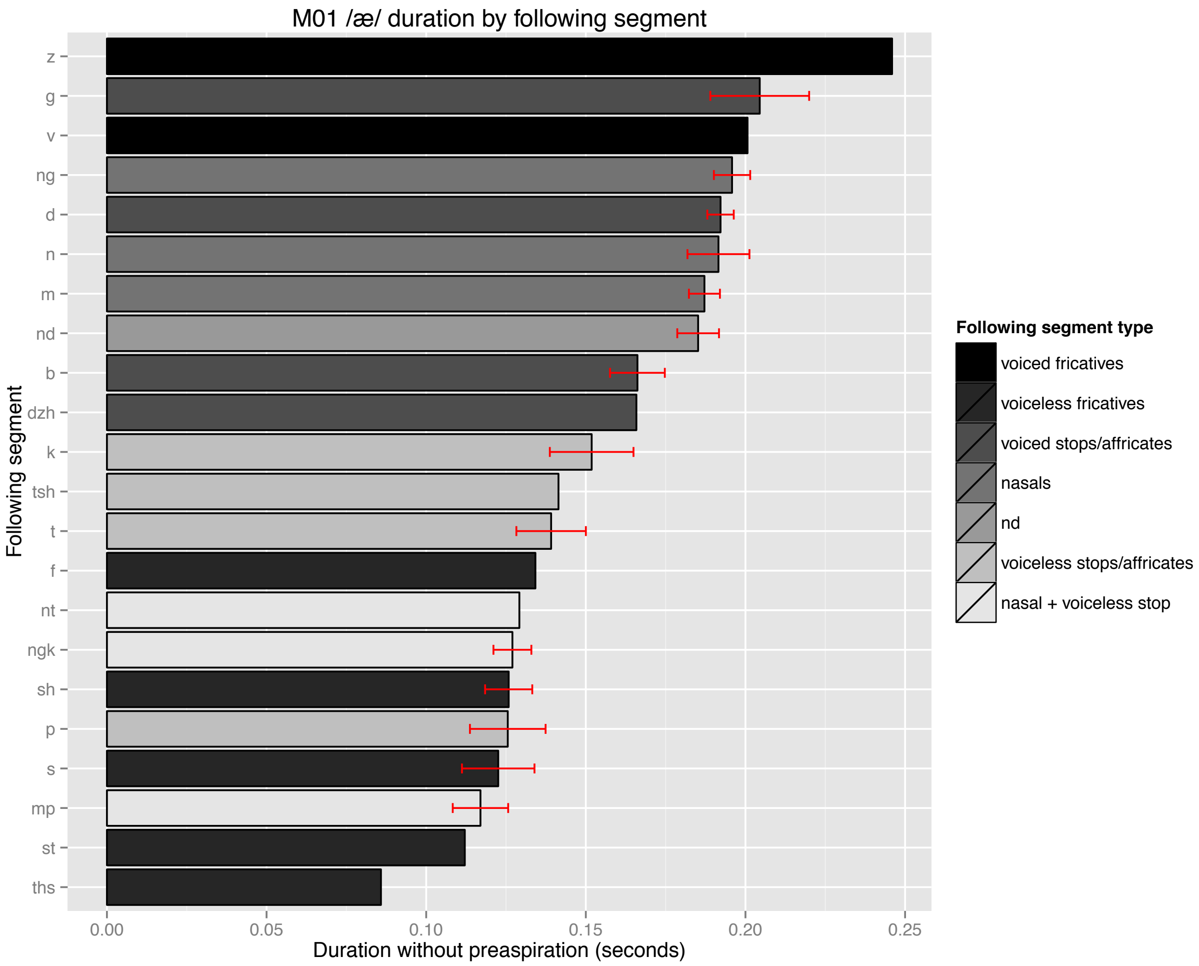

F12 /æ/ duration by following segment
Following segment
z
d
ng
g
n
tsh
m
t
nd
dzh
b
nt
v
p
f
s
ngk
k
mp
sh
ths
st
0.00
0.05
0.10
0.15
0.20
Duration without preaspiration (seconds)
Following segment type
voiced fricatives
voiceless fricatives
voiced stops/affricates
nasals
nd
voiceless stops/affricates
nasal + voiceless stop

