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The Status of L in British English Prenuclear Accents

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The aim of this paper is to investigate whether the F0 valleys observed between H* prenuclear accents in British English neutral declaratives are the result of a phonetic transition between F0 peaks or must be specified as a phonological target. The scaling and the alignment of the F0 valleys are examined in 72 declarative sentences, produced by a British English native speaker, which differ in the number of unaccented syllables (or temporal distance) between prenuclear H* accents. If the number of unaccented syllables between accents affects the alignment and the scaling of the F0 dip, then the valley must be interpreted as a phonetic transition; otherwise, it must be specified as a phonological target. The results show that the scaling of the F0 valley is not affected by the number of intervening syllables between accents and that its alignment is stable in time with respect to the preceding H*. Thus, prenuclear F0 valleys are not a mere phonetic transition between H* pitch accents but an intended target which corresponds to the trailing tone of a bitonal accent (i.e. H*+L).

1. Introduction

The aim of this paper is to analyse the status of the F0 valleys produced between H* prenuclear accents in British English neutral declaratives. In particular, we investigate whether the dip observed between the F0 peaks basically responds to a phonetic transition between H* pitch accents or is a phonological target, namely, the leading or the trailing tone of a bitonal accent (i.e. L+H* or H*+L).

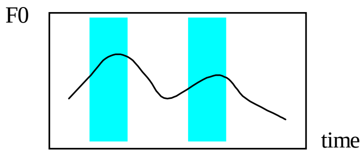
In this paper, the F0 contours of a British English native speaker will be examined within the tenets of the Autosegmental-Metrical (AM) approach of intonational analysis (Pierrehumbert 1980; Beckman and Pierrehumbert 1986; Pierrehumbert and Beckman 1988; Beckman and Hirschberg 1994; Ladd 1992, 1996; among many others). Within the AM approach, pitch patterns consist of a sequence of categorically distinctive entities, associated with elements of the segmental string and with the edges of prosodic domains.[1] The association of these entities with the text is governed by principles of prosodic organisation, according to which either prominent syllables or prosodic edges are possible anchors for phonological events.

There are three kinds of phonological events: the *pitch accents,* which consist of local F0 movements that accompany prominent syllables (stressed syllables), the *phrase accents,*

1. In this paper, the terms “pitch” and “F0” are used interchangeably. Pitch is the perceptual sensation of fundamental frequency (F0), which is the acoustic correlate of vocal fold vibration.

which mark the end of an intermediate phrase, and the *boundary tones,* which signal the end of an Intonational Phrase. The tonal properties of pitch accents, phrase accents and boundary tones are transcribed as H and L, which stand for relatively high and relatively low F0 targets. The rhythmic properties are indicated by assigning an asterisk [*] following the tone that marks a pitch accent, a hyphen [–] after the tone for the phrase accent, and [%] after the tone for the boundary tone. Whereas phrase accents and boundary tones are only monotonal (H-, L-, H%, L%), pitch accents can be both monotonal (H*, L*) and bitonal (L*+H, L+H*, H*+L, H+L*). Bitonal accents can be left-headed or right-headed depending on whether the first or the second element of the accent is associated with the metrically strong syllable. As in monotonal pitch accents, the tone associated with the accented syllable is marked with an asterisk.

Between tonal events, the F0 contour is phonologically unspecified (Pierrehumbert and Beckman 1988). However, the overall contour can be accounted for by phonetic interpolation rules that specify the transition between two tonal values (Pierrehumbert 1980; Ladd 1983b; Grice 1995a). The interpolation between H and L involves a fall and between L and H a rise. Between two Ls the interpolation is level and between two Hs it shows a sag in the F0 contour. An example of the modelling of an F0 trace according to the AM approach is illustrated in Figure 1. The F0 contour shows a rise in the vicinity of the stressed syllables of *married* and *Melanie*. This rise is interpreted as an H* pitch accent associated with the accented syllables. An L- phrase accent and an L% boundary tone account for the falling intonation at the end of the sentence.



He married Melanie
H* H* L-L%

Figure 1: Schematised F0 contour and tonal interpretation for the sentence "He married Melanie." Stressed syllables are underlined. The shaded areas show the limits of the accented syllables.

