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POSITIONAL DETERMINATION OF THE QUALITY OF SCHWA IN ENGLISH

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The prototypical articulatory-acoustic properties of schwa being normally thought of as definitional, this vowel sound is typically described in terms of tongue position as a mid-central, neutral vowel sound. At the same time, instrumental analysis shows that schwa in English is context-driven to a much larger extent than any other vowel; articulatorily, it is in fact “inherently unspecified for tongue position”, and acoustically, a comparison of the experimental data with this first approximation model does not show a good agreement, hence the interest of a systematic contextual study of schwa.

Keywords: acoustic phonetics, schwa vowel, context-driven quality

The prototypical articulatory-acoustic properties of schwa being normally thought of as definitional, this vowel sound (occurring in unstressed syllables in English) is typically described in terms of tongue position as a mid-central, neutral vowel sound, corresponding to “the single uniform tube acoustic model of the vocal tract” (Rosner & Pickering 1994: 34). At the same time, instrumental analysis shows that schwa in English is context-driven – much more than any other vowel –, to the extent of being considered by some, articulatorily, as “inherently unspecified for tongue position” (Bates 1995: 266–267). Not surprisingly, therefore, the experimental acoustic data are hardly in line with such a simple first approximation assumption of constant phonetic features, hence the interest of a systematic contextual study of schwa. Furthermore, like other monophthongs, more or less gliding in English – and unlike in French, for example, in which “each oral vowel can be fully specified by a single spectrum” (Vaissière 2007: 59) –, schwa retains rather rarely the same quality throughout its duration (which is explainable by its relatively low, only occasional informative value¹, related to the prosodic features in short unstressed syllables): thus the spectral variability of this [ə] vowel manifests itself both as a discrete (contextual-dependent) and continuous (time-dependent or dynamic) phenomenon, and hence readily describable in the F2/F1 acoustic plane using the software tool *SaRP*.

Observing the patterns of the positionally determined variability of this vowel was indeed greatly facilitated in this study by the use of a new software tool called *SaRP* – *Speech Analyzer Rapid Plot* (<http://web.uni-plovdiv.bg/rousni/sarp/>). This add-on for *Speech Analyzer* was designed in view of the frequent need of language researchers and students for accessing, collecting, manipulating and representing acoustic data, in particular in order to create vowel charts. F2/F1 vowel space mapping is essential for the acoustic description of the vowel system of any language. Vowel plots for a given language or dialect (or individual speaker) being easily interpretable in terms of articulatory characteristics, these graphical representations are also valuable in the field of language teaching, learning and assessment or self-assessment. The *SaRP* tool, which is an extension to the programme *Speech Analyzer* version 3 or later, (<http://www.sil.org/computing/sa/index.htm>) allows creating informative charts in an easy and interactive manner.

¹ For example in *accept*, by opposition with *except*.

As far as vowel quality is concerned, which is represented well enough for our purpose by F1/F2 measurements, the contextual dispersion of schwa is, in fact, so severe and pervasive that one may even think of a “vowel triangle” formed by joining the extreme peripheral markers’ positions in a scatter chart built from a set of schwa realisations plotted on the F2/F1 vowel space (see Fig. 1). This term of *vowel triangle* relates here to the notion of dispersion, in contrast with the well-known inter-vowel triangle or quadrilateral. Conceptually, shape and area of such a triangle may be relevant as parameters, evaluating among others, the degree and nature of coarticulation for particular speech styles.