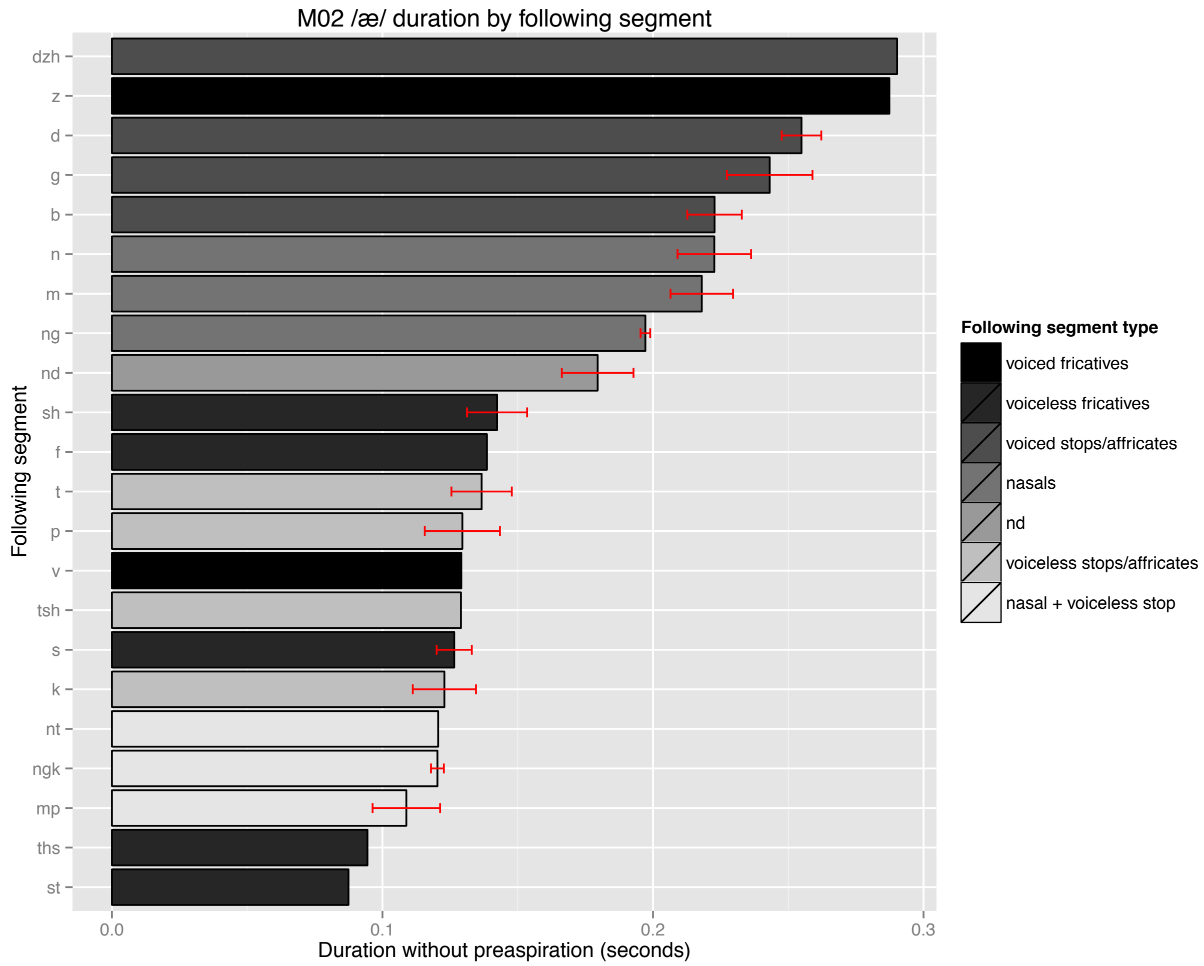


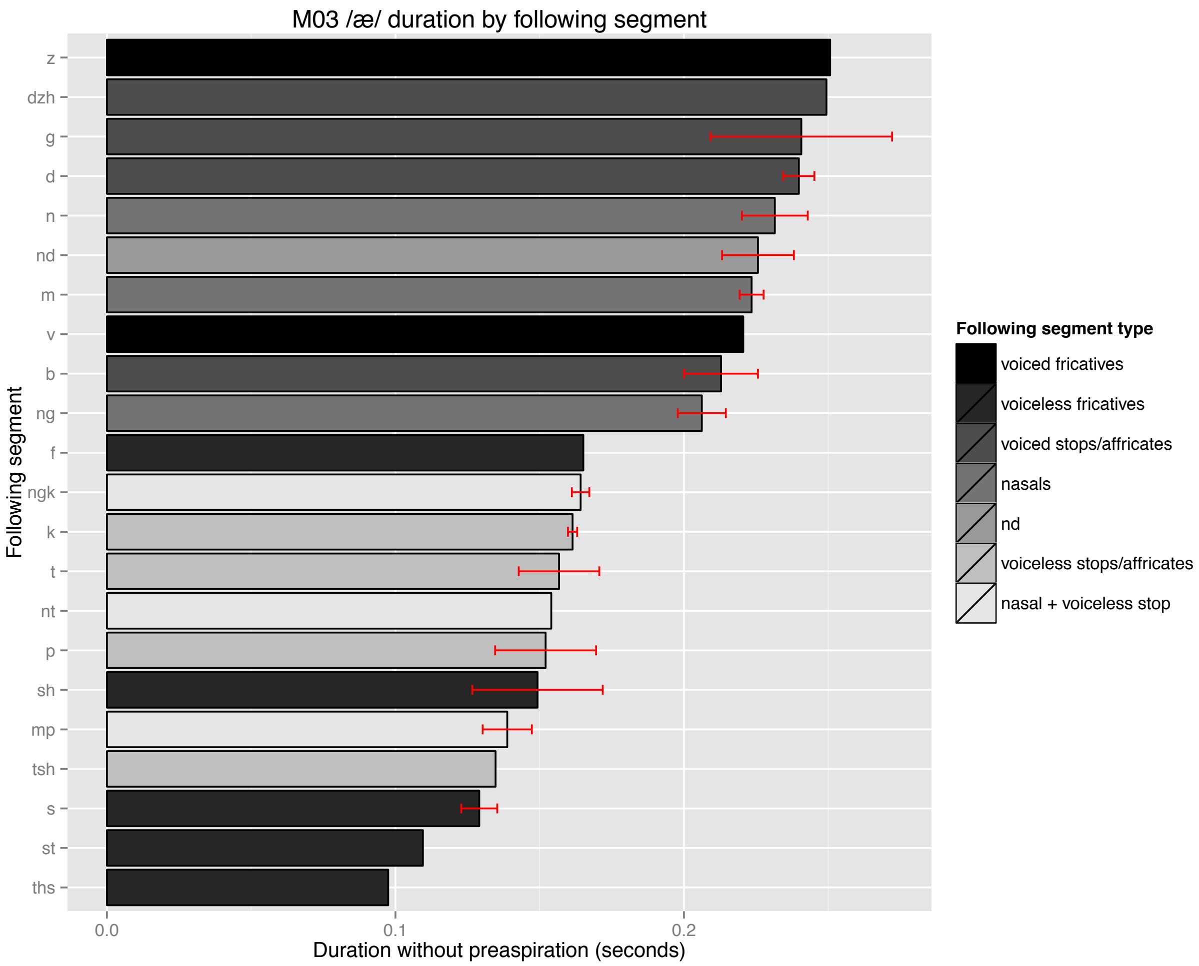
F13 /æ/ duration by following segment
Following segment
z
ng
v
m
d
n
g
nd
b
k
t
ngk
s
dzh
ths
nt
mp
p
st
sh
tsh
f
0.00
0.05
0.10
0.15
0.20
Duration without preaspiration (seconds)
Following segment type
voiced fricatives
voiceless fricatives
voiced stops/affricates
nasals
nd
voiceless stops/affricates
nasal + voiceless stop

