

Appendix A

Speech segmentation criteria

The location of segment boundaries in Experiment 1 and Experiment 2o is determined by inspection of speech waveforms and spectrograms. The criteria used in making such judgements are given here. For consistency, where alternatives are available, a single criterion is applied to all examples of a particular test item for a particular speaker. The parameters of application of certain criteria, for example, the choice of which formant break to associate with a given stop closure, is applied with similar consistency. Where labels are associated with the start or end of pitch periods, they are placed at the point of zero crossing on the waveform.

Stop closure: The end of pitch period before a significant drop in waveform amplitude or at a break in a particular formant.

- Following a fricative, the drop in spectrogram energy intensity in a particular frequency range may be used.

Glottalised stop closure: The end of pitch period preceding a break in formant structure.

- A change in the shape of successive pitch periods may be taken as a guide: for example, lengthening or doubling.

Stop release: The start of waveform burst; the first used if multiple bursts are present.

Vowel start/end: The start/end of a pitch period corresponding to appearance/disappearance of a particular formant.

- The shape and magnitude of successive pitch periods may be also used as a guide.

Nasal start/end: The start/end of a pitch period corresponding to the appearance/disappearance of nasal formants on spectrogram.

- Where a nasal adjoins a vowel, the waveform amplitude minimum is usually a reliable criterion.

Fricative start/end: The start/end of continuous spectrogram energy in a particular frequency range. Additional criteria for particular speakers and phonemes include:

- the end/start of a particular preceding or following formant;
- the end/start of spectrogram voicing (for voiceless fricatives);
- a change in amplitude of waveform periodicity.

Certain sequences, such vowel-approximant or approximant-vowel, are particularly difficult to label reliably and are avoided. Where approximants are present in the experimental materials, their start and end points are determined with reference to the adjacent consonant.

Appendix B

Experiment 1: Measured syllable duration by phrase

Test phrase (target syllable underlined)	Target syllable duration (ms)	Number of tokens
<i><u>bake</u> enforce</i>	254.2	23
<i><u>bacon</u> force</i>	224.1	22
<i><u>can</u> inspire</i>	242.5	24
<i><u>cannon</u> spire</i>	224.0	24
<i><u>thank</u> fulfil</i>	227.8	21
<i><u>thankful</u> Phil</i>	199.9	24
<i><u>cube</u> explain</i>	249.0	23
<i><u>cubics</u> plane</i>	197.2	24
<i><u>toe</u> content</i>	186.0	24
<i><u>token</u> tent</i>	124.9	24
<i><u>pay</u> perform</i>	186.8	23
<i><u>paper</u> form</i>	139.2	24
<i><u>dan</u> surprise</i>	248.5	24
<i><u>dancer</u> prize</i>	217.4	23
<i><u>day</u> today</i>	176.3	23
<i><u>data</u> day</i>	135.1	24

Table B.1: Durations by phrase type: left-headed words; reduced central syllable

Test phrase (target syllable underlined)	Target syllable duration (ms)	Number of tokens
<i><u>knee</u> capsize</i>	228.4	23
<i>kneecap <u>size</u></i>	192.7	21
<i><u>near</u> bisect</i>	269.9	22
<i>nearby <u>sect</u></i>	249.6	16
<i><u>there</u> foreclose</i>	194.4	24
<i>therefore <u>close</u></i>	155.0	22
<i><u>skim</u> Peking</i>	408.0	22
<i><u>skimpy</u> king</i>	336.6	23
<i><u>shake</u> downstairs</i>	334.2	22
<i>shakedown <u>stairs</u></i>	314.9	22
<i><u>there</u> foursquare</i>	188.8	23
<i>therefore <u>square</u></i>	161.6	22
<i><u>crow</u> barbette</i>	232.8	24
<i>crowbar <u>bet</u></i>	210.1	24
<i><u>hard</u> whereby</i>	411.7	21
<i>hardware <u>buy</u></i>	335.4	22

Table B.2: Durations by phrase type: left-headed words; full central syllable

Test phrase (target syllable underlined)	Target syllable duration (ms)	Number of tokens
<i>bake <u>enforce</u></i>	311.2	23
<i>bacon <u>force</u></i>	307.1	21
<i>can <u>inspire</u></i>	461.9	24
<i>cannon <u>spire</u></i>	466.3	22
<i>thank <u>fulfil</u></i>	345.5	21
<i>thankful <u>Phil</u></i>	351.2	23
<i>cube <u>explain</u></i>	289.2	24
<i>cubics <u>plane</u></i>	325.0	21
<i>toe <u>content</u></i>	371.0	23
<i>token <u>tent</u></i>	391.6	24
<i>pay <u>perform</u></i>	326.2	24
<i>paper <u>form</u></i>	343.0	22
<i>dan <u>surprise</u></i>	421.8	23
<i>dancer <u>prize</u></i>	429.0	22
<i>day <u>today</u></i>	289.0	24
<i>data <u>day</u></i>	312.6	22

Table B.3: Durations by phrase type: right-headed words; reduced central syllable.

Test phrase (target syllable underlined)	Target syllable duration (ms)	Number of tokens
<i>knee cap<u>size</u></i>	378.0	22
<i>kneecap <u>size</u></i>	412.0	19
<i>near <u>bisect</u></i>	373.5	21
<i>nearby <u>sect</u></i>	409.1	17
<i>there fore<u>close</u></i>	400.5	24
<i>therefore <u>close</u></i>	408.0	20
<i>skim <u>Peking</u></i>	355.5	22
<i>skimpy <u>king</u></i>	372.7	22
<i>shake down<u>stairs</u></i>	401.7	20
<i>shakedown <u>stairs</u></i>	409.9	20
<i>there four<u>square</u></i>	434.1	23
<i>therefore <u>square</u></i>	453.0	23
<i>crow bar<u>bette</u></i>	329.3	23
<i>crowbar <u>bet</u></i>	344.1	22
<i>hard where<u>by</u></i>	360.1	23
<i>hardware <u>buy</u></i>	379.9	21