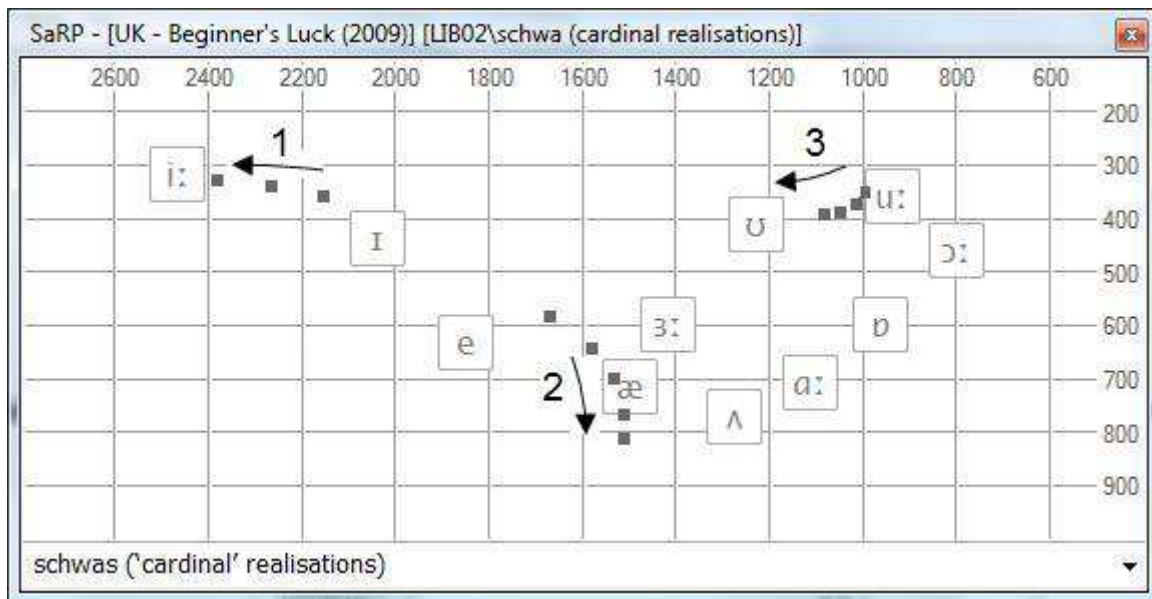


Fig. 1: Markers 1, 2 and 3 refer to three vocalic samples from an audio text (*Beginner's Luck* by Chris Rose, British Council Podcasts²) read by a native speaker of Standard Southern British English

- 1 – *This gave the boy so much pleasure that a few days later he tried exactly the same trick again*
- 2 – *ten minutes later*
- 3 – *the motto of the organisation*

Such a large dispersion – symbolised here by a sort of uni-vowel triangle which is commensurable with the cardinal vowels diagram – is only partially due to inter-speaker variability. Our systematic instrumental observations of schwa productions by native speakers of Standard Southern British English (carried out so far for about ten different male natives, all of them speakers on the BBC) indicate that the acoustic, and therefore articulatory nature of this so-called “neutral vowel [which] can be considered as a kind of homebase to which the tongue returns frequently in the course of speech” (Kühnert & Fougeron 2004: 1) is rather governed by a double functional principle: the *principle of economy*: “languages tend to get rid of anything that is superfluous”, and the *principle of emphasis*: “languages tend to stress or exaggerate anything that is necessary” (Passy 1891 : 227). Paul Boersma disentangles Passy’s two principles into “a more fundamental speaker-oriented principle of minimization of articulatory effort and an equally basic listener-oriented principle of

² <<http://www.britishcouncil.org/learnenglish-podcasts-stories-beginners-luck.htm>>

minimization of perceptual confusion” (Boersma 1998: 2). Since a particular contextual condition favours the one or the other tendency, this especially flexible vowel is often produced with spectral characteristics more or less close to those of some non-neutral vowel. In view of this, acoustic data don’t support the conception – such as that put forward by Kühnert & Fougeron (2004) – that the centrality of schwa is a most relevant feature. Figure 2 visualises a “schwa-triangle” established by plotting, in the F2/F1 vowel space, all three occurrences of schwa in the utterance *If you keep him talking, I’ll go on his computer and get rid of it.*