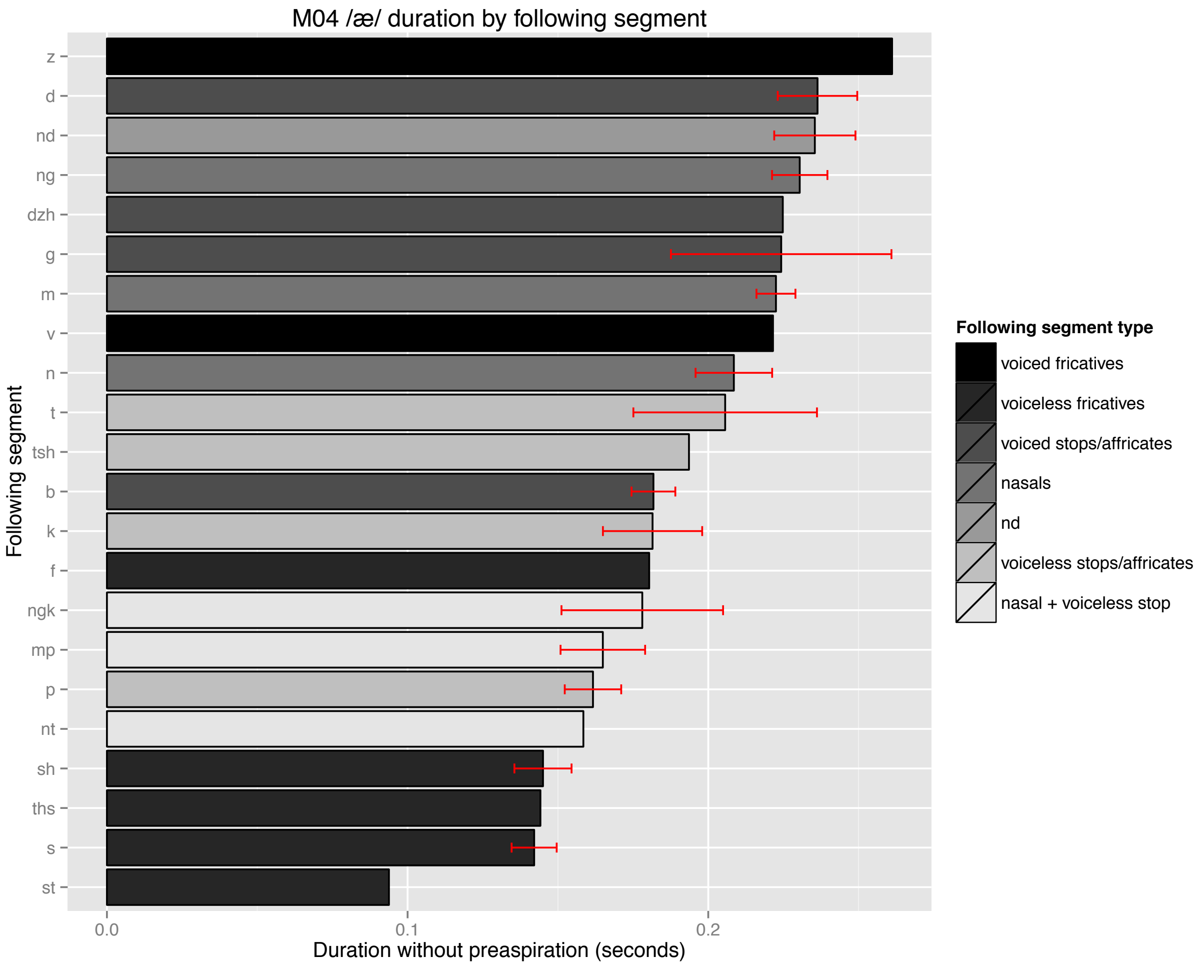

F14 /æ/ duration by following segment
z
g
dzh
v
d
ng
m
n
b
t
nd
k
f
tsh
s
sh
ths
p
ngk
st
mp
nt
Following segment
0.0
0.1
0.2
0.3
Duration without preaspiration (seconds)
Following segment type
voiced fricatives
voiceless fricatives
voiced stops/affricates
nasals
nd
voiceless stops/affricates
nasal + voiceless stop