Most studies on the intonation of declarative sentences in British and American English (Steele and Altom 1986; Silverman and Pierrehumbert 1990; among others) have shown that prenuclear accents involve an F0 rise in the vicinity of the accented syllables. This rising movement has been classified as H*. However, these studies have also shown that at the phonetic level the synchronisation between an F0 feature and a prominent syllable is not always perfect. Sometimes the F0 peak corresponding to the H* pitch accent is not realised within the accented syllable but aligned considerably later. Thus, studies within the AM model have drawn a distinction between *association* and *alignment* (Ladd 1983a, 1996). Whereas association is an abstract structural property, alignment is a phonetic property of the timing of F0 events and segmental events. Studies on the alignment of F0 contours in several languages have argued that the location of peaks in H* pitch accents depends on a number of factors, such as segmental duration, the presence of word or phrase boundaries, and stress clash contexts, among others. F0 peaks are more delayed as the duration of the accented syllable increases and retracted when adjacent to word, intermediate phrase or Intonation Phrase boundaries and in stress clash contexts.

Despite the large amount of work devoted to the alignment of H* prenuclear accents in English and in many other languages (see Prieto, et al. 1994, 1995 for Mexican Spanish), little research has been devoted to the analysis of the F0 valleys observed between peaks. The F0 contours of neutral declarative sentences in English show a decrease in F0 between H* pitch accents. However, the nature of such valleys remains uncertain. In this paper, we seek to investigate whether the F0 dips observed between H* pitch accents are a phonetic effect or a phonological entity; in other words, whether they are the result of a transition between peaks or an intended low target. In order to clarify the status of F0 valleys in prenuclear accents, we will examine the scaling and the alignment of the valleys in sentences where prenuclear H* accents are separated with a different number of syllables. The predictions are as follows: if the number of unaccented syllables between H* accents affects the alignment and the scaling of an F0 valley, then the dip is the result of a phonetic transition (i.e. the higher the number of syllables, the later and lower the dip). If on the contrary, the F0 valley is fixed in time and F0 irrespective of the number of unaccented syllables, then the dip has to be interpreted as an L tonal target, which could be the leading or the trailing tone of a bitonal accent (L+H* or H*+L). Grice (1995b) has shown that leading and trailing tones are fixed in time with respect to the starred one.

2. Experimental design

In order to investigate the status of F0 valleys in prenuclear accents, 72 declarative sentences were designed. The data consisted of Subject-Verb-Object structures produced with a neutral or unmarked intonation. The number of stresses per sentence varied between 3 and 4. Thus, the number of prenuclear stresses varied between 2 and 3. Longer sentences were not included to avoid the division of utterances into more than one Intonation Phrase. The number of unstressed syllables between stresses varied between 1 and 3. However, as we will see in section 4, since the speaker did not accentuate all stressed syllables, the number of unaccented syllables between accents reached 8 in certain cases.[2] Sentences were designed with the maximum number of voiced segments possible to avoid interrupted F0 contours. See the Appendix at the end of the paper for the list of sentences.

The sentences were produced by a 30 year-old-female speaker of a Southern (London) variety of British English. At the time of the recording, the speaker was following postgraduate studies in linguistics at University College, London. The speaker will be identified as KF in the following sections. The sentences were gathered by means of a reading activity. The speaker was given a list of structures and was asked to read them in a neutral way, as if they were answers to the question "What happens?"

2. Most literature on English intonation (O'Connor and Arnold 1973; Couper-Kuhlen 1986; Cruttenden 1986; Ladd 1996) differenciates between stressed and accented syllables. A stressed syllable is a syllable which is rhythmically prominent. All stressed syllables can get a pitch accent and hence become accented. However, the presence of this accent is optional.

The data were recorded in the anechoic room of the Department of Phonetics and Linguistics of University College, London. For each sentence, speech and laryngeal (Lx) signals were obtained. Speech was recorded with a B&K sound level meter of the type 2231, which was fitted with a 4165 microphone. The microphone was placed at about twenty centimetres from the speaker. The laryngeal signal was obtained by means of a laryngograph processor. The laryngograph is an apparatus used to record vocal fold vibration. It operates by passing a weak electric current between a pair of electrodes placed in contact with the skin on both sides of the larynx. The variation of electrical impedance produced by the vibration of the vocal folds is measured by the device. Thus, the output of the device is a signal analogous to the degree of vocal fold contact at a given instant. This waveform of impedance against time is known as Lx. Lx may be further processed to derive information about the duration of the period of vocal fold vibration (Tx) and to measure instantaneous fundamental frequency (F0). A Thandar portable DRO 26 oscilloscope was also used to check the activity of the vocal folds. Both speech and Lx signals were recorded on a Sony 1000 ES DAT recorder.