Table B.4: Durations by phrase type: right-headed words; full central syllable

Appendix C

Experiment 2: Sentence materials

Left-headed keywords	Right-headed keywords
John THREW the cap to the BED again. John THREW the captain the BADGE again. John THREW the captaincy BADGE again.	JOHN saw Jessica mend it AGAIN. JOHN saw Jessie commend it AGAIN. JOHN saw Jess recommend it AGAIN.
Kate GAVE the sense of the SCRIPT away. Kate GAVE the ensor the SCRIPT again. Kate GAVE the ensorship SCRIPT away.	BETH saw Clematis pose it ALL. BETH saw Clemmie dispose it ALL. BETH saw Clem indispose it ALL.
Tim KNEW the dog may decline AGAIN. Tim KNEW the dogma declined AGAIN. Tim KNEW the dogmatist line AGAIN.	I CHECKED in every port for TOM. I CHECKED the old report for TOM. I CHECKED the misreport for TOM.
I SAW the fish again TODAY. I SAW the fissure crack TODAY. I SAW the fisherman TODAY.	GREG let big Oprah juice it ALL. GREG let Bobbie produce it ALL. GREG let Bob reproduce it ALL.
I SAW the mace unreclaimed AGAIN. I SAW the mason reclaimed it ALL. I SAW the masonry cleaned AGAIN.	I LET the dancer pose it TODAY. I LET the man suppose it TODAY. I LET him presuppose it TODAY.
Jim LIKES his part no more than MOST. Jim LIKES his partner more than MOST. Jim LIKES his partnership the MOST.	I SAW Widdicombe pose it AGAIN. I SAW Jodie compose it AGAIN. I SAW Joe decompose it AGAIN.
I MADE the spec to collect WOOD. I MADE the spectre collect WOOD. I MADE the spectacle from WOOD.	I MADE Burgundy send to them ALL. I MADE Megan descend to them ALL. I MADE May condescend to them ALL.
I HEARD the ten denied AGAIN. I HEARD the tendon go AGAIN. I HEARD the tendency TODAY.	You MUST continue main treatment NOW. You MUST maintain humane treatment NOW. You MUST cease inhumane treatment NOW.

Table C.1: The full set of experimental sentences for Keyword Series A. Keywords are shown in bold; the words to be emphasized in the unaccented keyword condition are shown in block capitals.

Left-headed keywords	Right-headed keywords
John THREW the cap to the BED again. John THREW the cap to the big BED again. John THREW the cap to the big red BED again.	JOHN saw Jessica mend it AGAIN. JOHNNY saw Jessica mend it AGAIN. JONATHAN saw Jessica mend it AGAIN.
Kate GAVE the sense of the SCRIPT away. Kate GAVE the sense of the new SCRIPT away. Kate GAVE the sense of the latest SCRIPT away.	BETH saw Clematis pose it ALL. BETHAN saw Clematis pose it ALL. BETHANY saw Clematis pose it ALL.
Tim KNEW the dog may decline AGAIN. Tim KNEW the dog may decline it AGAIN. Tim KNEW the dog may decline it all AGAIN.	I CHECKED in every port for TOM. I CHECKED one in every port for TOM. I CHECKED each one in every port for TOM.
I SAW the fish again TODAY. I SAW the fish again here TODAY. I SAW the fish again with it TODAY.	GREG let big Oprah juice it ALL. GREGOR let big Oprah juice it ALL. GREGORY let big Oprah juice it ALL.
I SAW the mace unreclaimed AGAIN. I SAW the mace unreclaimed once AGAIN. I SAW the mace unreclaimed by them AGAIN.	I LET the dancer pose it TODAY. I LET the tap dancer pose it TODAY. I LET the ballet dancer pose it TODAY.
Jim LIKES his part no more than MOST. Jim LIKES his part there no more than MOST. Jim LIKES his part in it no more than MOST.	I SAW Widdicombe pose it AGAIN. I SAW Ann Widdicombe pose it AGAIN. I SAW Anna Widdicombe pose it AGAIN.
I MADE the spec to collect WOOD. I MADE the spec to collect the WOOD. I MADE the spec to collect all the WOOD.	I MADE Burgundy send to them ALL. I MADE Pete Burgundy send to them ALL. I MADE Peter Burgundy send to them ALL.
I HEARD the ten denied AGAIN. I HEARD the ten denied it AGAIN. I HEARD the ten denied it all AGAIN.	You MUST continue main treatment NOW. You MUST not continue main treatment NOW. You MUST really continue main treatment NOW.

Table C.2: The full set of experimental sentences for Keyword Series B. Keywords are shown in bold; the words to be emphasized in the unaccented keyword condition are shown in block capitals. Due to an oversight in the preparation of the experimental materials, the phonetic environment immediately following the test syllable **part** is not constant within the keyword triad, as discussed in Chapter 4, and so this keyword is excluded from these analyses.

Left-headed keywords	Right-headed keywords
John THREW the cap to the BED again. John THREW the captain to the BED again. John THREW the captaincy to the BOARD again.	JOHN saw Jessica mend it AGAIN. JOHN saw Alison commend it AGAIN. JOHN saw Alison recommend it AGAIN.
Kate GAVE the sense of the SCRIPT away. Kate GAVE the ensor for the SCRIPT again. Kate GAVE the ensorship of the SCRIPT away.	BETH saw Clematis pose it ALL. BETH saw Clematis dispose it ALL. BETH saw Clematis indispose it ALL.
Tim KNEW the dog may decline AGAIN. Tim KNEW the dogma may decline AGAIN. Tim KNEW the dogmatist may decline AGAIN.	I CHECKED in every port for TOM. I CHECKED in the old report for TOM. I CHECKED in every misreport for TOM.
I SAW the fish again TODAY. I SAW the fissure behind TODAY. I SAW the fisherman again TODAY.	GREG let big Oprah juice it ALL. GREG let big Oprah produce it ALL. GREG let big Olive reproduce it ALL.
I SAW the mace unreclaimed AGAIN. I SAW the mason disinclined it ALL. I SAW the masonry disinterred AGAIN.	I LET the dancer pose it TODAY. I LET the postman suppose it TODAY. I LET the dancer presuppose it TODAY.
Jim LIKES his part no more than MOST. Jim LIKES his partner no more than MOST. Jim LIKES his partnership no more than MOST.	I SAW Widdicombe pose it AGAIN. I SAW Robinson compose it AGAIN. I SAW Robinson decompose it AGAIN.
I MADE the spec to collect WOOD. I MADE the spectre to collect WOOD. I MADE the spectacle to collect WOOD.	I MADE Burgundy send to them ALL. I MADE Robinson descend to them ALL. I MADE Burgundy condescend to them ALL.
I HEARD the ten denied AGAIN. I HEARD the tendon denied AGAIN. I HEARD the tendency denied AGAIN.	You MUST continue main treatment NOW. You MUST develop humane treatment NOW. You MUST abandon inhumane treatment NOW.