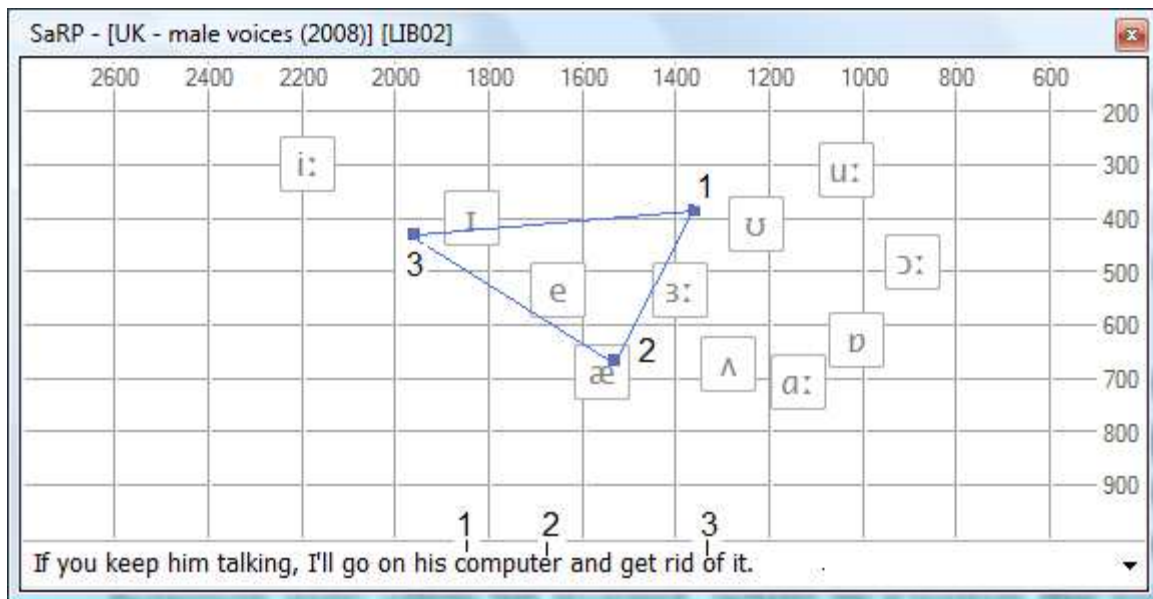


Fig. 2: A vowel triangle formed by joining the positions of the three schwa-productions in the utterance *If you keep him talking, I’ll go on his computer and get rid of it.*, and showing that the centrality of schwa is only a theoretical constant.

In Fig.2, the position of the marker 3 (the /ə/ in *rid of it*) is obviously inadequate when compared with that of the labelled marker /I/, which is due to the fact that the labelled markers here correspond to another speaker’s “canonical” pronunciation of the vowels. Knowing this, the background vowel chart must only be viewed as a rough reference. What is relevant here is the relative (and rather extreme) positions of the schwa vowels in the same utterance, giving a good representation of observed patterns of phonetic variability of this phoneme.

According to Barry Heselwood (Heselwood 2007: 148), “two types of function are identified for schwa: anaptyctic (e.g. *today, abbot*), and positional (e.g. *support, lotus*) [in opposition to *sport* and *lotes*, respectively]” In the word *computer*, the first occurrence of schwa is anaptyctic and the second positional since a consonant sequence such as /k_mmp/ is unpronounceable and therefore needs the insertion of a support vowel (a manifestation of the phenomena of epenthesis), whereas the final vowel segment in *computer* (this word is followed here by a pause) functions, phonologically, as a distinctive segment (in opposition to the constitutive function of a segment) by virtue of the opposition segment position / empty position. The last schwa (... *and get rid of it*) is also anaptyctic, since it is inserted into

the sequence as a vowel sound, qualitatively assimilated to neighbouring sounds and for that reason different from theoretical canonical schwa, mainly in order to facilitate pronunciation.

The phonological distinction between *anaptyctic* and *positional* schwas could be usefully transposed to the study of the positionally determined articulatory and acoustic features of this vowel, in so far as, logically, anaptyctic schwas are expected to be influenced by the phonetic context to a more considerable extent than positional schwas, all other things being equal. The vowel quality (and quantity) of a positional schwa should tend, in general, to be syntagmatically more contrastive. In our example (*I'll go on his computer # and...*), schwa is quite open, long and intense (i.e. typically vocalic) and the following long pause eliminates the possibility to explain it only by reference to the following vowel in the word *and*. We rather think that the influence is progressive; here it is not a matter of vowel harmony, but inversely of an emphasis of the contrast between the two contiguous vowels, as shown in the Fig. 3.