3. Analysis of the data

Auditory and acoustic analyses of the data were performed. The acoustic analysis of the data was done by means of the Speech Filing System (SFS) program, which allowed us to obtain F0 traces from the laryngeal signal and perform a time-aligned inspection of the speech waveform and the F0 trace. The speech and laryngeal signals obtained in the recordings were played on a Sony 1000 ES DAT recorder and transferred to a Sun Sparc-10 computer in which SFS ran. Acquisition of the signals was done at a 16 KHz sampling rate, following the routines of the program. An anti-aliasing filter set at a 6.4 KHz cut-off point was used to prevent signals half above the sampling rate from being acquired. F0 traces were obtained from the laryngeal signal by means of the VTX and FX programs. VTX converted the laryngeal waveform (Lx) into excitation period measurements (Tx). FX converted excitation period measurements into F0 traces.

Figure 2 below illustrates the SFS display screen for the sentence *Amelia married a marine.* The top screen displays the speech waveform and the middle screen shows the F0 contour. Finally, the last screen is used to annotate relevant points in the utterance. For each sentence, the beginning of each syllable is marked with a vertical line so as to see the synchronisation between the segmental string and the F0 movements.

4. Results

As expected, the F0 traces of English declaratives produced with a neutral reading showed an F0 rise in the vicinity of the accented syllables both in prenuclear and in nuclear positions, followed by a fall over the postaccented syllables. Not all stressed syllables became accented. The first and last stressed syllables were always accented and medial stressed syllables were more likely not to have an accent. This implies that utterances with three stresses tended to have two pitch accents and those with four stresses generally had three pitch accents (the second stress did not become accented). Sentences were uttered with no evident prosodic breaks.

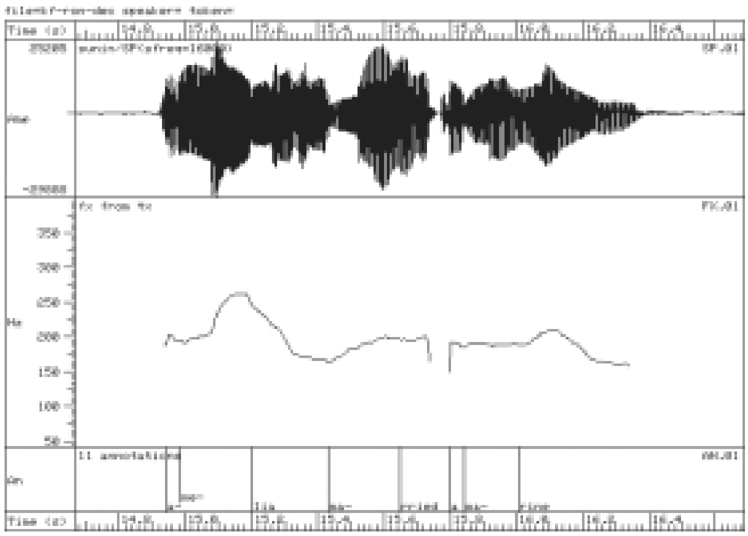


Figure 2: Speech waveform and F0 contour for the sentence
"Amelia married a marine."

A closer look at prenuclear accents showed that the F0 peak tends to be aligned near the end of the accented syllable. The location of the peak tends not to exceed (or exceeds by very little) the right-hand boundary of the accented syllable. Between peaks the F0 contour descends into a dip. The phonological interpretation of this rise-fall F0 movement clearly involves an H* tone associated with the accented syllable, since the F0 peak is unequivocally positioned within (or very close to) the limits of the accented syllable. However, the status of the surrounding valleys is not clear. Basically, is the F0 dip a mere phonetic transition between peaks or is it specified as a tonal target? And if so, is the L a leading or a trailing tone of the starred H (i.e. L+H* or H*+L)?