Table C.3: The full set of experimental sentences for Keyword Series C. Keywords are shown in bold; the words to be emphasized in the unaccented keyword condition are shown in block capitals.

Left-headed keywords	Right-headed keywords
John DESIGNED the cap . John DESIGNED the cap then. John DESIGNED the cap today.	Mend it AGAIN for me please. Now mend it AGAIN for me please. Will you mend it AGAIN for me please.
Kate EXPLAINED the sense . Kate EXPLAINED the sense well. Kate EXPLAINED the sense again.	Pose it ALL today. Now pose it ALL today. Can you pose it ALL today.
Tim thought I KNEW the dog . Tim thought I KNEW the dog then. Tim thought I KNEW the dog again.	Port some QUICKLY please. Now port some QUICKLY please. Can you port some QUICKLY please.
Bob said he SAW the fish . Bob said he SAW the fish off. Bob said he SAW the fish again.	Juice it TODAY please. Now juice it TODAY please. Can you juice it TODAY please.
Albert THREW the mace . Albert THREW the mace up. Albert THREW the mace again.	Pose it TODAY please. Now pose it TODAY please. Can you pose it TODAY please.
I hope Jim FINDS his part . I hope Jim FINDS his part soon. I hope Jim FINDS his part again.	Pose it AGAIN for me please. Now pose it AGAIN for me please. Will you pose it AGAIN for me please.
I FOUND an awful speck . I FOUND an awful speck there. I FOUND an awful speck today.	Send it TODAY please. Now send it TODAY please. Will you send it TODAY please.
Jill OBSERVED the ten . Jill OBSERVED the ten then. Jill OBSERVED the ten today.	Main roads SCARE me a lot. The main roads SCARE me a lot. All the main roads SCARE me a lot.

Table C.4: The full set of experimental sentences for Keyword Series D. Keywords are shown in bold; the words to be emphasized in the unaccented keyword condition are shown in block capitals.

Left-headed keywords	Right-headed keywords
John DESIGNED the cap . John MALIGNED the captain . John RESIGNED the captaincy .	Mend it AGAIN for me please. Commend it AGAIN for me please. recommend it AGAIN for me please.
Kate EXPLAINED the sense . Kate EXPLAINED the sensor . Kate EXPLAINED the sensorship .	Pose it ALL today. Dispose it ALL today. Indispose it ALL today.
Tim thought I KNEW the dog . Tim thought I KNEW the dogma . Tim thought I KNEW the dogmatist .	Port some QUICKLY please. Report some QUICKLY please. Misreport some QUICKLY please.
Bob said he SAW the fish . Bob said he SAW the fissure . Bob said he SAW the fisherman .	Juice it TODAY please. Produce it TODAY please. Reproduce it TODAY please.
Albert THREW the mace . Albert THREW the mason . Albert THREW the masonry .	Pose it TODAY please. Suppose it TODAY please. Presuppose it TODAY please.
I hope Jim FINDS his part . I hope Jim FINDS his partner . I hope Jim FINDS his partnership .	Pose it AGAIN for me please. Compose it AGAIN for me please. Decompose it AGAIN for me please.
I FOUND an awful spec . I FOUND an awful spectre . I FOUND an awful spectacle .	Send it TODAY please. Descend it TODAY please. Condescend it TODAY please.
Jill OBSERVED the ten . Jill OBSERVED the tendon . Jill OBSERVED the tendency .	Main roads SCARE me a lot. Humane roads SCARE me a lot. Inhumane roads SCARE me a lot.

Table C.5: The full set of experimental sentences for Keyword Series E. Keywords are shown in bold; the words to be emphasized in the unaccented keyword condition are shown in block capitals.

Block	Composition	Number of sentences
A	left-headed, utterance-medial, unaccented	56
	right-headed, utterance-medial, unaccented	56
B	left-headed, utterance-edge, unaccented	40
	right-headed, utterance-edge, accented	40
	right-headed, utterance-medial, accented	56
C	left-headed, utterance-edge, accented	40
	left-headed, utterance-medial, accented	56
	right-headed, utterance-edge, unaccented	40

Table C.6: Division of experimental sentences in Experiment 2 for the purposes of recording.

Appendix D

Experiment 2: Excluded utterances

Utterances were excluded from Experiment 2 analysis because: the lexical content of the utterance was misread; the keyword received an accent in the unaccented condition; the keyword did not receive an accent in the accented condition; primary lexical stress was misplaced within the keyword; there was an intonational phrase boundary adjacent to the keyword. The excluded utterances are listed in Tables D.1–D.3.

Series	Keyword	Subject	Sentence
A	<i>compose</i>	1	* I saw Widdicombe POSE it again
		5	* I SAW Widdicombe pose it AGAIN
		5	I SAW Joe decompose it AGAIN
		5	I saw Joe DECOMPOSE it again
	<i>dispose</i>	1	Beth saw Clem INDISPOSE it all
		3	Beth saw Clem INDISPOSE it all
		6	* Beth saw Clematis POSE it all
	<i>juice</i>	4	Greg let Bob REPRODUCE it all
		6	Greg let Bob REPRODUCE it all
	<i>main</i>	3	You must cease INHUMANE treatment now
	<i>mend</i>	6	JOHN saw Jessie commend it AGAIN
	<i>port</i>	2	I checked the MISREPORT for Tom
4		I checked the MISREPORT for Tom	
B	<i>compose</i>	1	* I saw Widdicombe POSE it again
		5	* I SAW Widdicombe pose it AGAIN
	<i>dispose</i>	3	BETHAN saw Clematis pose it ALL
		6	* Beth saw Clematis POSE it all

Table D.1: Experiment 2 utterances for right-headed keywords (part 1) for which pairs of tokens are excluded from analysis. * indicates that the sentence is common to Series A, B and C.