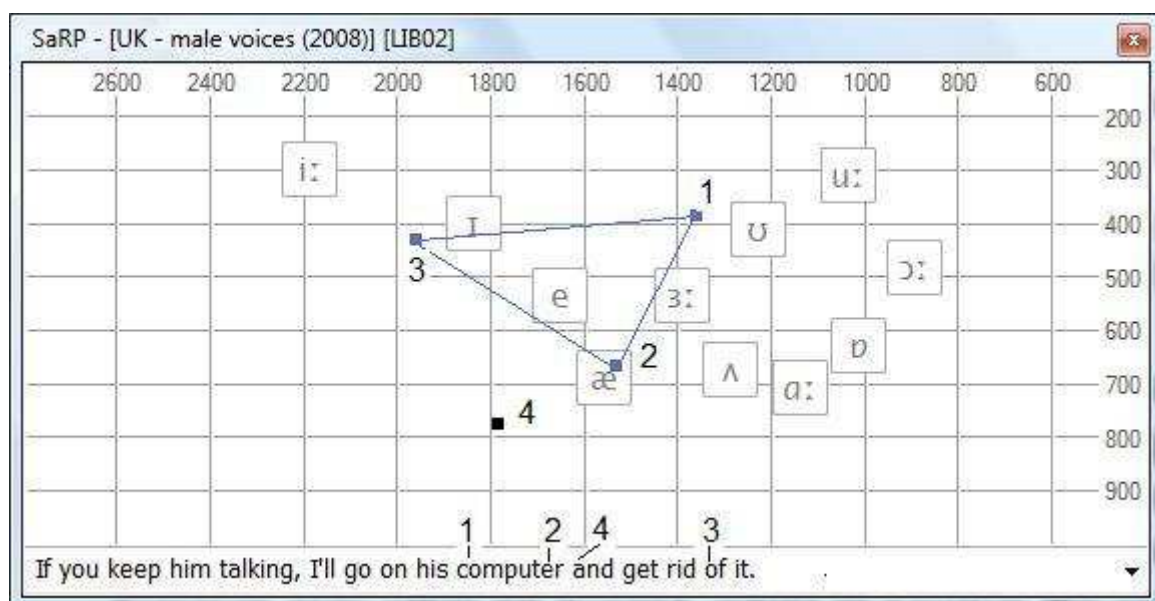


Fig. 3: The “positional”, distinctive schwa in *computer* (marker 2), coinciding with the prototypical /æ/, versus the following emphasised /æ/ (marker 4) in the word *and*.

Fig.3 shows in a condensed form the results obtained in our experiments³. One can see that substantial variation occurs in the F1 and F2 values of the so-called mid central vowel in English. These results confirm in a tangible way the well-known (but nonetheless arguable) ‘targetlessness’ of schwa: theoretically, “schwa does have a target lingual gesture but it can be completely overridden by the gestures of neighbouring segments.” (Browman & Goldstein 1992: 26) What is not confirmed, on the other hand, is our hypothesis that a distinctive schwa may resist coarticulation better than a constitutive (or support) schwa. Thus, the sequence of two grammatical words *and*, at the same time, minimal pair ‘*in an*’ (*Mark wrote bad things about Peter in an email*) presents a curious pronunciation “inversion” (undoubtedly due to the gestures of neighbouring segments), since the two consecutive vowels /I/ and /ə/ are respectively produced as /ə/ and /I/ (see Fig. 4). It is clear that exploiting global high level pragmatic, semantic and syntactic information contributes more

³ Being an integral part of the *SaRP* data, the entire sound library named *UK - schwa*, with multiple sound collections, is downloadable therefore all acoustic analyses are reproducible.

than exploiting low level spectral contrasts between /ə/ and any other vowel in English to enhance speech comprehension, a nice example of top-down information process.