In order to decide whether the F0 dip observed between peaks is basically due to a phonetic transition or is actually an intended tonal target, the scaling and alignment of the valley in prenuclear accents were analysed in more detail. The parameter used to investigate the status of the F0 dip was the number of unaccented syllables (or temporal distance) between accents. This parameter has been used cross-linguistically (English: Pierrehumbert 1980; Greek: Arvaniti and Ladd 1995, Arvaniti, et al. 1998; or Neapolitan Italian: D'Imperio 1999; among others) to clarify the tonal status of particular F0 turning points. The rationale proposed in these studies is that if the number of unaccented syllables between accents affects the alignment and the scaling of an F0 valley, then the dip is the result of a phonetic transition (i.e. the higher the number of syllables, the later and lower dip). If on the contrary, the F0 valley is fixed in time and F0 irrespective of the number of unaccented syllables, then the dip has to be interpreted as an L tonal target.

According to these statements, the following predictions can be made. If prenuclear accents correspond to H*, 1) the F0 dip between peaks should fall gradually until just before the second H* at which point the F0 rises abruptly, and 2) the F0 dip should become deeper as the temporal distance between peaks (or the number of intervening syllables) increases. If prenuclear accents are H*+L, the valley is expected to have a rather constant F0 value irrespective of the number of intervening syllables between peaks and the L is also expected to be fixed in time with respect to the *preceding* H*. If prenuclear accents are L+H*, the L has to have a constant F0 value and has to be aligned at a fixed position with respect to the *following* H* (Grice 1995b).

Before analysing the scaling and alignment of L values, it was considered necessary to confirm the fact that an increase in the number of syllables does correspond to an increase in temporal distance. Thus, productions were divided into three sets of data according to the number of intervening syllables between accents: (I) 1–2 syllables (29 observations), (II) 3–4 syllables (39 observations), and (III) 5–8 syllables (18 observations).[3] For each set, the duration of the segmental material between accents was measured. The mean duration of the three sets of unaccented syllables is displayed in Table 1. As expected, an increase in the number of unaccented syllables or segmental material between accents corresponds to an increase in the temporal distance.

	Number of unaccented syllables		
	1–2	*3–4*	*5–8*
Mean duration(s)	0.482	0.766	1.026

Table 1: Mean duration of various numbers of unaccented syllables between accents

Given these results, the first step was to analyse the scaling of the F0 dip. F0 values were obtained for all valleys (or lowest F0 point between peaks) for the three sets of data (1–2, 3–4, and 5–8 unaccented syllables). Figure 3 plots the mean values and the standard

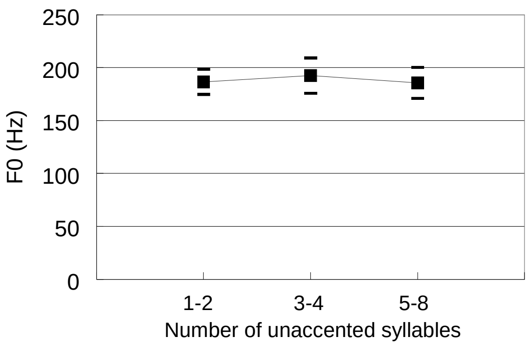


Figure 3: Mean values and standard deviations for the scaling of L as a function of the number of unaccented syllables between accents

3. If the speaker had accented all stressed syllables, the number of unaccented syllables between accents would have varied between 1 and 3, since there were no more than 3 unstressed syllables between stresses. However, since in several cases the speaker did not accentuate all stressed syllables, then the number of unaccented syllables between accents increased up to 8.

deviations for the scaling of L as a function of the number of unaccented syllables between accents. The results suggest a rather fixed scaling of the L value, since the F0 dip does not increase as the number of intervening syllables increases. The data were analysed statistically using an analysis of variance in which the independent variable was the number of unaccented syllables. Setting the *p* value at 0.01, the statistical analysis confirms that the number of intervening syllables between accents does not significantly affect the scaling of L (p=0.16, F=1.83). See Table 2 for further details on the statistical analysis.

Number of unaccented syllables	*1–2*	*3–4*	*5–8*
Mean F0 values of L (Hz)	186.7	193.4	185.6
Variance	142.7	279.9	213.8
ANOVA	p = 0.16 F = 1.83		

Table 2: Statistical results of the analysis of variance for the scaling of L as a function of the number of unaccented syllables between accents

These findings indicate that the L value is not the result of a phonetic transition but seems to be specified as a phonological target. Thus, the possibility of analysing prenuclear accents as monotonal accents (H*) is ruled out by the scaling evidence. Next, the status of L as a leading tone (L+H*) or as a trailing tone (H*+L) is examined according to the alignment evidence. As stated before, 1) if L is part of H*+L, its location has to be fixed with respect to the preceding H*, and 2) if L is part of L+H*, its location has to be fixed with respect to the following H*. This is schematised in Figure 4, where the shaded areas correspond to the accented syllables (H*) and the white areas show an increase in the number of unaccented syllables between accents.