Series	Keyword	Subject	Sentence
C	<i>compose</i>	1	* I saw Widdicombe POSE it again
		5	* I SAW Widdicombe pose it AGAIN
		6	I saw Robinson COMPOSE it again
	<i>dispose</i>	1	Beth saw Clematis INDISPOSE it all
		3	Beth saw Clematis INDISPOSE it all
		6	* Beth saw Clematis POSE it all
6		BETH saw Clematis dispose it ALL	
<i>juice</i>	4	Greg let big Olive REPRODUCE it all	
<i>port</i>	1	I checked in every MISREPORT for Tom	
	2	I checked in every MISREPORT for Tom	
	3	I checked in every MISREPORT for Tom	
	4	I checked in every MISREPORT for Tom	
	6	I checked in every MISREPORT for Tom	
<i>send</i>	6	I MADE Robinson descend to them ALL	
D	<i>dispose</i>	3	* Pose it ALL today
		3	Now pose it ALL today
		5	Now pose it ALL today
		5	Can you pose it ALL today
	<i>send</i>	6	* Send it TODAY please
		6	Now send it TODAY please
6		Will you send it TODAY please	
E	<i>dispose</i>	1	Indispose it ALL today
		5	Indispose it ALL today
		6	Indispose it ALL today
		3	* Pose it ALL today
	<i>juice</i>	4	REPRODUCE it today please
		6	REPRODUCE it today please
	<i>port</i>	4	MISREPORT some quickly please
		2	MISREPORT some quickly please
	<i>send</i>	6	* Send it TODAY please
		6	Descend it TODAY please
6		Condescend it TODAY please	
<i>suppose</i>	2	PRESUPPOSE it today please	

Table D.2: Experiment 2 utterances for right-headed keywords (part 2) for which pairs of tokens are excluded from analysis. * indicates that the sentence is common to Series A, B and C or common to Series D and E

Series	Keyword	Subject	Sentence	
A	<i>dog</i>	1	Tim knew the DOGMA declined again	
		5	* Tim knew the DOG may decline again	
	<i>fish</i>	1	I saw the FISSURE crack today	
5		I saw the FISSURE crack today		
	<i>ten</i>	5	* I heard the TEN denied again	
B	<i>dog</i>	4	Tim knew the DOG may decline it all again	
		5	* Tim knew the DOG may decline again	
		5	Tim knew the DOG may decline it all again	
	<i>fish</i>	5	I saw the FISH again here today	
	<i>mace</i>	1	I saw the MACE unreclaimed by them again	
		4	I saw the MACE unreclaimed by them again	
		5	I SAW the mace unreclaimed once AGAIN	
			5	I SAW the mace unreclaimed by them AGAIN
	<i>speck</i>	5	I made the SPEC to collect the wood	
	<i>ten</i>	1	I heard the TEN denied it again	
4		I heard the TEN denied it again		
4		I heard the TEN denied it all again		
5		* I heard the TEN denied again		
5		I heard the TEN denied it again		
		5	I heard the TEN denied it all again	
C	<i>dog</i>	5	* Tim knew the DOG may decline again	
	<i>fish</i>	1	I saw the FISSURE behind today	
		4	I saw the FISSURE behind today	
		5	I saw the FISSURE behind today	
	<i>mace</i>	1	I saw the MASON disinclined again	
		1	I saw the MASONRY disinterred again	
		6	I SAW the masonry disinterred AGAIN	
<i>speck</i>	3	I MADE the spectacle to collect WOOD		
	5	I made the SPECTACLE to collect wood		
<i>ten</i>	5	* I heard the TEN denied again		
D	<i>dog</i>	1	Tim thought I KNEW the dog again	
	<i>ten</i>	1	Jill observed the TEN today	
E	<i>cap</i>	1	John RESIGNED the captaincy	
	<i>mace</i>	5	Albert THREW the mason	

Table D.3: Experiment 2 utterances for left-headed keywords for which pairs of tokens are excluded from analysis. * indicates that the sentence is common to Series A, B and C.

Appendix E

Experiment 2: Keyword labelling

The placement of labels for test syllable constituents is shown in Tables E.1 and E.2.

The placement of labels for other syllables in keywords is shown in Tables E.3 and E.4.

Keyword	Test syllable	onset		nucleus	coda	end
			aspiration			
<i>cap</i>	/kæp/	/k/ closure	/k/ release	/æ/ start	/p/ closure	/p/ release
<i>sense</i>	/sens/	/s/ start		/ɛ/ start	/n/ start	/s/ end
<i>dog</i>	/dɒg/	/d/ closure		/d/ release	/g/ closure	/g/ release
<i>fish</i>	/fɪʃ/	/f/ closure		/ɪ/ start	/ʃ/ start	/ʃ/ end
<i>mace</i>	/meɪs/	/m/ start		/eɪ/ start	/s/ start	/s/ end
<i>part</i>	/pɑt/	/p/ closure	/p/ release	/ɑ/ start	/t/ closure	/t/ release
<i>speck</i>	/spɛk/	/s/ start		/p/ release	/k/ closure	/k/ release
<i>ten</i>	/tɛn/	/t/ closure	/t/ release	/ɛ/ start	/n/ start	/n/ end

Table E.1: Placement of test syllable labels for the left-headed keywords in Experiment 2. Each subsyllabic constituent is identified by the label (in bold) placed at its start.