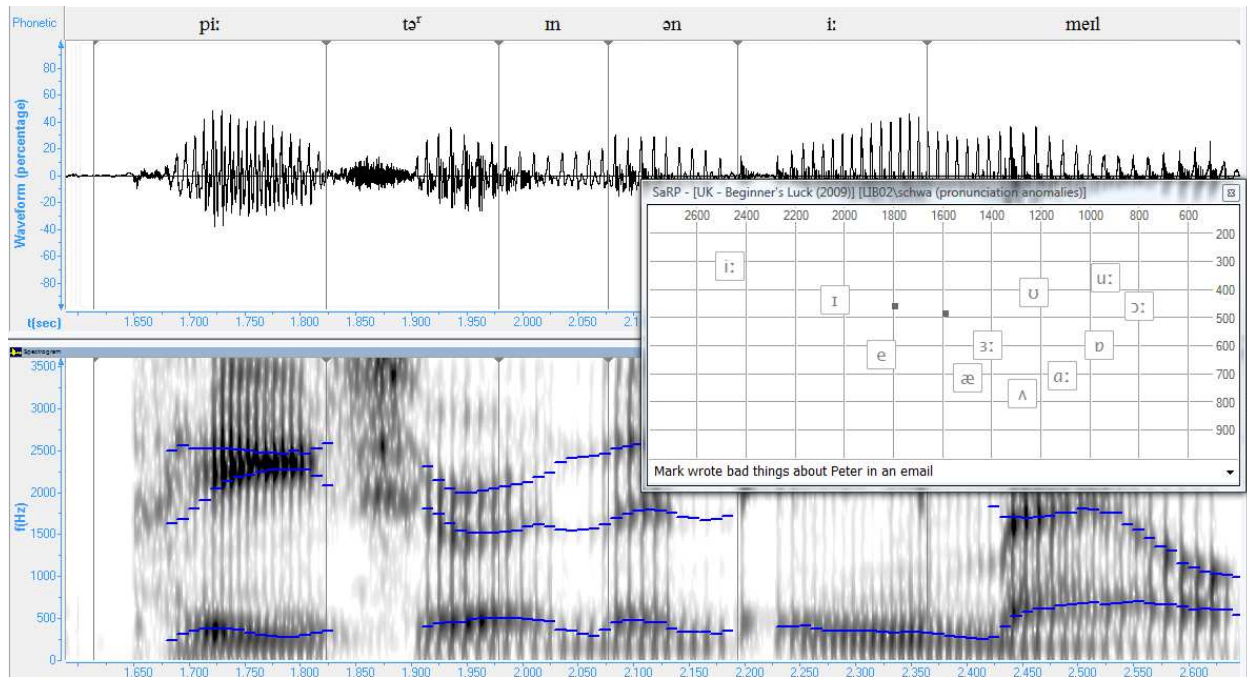


Fig. 4: The two consecutive vowels /ɪ/ and /ə/ in the sequence ‘in an’ are respectively produced as /ə/ and /ɪ/.

Contextual factors in schwa productions do not limit themselves to *the gestures of neighbouring segments*, but the following point of view is even more reductive: “The actual least-effort position of the jaw and other articulators will depend on the neighbouring consonants, so that the actual realization of the reduced vowel varies according to the phonetic context” (Boersma 1998: 215). In fact, the actual realisation of schwa also depends on the prosody of the sentence and, through vowel harmony, on the neighbouring vowels. Finally, with respect to inter-speaker variability, positional determination of the quality of schwa for each individual speaker should be studied by reference to the vowel quadrilateral of the same speaker. It’s because “a listener relates every vowel he hears to what he has perceived as the speaker’s personal range of vowel variation, rather than to any absolute formant values”⁴.

From this perspective, it is necessary to have a convenient software tool at hand that is capable of reliably retrieving and efficiently managing formant values for vowels in large corpus of linguistic data. Thus, for each short audio text used to retrieve and represent

⁴ <<http://www.phon.ucl.ac.uk/home/wells/formants/preldis.htm>> Wells wrote in, *A study of the formants of the pure vowels of British English* “...it seems to have been conclusively shown by Ladefoged and Broadbent [26] that a listener relates every vowel he hears to what he has perceived as the speaker’s personal range of vowel variation, rather than to any absolute formant values. An /e/ is identified as such not because of a particular ratio of F1 to F2 or of mel-scale F1/F3 to F2/F3, but because its formants lie at a particular point in the interval between the observed values of the extremes manifested in /i/ and /A/. This is only to be expected in view of the fact that it is a linguistic activity that is under investigation, and all linguistic activities are relative rather than absolute.”