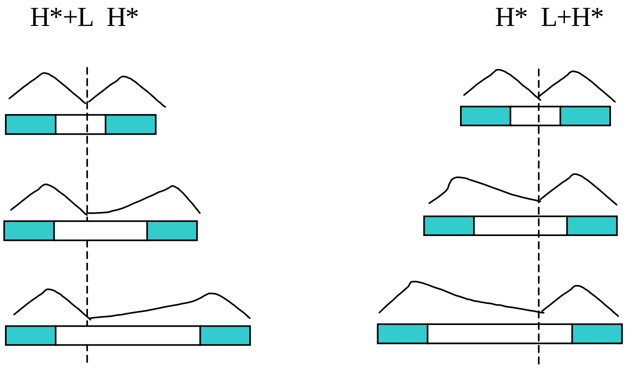


Figure 4: Schematised differences in the alignment of L in H*+L H* and H* L+H* sequences. Shaded areas correspond to accented syllables and white areas to unaccented syllables

Figure 5 below plots the mean values for the following measurements: (1) duration between the onset of the first H* and L (on1-valley), and (2) duration between L and the onset of the second H* (valley-on2) as a function of the number of unaccented syllables between accents. The results show that the L is located at a fixed position from the onset of the first accent and varies from the onset of the second accent. In other words, whereas the mean duration of distance “on1-valley” is very stable, the mean duration of the distance “valley-on2” alters according to the amount of segmental material. In order to confirm that the alignment of the L was fixed in time with respect to the previous H* and that the number of unaccented syllables had no effect on its location, an analysis of variance was performed for the “on1-valley” sample. The statistical results confirmed that the number of unaccented syllables does not have an effect on the alignment of the F0 valley (p=0.079, F=2.6). See Table 3 for further details on the statistical analysis. Thus, the location of the L is stable in time with respect to the preceding H* and hence, the phonological entity that better describes prenuclear accents in the data is H*+L.

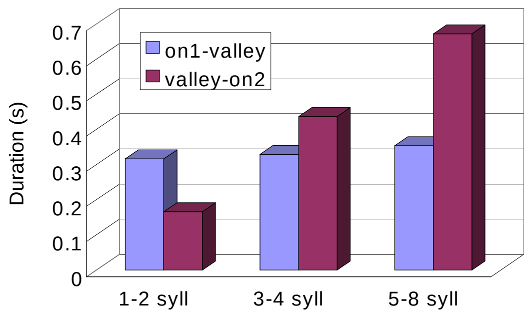


Figure 5: Mean values for the duration between the onset of the first accent and L (on1-valley) and for the duration between L and the onset of the second accent (valley-on2) as a function of the number of unaccented syllables between accents

Number of unaccented syllables	*1–2*	*3–4*	*5–8*
Mean duration “on1-valley”(s)	0.316	0.329	0.354
Variance	0.004	0.002	0.002
ANOVA	p = 0.079	F = 2.6	

Table 3: Statistical results of the analysis of variance for the duration “on1-valley” as a function of the number of unaccented syllables between accents

5. Discussion

The results on the scaling and alignment of the F0 valley in English prenuclear accents of neutral declaratives suggest that the L is phonologically specified as the trailing tone of a bitonal accent (H*+L), since the L has a stable F0 and is fixed in time with respect to the starred tone. This analysis is at odds with the initial versions of the AM model. In Pierrehumbert (1980) or Beckman and Pierrehumbert (1986), H*+L could not be applied to these kinds of F0 movements since this accent type was only used in downstepping sequences.

Downstep is a phenomenon which involves a linguistically controlled lowering of consecutive H tones. It has been observed cross-linguistically that the F0 tends to gradually lower over the course of an utterance (Ladd 1983b; Nolan 1995). Some studies propose that this lowering is a global component that affects the whole phrase or utterance

(Liberman 1975; Bruce 1977; Fujisaki 1983, 1988; Thorsen 1980; among others). However, within the AM model, pitch downtrends are analysed as a linguistically controlled mechanism, which involves a deliberate use of step accents, since it has been observed that an F0 peak in a descending contour could be expressed as a constant proportion of the previous peak (Pierrehumbert 1980; Liberman and Pierrehumbert 1984; Prieto et al. 1996; Möbius 1993).