Keyword	Test syllable	onset		nucleus	coda	end
			aspiration			
<i>mend</i>	/mɛnd/	/m/ start		/e/ start	/n/ start	/d/ release
<i>dispose</i>	/pəʊz/	/p/ closure	/p/ release	/əʊ/ start	/z/ start	/z/ end
<i>port</i>	/pɔt/	/p/ closure	/p/ release	/ɔ/ start	/t/ closure	/t/ release
<i>juice</i>	/dʒʊs/	/dʒ/ closure	/d/ release	/u/ start	/s/ start	/s/ end
<i>suppose</i>	/pəʊz/	/p/ closure	/p/ release	/əʊ/ start	/s/ start	/s/ end
<i>compose</i>	/pəʊz/	/p/ closure	/p/ release	/əʊ/ start	/s/ start	/s/ end
<i>send</i>	/sɛnd/	/s/ start		/ɛ/ start	/n/ start	/d/ release
<i>main</i>	/meɪn/	/m/ start		/eɪ/ start	/n/ start	/n/ end

Table E.2: Placement of test syllable labels for right-headed keywords in Experiment 2. Each subsyllabic constituent is identified by the label (in bold) placed at its start, except for *juice* where the “aspiration” label indicates the start of the fricated part of the affricate /dʒ/.

Keyword	Syllables	Position of label			
		Syllable-2 start	Syllable-2 end	Syllable-3 start	Syllable-3 end
<i>cap</i>	/kæp.tən.sɪ/	/t/ release		/n/ end	/ɪ/ end
<i>sense</i>	/sɛns.ə.ʃɪp/	/ə/ start		/ə/ end	/p/ release
<i>dog</i>	/dɒg.mə.tɪst/	/m/ start		/ə/ end	/t/ closure
<i>fish</i>	/fɪʃ.ə.mən/	/ʃ/ end		/ə/ end	/n/ end
<i>mace</i>	/meɪs.ən.ɪ/	/s/ end		/n/ end	/ɪ/ end
<i>part</i>	/pɑt.nə.ʃɪp/	/n/ start		/ə/ end	/p/ closure
<i>spec</i>	/spɛk.tə.kəl/	/t/ release		/ə/ end	/l/ end
<i>ten</i>	/tɛn.dən.sɪ/	/d/ closure		/n/ end	/ɪ/ end

Table E.3: Placement of additional syllable labels for the left-headed keywords in Experiment 2: syllable-2 immediately follows the primary stressed syllable in the disyllable and trisyllable; syllable-3 follows syllable-2 in the trisyllable. The test-syllable-final stops in *spec.ta.cle* and *cap.tain.cy* are not always released, thus the closure durations of the syllable-2 onsets are not reliably measurable and so the syllables are measured from the syllable-2 stop release. The syllable-3 final stops are not always released in *dogmatist* and *partnership* and so the syllable is measured up to the onset of stop closure.

Keyword	Syllables	Position of label			
		Syllable-3 start	Syllable-3 end	Syllable-2 start	Syllable-2 end
<i>mend</i>	/ɪɛ.kə.mɛnd/	/ɪ/ start	/k/ closure		/m/ start
<i>dispose</i>	/ɪn.dɪs.pəʊz/	/ɪ/ start	/d/ closure		/s/ end
<i>port</i>	/mɪs.ɪə.pɔt/	/m/ start	/ɪ/ start		/p/ closure
<i>juice</i>	/ɪi.pɪə.dʒus/	/ɪ/ start	/p/ closure		/d/ closure
<i>suppose</i>	/pɪ.sə.pəʊz/	/p/ closure	/s/ start		/p/ closure
<i>compose</i>	/di.kəm.pəʊz/	/d/ closure	/k/ closure		/p/ closure
<i>send</i>	/kɒn.də.sɛnd/	/k/ closure	/d/ closure		/s/ start
<i>main</i>	/m.hju.meɪn/	/ɪ/ start	/n/ end		/m/ start

Table E.4: Placement of additional syllable labels for the right-headed keywords in Experiment 2: syllable-2 immediately precedes the primary stressed syllable in the disyllable and trisyllable; syllable-3 precedes syllable-2 in the trisyllable.

Appendix F

Experiment 2: Results overview

	... in utterance	Number of added syllables:					
		0		1		2	
<i>Utterance- medial</i>	0	232	300	219	269	212	251
	1	231	299	219	270		
	2	234	298			211	242
<i>Utterance- edge</i>	0	216	278				
	1	232	296	235	274		
	2	233	300			225	265

Table F.1: Mean test syllable duration (ms) in Experiment 2 for the right-headed keywords *main*, *mend* and *send*, on the left in each cell for unaccented keywords and in bold on the right in each cell for accented keywords.

	...in utterance	Number of added syllables:					
		0		1		2	
<i>Utterance- medial</i>	0	293	349	286	331	279	306
	1	291	349	286	327		
	2	290	344			276	302
<i>Utterance- edge</i>	0	410	453				
	1	318	357	319	339		
	2	294	338			286	309

Table F.2: Mean test syllable duration (ms) in Experiment 2 for the left-headed keywords *fish*, *mace*, *sense* and *ten*, on the left in each cell for unaccented keywords and in bold on the right in each cell for accented keywords.

Appendix G

Experiment 2: Additional utterance-span results

There is a comparison in Experiment 2, reported in Section 4.5.1, of test syllable duration between those Series B and Series D sentences which differ in length by three or four syllables, intended to determine the effect of utterance length on stressed syllable duration. The results suggest domain-edge rather than domain-span interpretations: there is no significant durational variation on the test syllable nucleus, but the onset and coda manifest contrasting durational effects. The variations in test syllable onset and coda durations are considered here across the full set of keywords, regardless of utterance length.

Test syllable onset duration

In order to see if the pattern of differences in onset duration between Series B vs Series D relates to the likelihood of phrase boundary occurrence, the full set of keywords are examined. Table G.1 shows the mean durational difference which, as there is no interaction between utterance length and pitch accent, is pooled across accented and unaccented conditions.