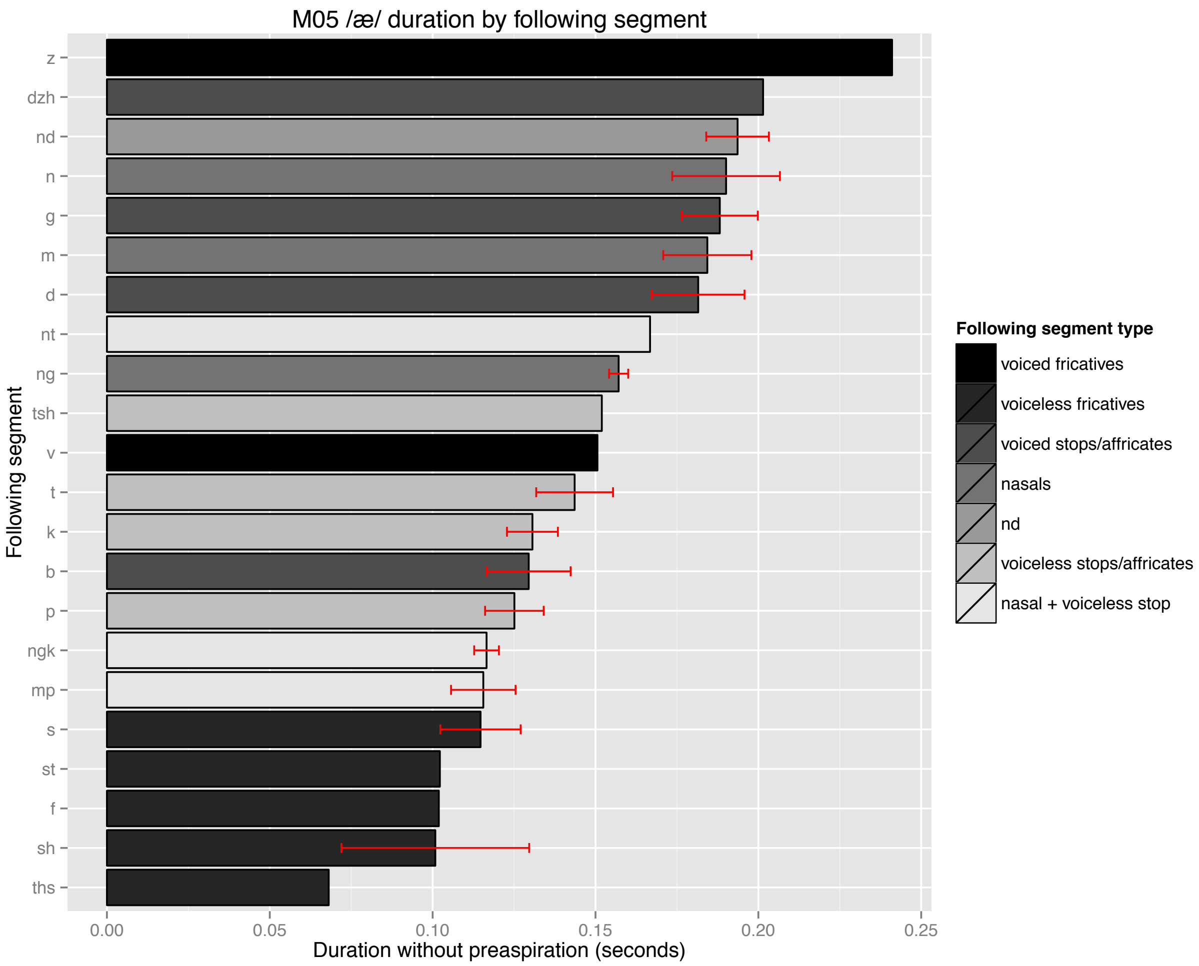

F15 /æ/ duration by following segment
z
m
d
g
nd
n
v
dzh
ng
t
b
tsh
nt
k
sh
ngk
p
st
ths
s
mp
f
Following segment
0.00
0.05
0.10
0.15
0.20
Duration without preaspiration (seconds)
Following segment type
voiced fricatives
voiceless fricatives
voiced stops/affricates
nasals
nd
voiceless stops/affricates
nasal + voiceless stop