The phonological characterisation of downstepping contours varies in the literature. Pierrehumbert (1980) proposes that downstep is triggered by the presence of certain sequences of tones which involve an L flanked by two Hs. Thus, for example, in the sequence H*+L H*, the second H* will be downstepped due to the preceding L tone. This means that the L has no manifestation in the F0 contour, but only has the effect of lowering the following H tone. If the tonal entity H*+L is used to indicate downstep of the following H tone, then it cannot be used to describe the data presented in this paper since we need an entity which specifies the presence of the low target. This problem, however, can be sorted out if we adopt a different interpretation of downstep.

Further research on downstep has shown that this phenomenon is not the result of bitonality but it is a property of the lowered tone itself (Ladd 1983b, 1996; Beckman and Hirschberg 1994; Pitrelli et al 1994; Grice 1995a; Grabe 1998). These studies argue that downstep is an independent intonational choice which has nothing to do with the tonal sequence. Thus, the sequence H*+L H* is transcribed H* !H*, where ! indicates [+ downstep]. With this reinterpretation of downstep, H*+L can legitimately be used to describe a fall, like that observed in the data.

The interpretation of the pitch movements observed in the data as H*+L agrees with those analyses that describe English F0 contours by means of left-headed accents (Gussenhoven 1984; Grabe 1998). In these studies, only two pitch accents (H*+L and L*+H) are taken as basic tones and all the other pitch patterns are derived from them by means of a set of phonological adjustment rules. In our data, the L*+H entity was not observed since the utterances examined in this paper were only produced with a neutral declarative intonation. However, the results concerning the stability in the alignment and in the scaling of L provide empirical support for a left-headed analysis of intonation.

6. Conclusion

In this paper, the nature of F0 valleys produced between prenuclear F0 peaks in British English declarative sentences has been analysed for one speaker following the tenets of the AM approach of intonational analysis. The scaling and the alignment of F0 valleys were examined in sentences with a different number of unaccented syllables between prenuclear F0 peaks. The results showed that the number of unaccented syllables had no effect on the scaling of the F0 dip. Furthermore, its alignment was fixed in time with respect to the previous H*, indicating that prenuclear accents in British English neutral declaratives must be interpreted as a bitonal accent (H*+L) which includes both an H and an L target rather than an H tone alone. These results support those studies that propose a left-headed account of pitch accents.

Appendix

List of sentences

Jo relies on my money
Ray resigned from his job
The law has to be modified
The meal was absolutely delicious
Mary learns modern languages
Molly made a marvellous dinner
The lawyer's reading the journal
The lady ordered an orange juice
Melanie will win the award
Marjorie married an Indian marine
Marilyn nurses the baby
The melody was amazing
The marmalade is on the fridge
The boys need a new game
Norma runs every morning
Marjorie adores movies
The girls believe in fairies
My neighbour married the model
Melanie ordered an orange juice
Ron amended the bill
Jonathan erases the message
Grandma's ironing the linen
The rain damages the harvest
Jeremy manages his company
Julie memorised the names
Ron's paying bills
Jeremy's wearing jeans
Amelia married a marine
The bluebells die with the rain
My mother loves babies
The lady's wearing diamonds
Gary borrowed the money
The general murdered the villain
Jimmy loves gardening
The barber adores Marilyn
Mary learns languages
Lee remembered the melody
John divided the legacy
The balloon was moving upwards
The name was written at the door
Millie lives in Ireland
Mini loves lemon marmalade
My mother loves babies
The nanny's ironing the linen
Marjorie married an Indian marine
Emily damaged the window
The gardener used to live in London
The lullaby brings good memories
The gardener mows the lawn
The bluebells die with the rain
Brenda removes the garbage
Josephine needed an explanation
The jam remained in the jar
The general murdered the villain
My brother remembers the rhymes
The boy delivered the magazines
Melanie's menacing the hostages
The journalist balances the disorder
The minister moderates the audience
John normalised the numbers
The journalist's ordering wine
Marilyn's boiling eggs
The nominee won the award
The jam remained in the jar
Nelly adores movies
John married Mary
The nanny sings a lullaby
The nanny's ironing the linen
John married Melanie
The lady ordered the marmalade
The boy delivered the magazines
The minister remembers the melody

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