The most noticeable trend in Table G.1 is that substantial lengthening of the onset in Series B is more widespread for right-headed keywords. A By-Subjects analysis finds a significant effect of Utterance Position for all right-headed keywords: $F(1,5) = 10.78$, $p < .05$ [by Items: $F(1,7) = 6.34$, $p < .05$]. Where right-headed keywords are preceded by a noun phrase/verb phrase boundary in the Series B sentence, a prosodic phrase boundaries may sometimes be realised. A prosodic phrase boundary seems less likely in the two Series B utterances which have a different syntactic environment for the keyword—*main* is within the verb phrase headed by the preceding verb; *port* is preceded by a noun-phrase-internal word boundary—and these two keywords do

Series B.3 utterance	Series D.3 utterance	Lengthening
<i>Right-headed keywords</i>		
I LET the ballet dancer pose it TODAY.	Can you pose it TODAY please.	17%
GREGORY let big Oprah juice it ALL.	Can you juice it TODAY please.	11%
JONATHAN saw Jessica mend it AGAIN.	Will you mend it AGAIN for me please.	10%
BETHANY saw Clematis pose it ALL.	Can you pose it ALL today.	10%
I MADE Peter Burgundy send to them ALL.	Will you send it TODAY please.	8%
You MUST really continue main treatment NOW.	All the main roads SCARE me a lot.	5%
I CHECKED each one in every port for TOM.	Can you port some QUICKLY please.	4%
I SAW Anna Widdicombe pose it AGAIN.	Will you pose it AGAIN for me please.	-10%
<i>Left-headed keywords</i>		
Tim KNEW the dog may decline it all AGAIN.	Tim thought I KNEW the dog again.	10%
I SAW the mace unreclaimed by them AGAIN.	Albert THREW the mace again.	9%
John THREW the cap to the big red BED again.	John DESIGNED the cap today.	4%
Kate GAVE the sense of the latest SCRIPT away.	Kate EXPLAINED the sense again.	4%
Jim LIKES his part in it no more than MOST.	I hope Jim FINDS his part again.	4%
I SAW the fish again with it TODAY.	Bob said he SAW the fish again.	2%
I HEARD the ten denied it all AGAIN.	Jill OBSERVED the ten today.	2%
I MADE the spec to collect all the WOOD.	I FOUND an awful speck today.	-4%

Table G.1: Percentage lengthening of test syllable onset in Keyword Series B.3 utterances compared with Keyword Series D.3 utterances. The test syllable is in bold; words emphasised in the unaccented condition are in capitals.

show less lengthening of the onset in Series B.

Variations in segmental environment are also a factor in these results. For most right-headed keywords, the test syllable is preceded by a vowel in both Series B and Series D utterances; for *compose*, however, the test syllable is preceded by a nasal consonant in Series B (*Widdicombe pose*) and a vowel in Series D (*Will you pose*), and it has a longer syllable onset in Series D. One possibility is that the /p/ is shortened in Series B because it is preceded by /m/: it is not clear whether consonants must be tautosyllabic for shortening in consonant clusters to occur. *Clematis pose* in Series B similarly has a test syllable onset /p/ preceded by another consonant, in contrast with Series D where it is preceded by a vowel. In this case, however, the shortening seen in *Widdicombe pose* is not observed.

For the left-headed keywords in Table G.1, all the test syllable onsets are noun-phrase-internal, and thus the likelihood of a phrase boundary seems low, although possibly more likely in the longer utterance. The small differences between Series B and Series D reflect this, except for the utterances for *dog* and *mace*, which do not appear to have any structural reasons for the more likely placement of phrase boundaries preceding the test syllable in Series B¹. A By-Subjects analysis finds a significant effect of Utterance Position on onset duration: $F(1,5.1) = 10.72$, $p < .05$ [by Items: $F(1,7.2) = 5.94$, $p < .05$] for all left-headed keywords shown in Table Table G.1.

¹The likely full vowel syllable in *dog may* could, however, cause lengthening in comparison to *dog again*.

One possible factor regarding the placement of boundaries in read speech is that subjects may pay less attention to syntax in their prosodic phrasing than when generating utterances spontaneously: factors such as utterance length and the relative lengths of potential phrases may have more weight in the reading task, where deep levels of linguistic processing may have less input into prosodic planning. In the extreme case, subjects reading lists of items tend to break the list into phrases containing equal numbers of words (Gee & Grosjean 1983). The reading of linguistically-meaningful written sentences may lie, in performance terms, between list-reading and natural speech: in the latter, where non-hesitation breaks are highly likely to delimit structurally-significant units and factors such as length and speech rate may affect how many such units are realised phrasally. In all cases, the occurrence of a phrase boundary at a given point in a particular utterance is a matter of probability: syntactically more important boundaries are more likely to be realised prosodically.

Overall, it seems that most right-headed keywords in Series B have syntactic structures which may induce prosodic boundaries and associated lengthening preceding the keyword, but such boundaries are less likely in Series D. As keyword-adjacent intonational phrase boundaries are excluded from the final data-set, the phrases associated with these boundaries will be below the intonational phrase: for example, the phonological phrase. The results for left-headed keywords are considered below in relation to variations in coda duration.

Test syllable coda duration

Test syllable codas show the opposite pattern to onsets in the comparison between Series B and D, being longer in the shorter Series D utterances; as discussed in Section 4.5.1, however, this effect does not seem likely to be interpretable as an utterance-span effect. To consider the interpretation of these results further, mean coda durations are shown in Table G.2 for all keywords, excluding those with frequently glottalised codas. Because there is no interaction between utterance length and pitch accent, the mean durational difference is pooled across accented and unaccented conditions.

A By-Subjects analysis finds that the effect of Utterance Position approaches significance for left-headed keywords: $F(1,5.1) = 4.22$, $p = .094$ [by Items: $F(1,4) = 2.85$, $p = .166$]. The explanation for the greater duration of test syllable codas in left-headed keywords in Series D seems likely to be their utterance-antepenultimate position, particularly as no other parts of the syllable show such lengthening. The only keyword which does not show this pattern is *ten*, which does not have a consistent phonetic environment between the two series.