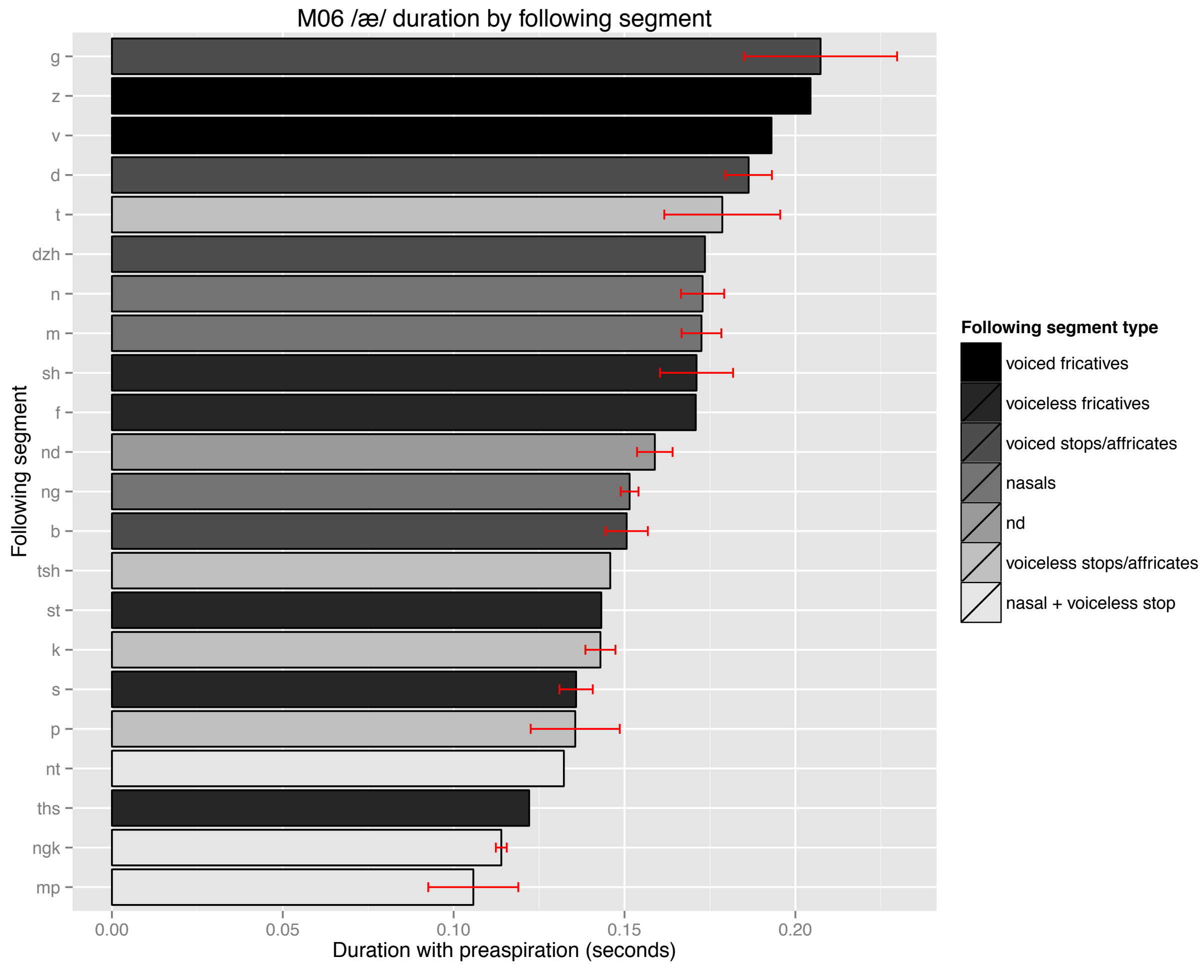

M01 /æ/ duration by following segment
z
g
v
ng
d
n
m
nd
b
dzh
k
tsh
t
f
nt
ngk
sh
p
s
mp
st
ths
Following segment
0.00
0.05
0.10
0.15
0.20
0.25
Duration without preaspiration (seconds)
Following segment type
voiced fricatives
voiceless fricatives
voiced stops/affricates
nasals
nd
voiceless stops/affricates
nasal + voiceless stop


M02 /æ/ duration by following segment
dzh
z
d
g
b
n
m
ng
nd
sh
f
t
p
v
tsh
s
k
nt
ngk
mp
ths
st
Following segment
0.0
0.1
0.2
0.3
Duration without preaspiration (seconds)
Following segment type
voiced fricatives
voiceless fricatives
voiced stops/affricates
nasals
nd
voiceless stops/affricates
nasal + voiceless stop


M03 /æ/ duration by following segment
Following segment
z
dzh
g
d
n
nd
m
v
b
ng
f
ngk
k
t
nt
p
sh
mp
tsh
s
st
ths
0.0
0.1
0.2
Duration without preaspiration (seconds)
Following segment type
voiced fricatives
voiceless fricatives
voiced stops/affricates
nasals
nd
voiceless stops/affricates