acoustic data about particular vowel productions, the analysis is done by referring the measurement results to a vowel chart established ad hoc – on the same basis: same text and same speaker) – as an idiolectal model describing, numerically and graphically, “the speaker’s personal range of vowel variation”. Our software tool *SaRP* (developed in LAPS Scientific Team in collaboration with the University of Plovdiv and described in greater detail in Nikolov, Dommergues & Ryst 2007: 88–95) allows managing an unlimited number of sound libraries and sound collections of analysed speech utterances, as well as an unlimited number of (easy editable) vowel quadrilaterals: vowel charts established each of them as a set of reference vowels.

Fig. 5 shows the F2/F1 set of marks of all the twelve schwa productions for a same speaker and a same word (*computer*, a statistical key word) in a same audio text (*Beginner’s Luck* by Chris Rose, British Council Podcasts⁵).

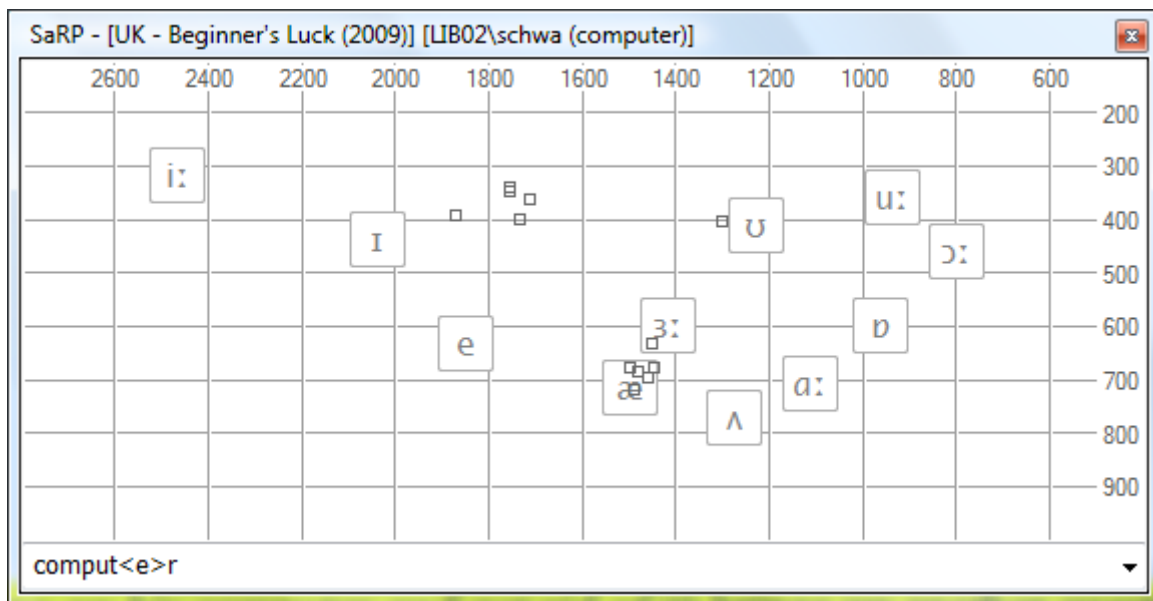


Fig. 5: The F2/F1 set of marks for the second /ə/ in *computer* – twelve tokens

At the end of an intonation unit (i.e. before a pause, including a psychological one, where delimitation is only based on prosodic and/or spectral contrasts), schwa tends to be pronounced rather as a *near-open front* vowel, to such an extent that it practically coincides with the canonical pronunciation of /æ/ for the same speaker. These conclusions are confirmed as well, in the same text and the same phonetic contexts, by the multiple instances of /ə/ in lexical words such as *liar*, *later*, *after*, *burger*, *either*, *Milner*, *brother*, etc. By analogy with the so-called target-undershoot model, we may speak here of an articulatory overshoot in such contexts.