In accordance with the word-level results presented in Section 4.6, it may be noted that there is no evidence of left-headed keywords in utterance-medial position (Series

Series B utterance	Series D utterance	Lengthening
<i>Right-headed keywords</i>		
I MADE Peter Burgundy send to them ALL.	Will you send it TODAY please.	22%
You MUST really continue main treatment NOW.	All the main roads SCARE me a lot.	14%
I SAW Anna Widdicombe pose it AGAIN.	Will you pose it AGAIN for me please.	4%
GREGORY let big Oprah juice it ALL.	Can you juice it TODAY please.	4%
BETHANY saw Clematis pose it ALL.	Can you pose it ALL today.	3%
I LET the ballet dancer pose it TODAY.	Can you pose it TODAY please.	2%
JONATHAN saw Jessica mend it AGAIN.	Will you mend it AGAIN for me please.	-8%
<i>Left-headed keywords</i>		
I SAW the mace unreclaimed by them AGAIN.	Albert THREW the mace again.	17%
Kate GAVE the sense of the latest SCRIPT away.	Kate EXPLAINED the sense again.	11%
John THREW the cap to the big red BED again.	John DESIGNED the cap today.	9%
I SAW the fish again with it TODAY.	Bob said he SAW the fish again.	3%
I HEARD the ten denied it all AGAIN.	Jill OBSERVED the ten today.	-7%

Table G.2: Percentage lengthening of test syllable coda in Keyword Series D.3 utterances compared with Keyword Series B.3 utterances, excluding keywords *port*, *speck*, *dog* and *part*. The test syllable is in bold; words emphasised in the unaccented condition are in capitals.

B) manifesting phrase-final lengthening effects: this includes those in the Series B.1 utterances, for example in Table 4.12, which are also used in Series A and Series C to examine word-level effects.

The interpretation of the results for right-headed keywords shown in Table G.2 as phrase-final lengthening is not compelling, as the syntactic structures of the Series D utterances do not appear likely to result in prosodic boundaries immediately following the test syllable². The results for onset duration discussed above suggest, however, that there is sometimes a phrase boundary preceding the right-headed keyword in Series B. The shortening of the codas in Series B could be interpreted as a compensatory adjustment to the phrase-initial lengthening of their onsets. A similar effect could account for the apparently anomalous lengthening of onset duration for Series B left-headed keywords compared with Series D: the codas appear to be lengthening due to their utterance-antepenultimate position in Series D, and thus the onsets may undergo some compensatory shortening. The tentative explanation is supported by the apparent occurrence of another compensatory effect in Experiment 2: the possible shortening of the syllable nucleus following word-initial lengthening. Compensatory effects are discussed in more detail in Chapter 5.

The effect in right-headed codas is only small, however, and a By-Subjects analysis of coda duration across all keywords except *port* finds a no significant difference

²It may be noted that the difference between coda duration in Series B and Series D may be affected for the keywords *dispose* (as in *Clematis pose*) and *juice* by the utterance-antepenultimate position of the keywords in Series B. As just noted for left-headed keywords, this position appears to cause some lengthening of the coda: thus, a tendency for some other reason towards lengthening of the coda in Series D may be masked.

between Series B and Series D: $F(1,5) = 2.43$, $p = .180$ [by Items: $F(1,6) = 2.27$, $p = .182$]. It may be noted, furthermore, that only two keywords, *send* and *main*, show a strong effect in this comparison, and both have differences in the following phonetic environment between Series B and Series D: there may be shortening of consonants in clusters in Series B for *send* and *main*, although it is not clear if this effect is reliable across syllable boundaries. (In contrast, as noted above, the Series D lengthening effect may be underestimated in the comparison for *dispose* and *juice*.) Indeed, the variability in the pattern of results for both onsets and codas in the Series B vs Series D comparisons indicates the importance of experimentally controlling influences on segmental duration other than those pertaining to the experimental conditions.

Appendix H

Experiment 2: Additional word-edge and word-span results

	Number of syllables in word		
	1	2	3
<i>Onset</i>			
Unaccented	95	77	76
Accented	125	95	79
<i>Vowel nucleus</i>			
Unaccented	98	102	98
Accented	116	119	110
<i>Coda</i>			
Unaccented	69	69	66
Accented	85	82	77

Table H.1: Mean duration (ms) of the subsyllabic constituents of the test syllable for right-headed keywords in Series C. The data-set for onset and nucleus is smaller than that for Series A because here the keyword *port* is excluded due to a cluster of missing measurements. The data-set for coda is equivalent to that for Series A, where *port* was also excluded. The means for onset, nucleus and coda duration are taken from all the keywords except *port*: data points = 252; missing = 3.6%.

Source of variation	By Subjects analysis			By Items analysis		
	Degrees of freedom	<i>F Ratio</i>	Significance level	Degrees of freedom	<i>F Ratio</i>	Significance level
<i>Onset</i>						
Word Length	2,10	52.69	p < .001	2,12.1	64.39	p < .001
Accent	1,5	24.27	p < .005	1,6.1	80.56	p < .001
Interaction	2,10.1	21.64	p < .001	2,12.7	64.67	p < .001
<i>Nucleus</i>						
Word Length	2,10.2	5.79	p < .05	2,12.2	3.70	p = .055
Accent	1,5	10.60	p < .05	1,6	19.98	p < .005
Interaction	2,10.2	1.63	p = .244	2,12.4	1.13	p = .354
<i>Coda</i>						
Word Length	2,10.2	10.01	p < .005	2,12.8	10.98	p < .005
Accent	1,5	28.03	p < .005	1,6	10.34	p < .05
Interaction	2,10.2	2.49	p = .131	2,12.85	2.05	p = .169

Table H.2: Results of analyses of variance for subsyllabic durations in right-headed keyword test syllables in Series C.

	Number of syllables in word		
	1	2	3
<i>Onset</i>			
Unaccented	112	106	104
Accented	133	123	120
<i>Nucleus</i>			
Unaccented	79	74	66
Accented	89	78	73
<i>Coda</i>			
Unaccented	104	107	105
Accented	131	123	113

Table H.3: Mean duration (ms) of the subsyllabic constituents of the test syllables for left-headed keywords in Series C. The means for onset and nucleus duration are taken from all the keywords excluding *dog* and *part*: data points = 216; missing = 4.2%. The means for coda duration are taken from the keywords *fish*, *mace*, *sense* and *ten*: data points = 144; missing = 4.9%.