nasal + voiceless stop


M04 /æ/ duration by following segment
z
d
nd
ng
dzh
g
m
v
n
t
tsh
b
k
f
ngk
mp
p
nt
sh
ths
s
st
Following segment
0.0
0.1
0.2
Duration without preaspiration (seconds)
Following segment type
voiced fricatives
voiceless fricatives
voiced stops/affricates
nasals
nd
voiceless stops/affricates
nasal + voiceless stop


M05 /æ/ duration by following segment
Following segment
z
dzh
nd
n
g
m
d
nt
ng
tsh
v
t
k
b
p
ngk
mp
s
st
f
sh
ths
0.00
0.05
0.10
0.15
0.20
0.25
Duration without preaspiration (seconds)
Following segment type
voiced fricatives
voiceless fricatives
voiced stops/affricates
nasals
nd
voiceless stops/affricates
nasal + voiceless stop


M06 /æ/ duration by following segment
g
z
v
d
t
dzh
n
m
sh
f
nd
ng
b
tsh
st
k
s
p
nt
ths
ngk
mp
Following segment
0.00
0.05
0.10
0.15
0.20
Duration with preaspiration (seconds)
Following segment type
voiced fricatives
voiceless fricatives
voiced stops/affricates
nasals
nd
voiceless stops/affricates
nasal + voiceless stop