Conversely, one can see Fig. 5 that inside expressions or phrases such as *computer screen*, *computer terminal* and *the computer in front of him*, schwa behaviour at end of word does not significantly differ from that in middle of word. Variability of schwa in middle of word mainly concerns the vowel aperture and, in consequence, the F2 value. The average

⁵ Ladefoged & Broadbent 1975. *Information carried by vowel*, Journal of the Acoustical Society of America, 29, pp. 98-104)

second formant frequency then depends progressively and/or regressively on the neighbouring vowels (as in the previous examples: *a few days later he...*, *the motto of the organisation*, *get rid of it*) or the neighbouring consonants (as in *computer screen* and *computer terminal*, with a rather front vowel, in contrast with *the computer in front of him*, with a rather back vowel). Schwa is rather back when followed by nasal consonants /m/ or /n/, apart from consonant /r/.

Often enough, particular realisations of schwa (especially its quality) will adapt and vary under consonantal influence throughout its duration, as is the case with the first /ə/ in the word *computer* under consideration here (see Fig. 6).

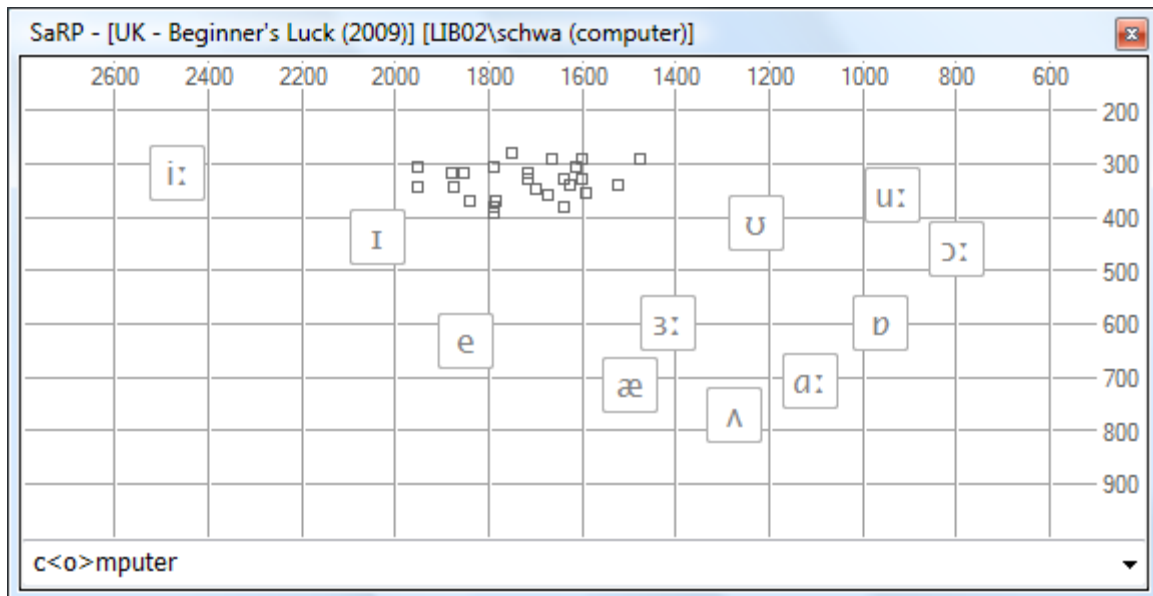


Fig. 6: The F2/F1 set of marks for the first /ə/ in *computer* – 12 tokens x 2 measurements

The first /ə/ in *computer* adapts itself to the following consonant /m/ by a falling transition of the F2 from a mean frequency of 1900 Hz to a frequency of 1400 Hz, the latter being characteristic of /m/ as defining one of the power consonant frequency ranges (by analogy with vowel formants). The transitional nature of interconsonantal schwa is best shown in Fig. 7.