	By Subjects analysis			By Items analysis		
Source of variation	Degrees of freedom	<i>F Ratio</i>	Significance level	Degrees of freedom	<i>F Ratio</i>	Significance level
<i>Onset</i>						
Word Length	2,10.4	7.95	p < .01	2,10.1	10.53	p < .005
Accent	1,5	8.54	p < .05	1,5.1	145.59	p < .001
Interaction	2,10.5	0.30	p = .744	2,10.6	5.88	p < .05
<i>Nucleus</i>						
Word Length	2,10.8	36.25	p < .001	2,10.1	27.24	p < .001
Accent	1,5.1	12.57	p < .05	1,5.1	58.08	p < .005
Interaction	2,12.5	5.65	p < .05	2,10.2	1.51	p = .267
<i>Coda</i>						
Word Length	2,11.2	3.23	p = .078	2,6	0.97	p = .433
Accent	1,5.1	5.33	p = .068	1,3	16.67	p < .05
Interaction	2,12.2	6.19	p < .05	2,6.1	3.00	p = .124

Table H.4: Results of analyses of variance for subsyllabic durations in left-headed key-word test syllables in Series C.

Appendix I

Experiment 2: Additional utterance-final results

Keyword	Utterance position			
	Final		Medial	
<i>captain</i>	160	166	153	167
<i>dogma</i>	106	118	132	122
<i>fissure</i>	88	85	44	44
<i>mason</i>	109	111	94	102
<i>partner</i>	113	115	94	97
<i>censor</i>	77	83	35	39
<i>spectre</i>	119	123	78	83
<i>tendon</i>	151	157	166	182

Table I.1: Mean final unstressed syllable duration (ms) for left-headed disyllabic keywords Series C and Series E: data points = 24 for each keyword; missing = 0 for all keywords, except *fissure* (3 missing) and *mace* (2 missing). In each cell, durations on the left are from unaccented context; durations in bold on the right are from accented context.

Keyword	Utterance position			
	Final		Medial	
<i>captaincy</i>	135	148	122	135
<i>dogmatist</i>	61	69	69	69
<i>fisherman</i>	29	35	31	31
<i>masonry</i>	84	89	66	68
<i>partnership</i>	51	62	56	58
<i>ensorship</i>	34	30	31	31
<i>spectacle</i>	59	59	51	55
<i>tendency</i>	143	137	109	133

Table I.2: Mean penultimate unstressed syllable duration (ms) for left-headed trisyllabic keywords Series C and Series E: data points = 24 for each keyword; missing = 0 for all keywords, except *captaincy* (1 missing), *mace* (2 missing) and *speck* (2 missing). In each cell, durations on the left are from unaccented context; durations in bold on the right are from accented context.

Appendix J

Experiment 2: Additional pitch accent results

	Degrees of freedom		F Ratio		Significance level	
<i>Right-headed</i>						
Onset	1,5	(1,7.1)	26.64	(398.34)	p < .005	(p < .001)
Nucleus	1,5	(1,7)	16.38	(19.34)	p < .01	(p < .005)
Coda	1,5	(1,6)	35.98	(15.21)	p < .005	(p < .01)
<i>Left-headed</i>						
Onset	1,5	(1,7.1)	11.92	(223.06)	p < .05	(p < .001)
Nucleus	1,5.1	(1,7)	13.32	(22.96)	p < .05	(p < .005)
Coda	1,5	(1,2)	5.57	(5.16)	p = .065	(NS)

Table J.1: Results of analyses of variance for the effect of Accent on the duration of subsyllabic constituents of the test syllable for monosyllabic keywords in utterance-medial keyword series. In each cell, the results of By-Subjects analyses are on the left and the results of By-Items analyses are in parentheses on the right. The data-sets used are described in the tables of mean duration in Section 4.9.1. NS = not significant, thus $p > .05$.

	Degrees of freedom		F Ratio		Significance level	
<i>Right-headed</i>						
Onset	1,5	(1,7)	21.25	(50.07)	p < .01	(p < .001)
Nucleus	1,5	(1,7)	12.67	(24.12)	p < .05	(p < .005)
Coda	1,5	(1,6)	14.70	(8.81)	p < .05	(p < .05)
<i>Left-headed</i>						
Onset	1,5	(1,7.5)	10.37	(340.53)	p < .05	(p < .001)
Nucleus	1,5.1	(1,7.1)	4.90	(6.39)	p = .077	(p < .05)
Coda	1,5.2	(1,3)	7.68	(11.39)	p < .05	(p < .05)

Table J.2: Results of analyses of variance for the effect of Accent on the duration of sub-syllabic constituents of the test syllable for disyllabic keywords in utterance-medial keyword series. In each cell, the results of By-Subjects analyses are on the left and the results of By-Items analyses are in parentheses on the right. The data-sets used are described in the tables of mean duration in Section 4.9.1. NS = not significant, thus $p > .05$.

	Degrees of freedom		F Ratio		Significance level	
<i>Right-headed</i>						
Onset	1,5	(1,6.1)	6.28	(5.18)	p = .054	(p = .062)
Nucleus	1,5	(1,6)	5.84	(14.55)	p = .060	(p < .01)
Coda	1,5	(1,6)	37.39	(5.84)	p < .005	(p = .052)
<i>Left-headed</i>						
Onset	1,5	(1,7.1)	9.99	(113.90)	p < .05	(p < .001)
Nucleus	1,5	(1,7.1)	5.31	(16.23)	p = .069	(p < .01)
Coda	1,5	(1,3.1)	4.47	(13.93)	p = .088	(p < .05)

Table J.3: Results of analyses of variance for the effect of Accent on the duration of sub-syllabic constituents of the test syllable for trisyllabic keywords in utterance-medial keyword series. In each cell, the results of By Subjects analyses are on the left and the results of By Items analyses are in parentheses on the right. The data-sets used are described in the tables of mean duration in Section 4.9.1. NS = not significant, thus $p > .05$.