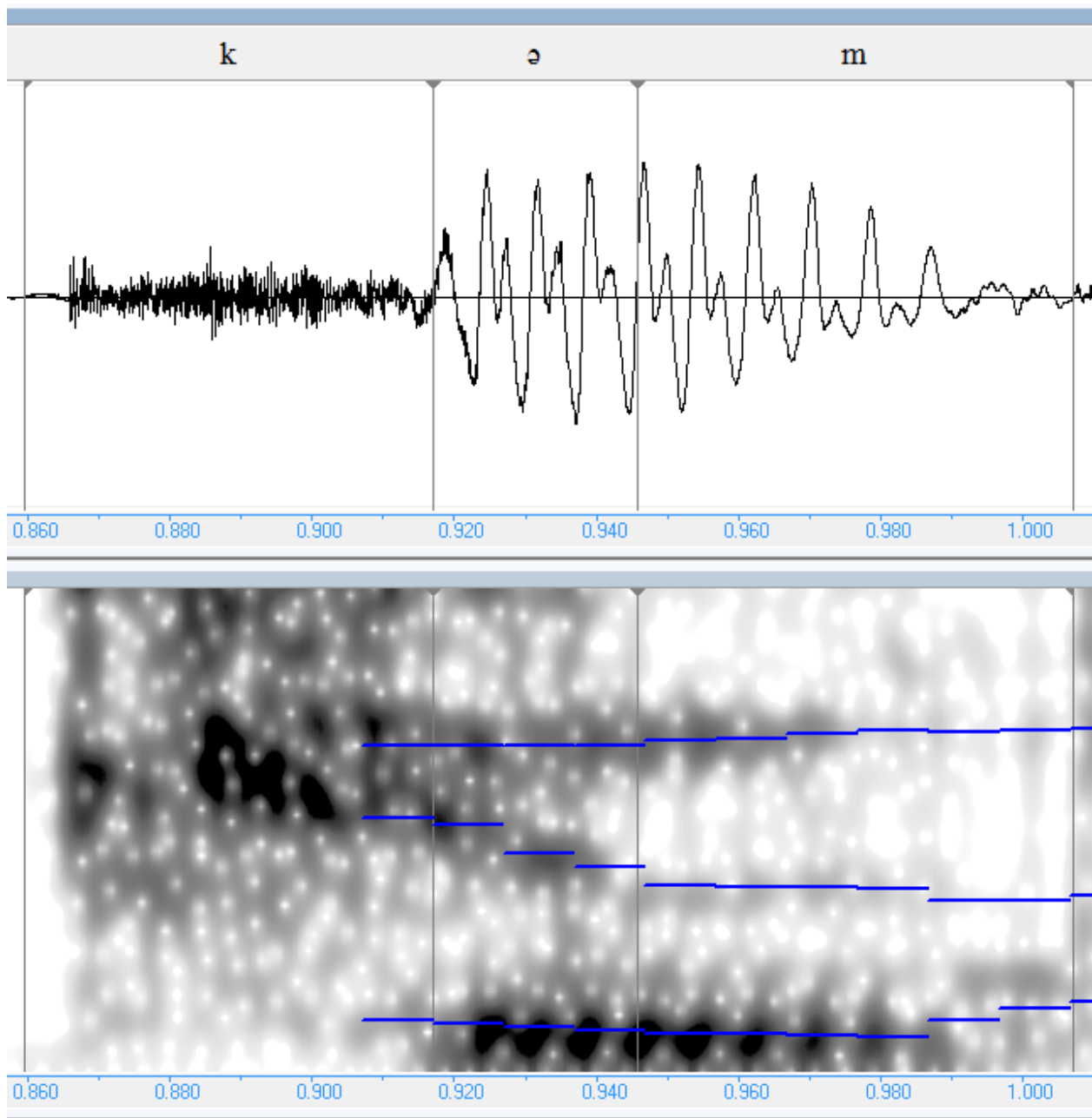


Fig. 7: The transitional nature of F2 formant tracks for the first syllable in *computer* (*James looked to the computer screen in front of him*) – .

Following Catford (Catford 1985: 340) and Messum (Messum 2002: 24), interconsonantal schwa can be labelled “an ‘open transition’ between the two consonants involved, meaning that the first consonant is produced and that when this is complete we follow it with the second. This contrasts with a ‘closed transition’ when the articulations of the two consonants overlap”.

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