

Palatogram reading as a phonetic skill: the answer to issue 24(1)'s EPG "mystery" sentence

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1. Introduction

In issue 24(1): 21-34 of the *Journal of the International Phonetic Association*, we reviewed the technique of dynamic electropalatography (EPG) (also known as dynamic palatography or palatometry) for recording information about the tongue's contact with the hard palate over time (Byrd 1994). The purpose of that note was to provide an introduction to interpreting palatograms, much in the same way that phonetics students learn to read spectrograms. In this brief follow-up, we will decipher and discuss the "mystery" palatogram presented as Sentence 2 in the original tutorial. The frame-by-frame data on this sentence occurred on pages 32 – 34 there. Readers should consult these pages to follow along with the discussion below. Examples of palatograms for a variety of sounds as produced by the same speaker were also included there.

The mystery EPG palatogram and corresponding audio waveform were identified in the original tutorial as being an English sentence containing no proper names spoken by a speaker from Southern California. A list of post-puzzle hints revealed that the sentence included four words, one bilabial stop, a diphthong, two liquids, and a devoiced final phone. Twelve time points were specified for reference purposes in both the waveform and the palatogram series—labeled A – L.

1. Walking through the "mystery" sentence

For the interval between landmarks A and B, we see in the waveform a medium high amplitude aperiodic signal. In the palatograms, we observe an anterior channel whose narrowest point is three electrodes back from the front of the pseudopalate. A substantial amount of lateral bracing is also apparent. From these facts we can hypothesize the articulation [ʃ].

ʃ

For the interval from B to C, we observe a relatively high amplitude, periodic signal in the waveform. In the EPG series, we see that the tongue is still quite high in the mouth; that is, there is substantial contact of the sides of the tongue with the pseudopalate. There is no medial lingual constriction, however. We can hypothesize a fairly short high or mid-high vowel.

ɪ
i

At the reference time point C we see a medium amplitude, probably periodic, interval in the waveform. Crucially in the palatograms from time .24 to .32 we see a light (relatively uncompressed) midsagittal closure in the alveolar region that occurs concomitantly with an asymmetrical dorsal contact pattern, such that an airflow channel appears on one side of the pseudopalate while dorsolateral linguapalatal contact is maintained on the other side. As we saw in the earlier tutorial, this is typical of a syllable-initial (i.e. 'light') [l]. We hypothesize:

f	i	.l	
	l		

Between time points C and D in the waveform we see a high amplitude periodic signal. This is apparently a vocalic interval. In the palatograms during roughly this interval (time .36 to .48) we see nearly a complete lack of linguapalatal contact followed by a raising of the rear of the tongue with no significant constriction (i.e. no closure or channel). Now, we can peek ahead and see that a dorsal constriction is upcoming; so it is difficult to say whether the raising of the tongue rear during the end of this interval is due to co-production with an upcoming dorsal consonant or is specific to the vocalic articulation. We will have to propose a couple of choices. This vowel is probably a fairly low, back vowel. (Recall from the tutorial that [æ] and [u] would have lateral contact on this pseudopalate.) It may also be a diphthong that moves from a low, back articulation to a relatively high front articulation. Note that it is the longest vowel in the sentence. We hypothesize:

f	i	.l	a
	l		o
			ai

From reference time point D through E, there is a voiceless closure in the waveform. This interval is followed by what appears to be a small stop release burst. The first two palatograms during this interval show the formation of a velar closure. On the third palatogram in this interval, the co-production of the velar closure with an alveolar closure is apparent. The final palatogram in the D to E interval shows only an alveolar closure. In combination, the waveform and palatograms tell us that a sequence of two voiceless stops has been produced (*co-produced*, to be exact). These are hypothesized to be [k] followed by [t]. An acoustic release is apparent only for the final stop as the release of the first occurs during the closure interval of the second. We continue our transcription:

f	i	.l	a	k	t
	l		o		
			ai		

Between reference points E and F we see a very low amplitude consonantal interval that could be a voiced stop or a low-amplitude fricative. However, an examination of the palatograms during this period shows no stop or fricative articulation—that is, no closure or channel formation. The contact pattern is simply that of a mid vowel. We have a

puzzle! How can the waveform convince us that we have a stop or fricative and the EPG contact pattern show no evidence of such a consonant? Ah, but of course, we must remember that EPG provides no direct information about *lip* aperture. In light of this, we are led to the hypothesis that the articulation is likely to be one of: [b], [v], [f]. Further, since we know that [t (b, v, f)] is not a permissible tautosyllabic cluster in English, we can hypothesize an intervening syllable boundary. We propose:

ʃ	i	.l	ɑ	k'	t	.b
	ɪ		o			v
			aɪ			f

Well, we've now reached the halfway point. The next interval from F to G is vocalic, that is, large amplitude and periodic. The palatograms indicate little linguapalatal contact but slightly more than the preceding hypothesized low vowel. We can hypothesize a mid-low back vowel. (Remember from the tutorial's example palatograms that the front vowels and high back vowels have more lateral bracing than we see here). One fact with which the reader may not be familiar is that speakers from Southern California (as is our speaker here) rarely have an [ɔ] in their vowel inventory. We propose:

ʃ	i	.l	ɑ	k'	t	.b	ʌ
	ɪ		o			v	
			aɪ			f	

The interval from .82s to 1.00s was noted in the original tutorial presentation as having successive frames with .02s increments (as compared to .04s for the rest of the "mystery" palatogram). We observe one frame during this period (at .94s) in which a small closure area appears in the alveolar region. In the waveform at time point G (also at .94s), we see a very brief voiced closure. This short closure is a strong candidate for an alveolar tap [ɾ]. If we compare the contact pattern with the alveolar tap shown in the tutorial (Figure 7), we see a strong similarity. We propose:

ʃ	i	.l	ɑ	k'	t	.b	ʌ	ɾ
	ɪ		o			v		
			aɪ			f		

Next we consider the interval from G to H. Here we see a medium amplitude periodic signal in the waveform. In the palatograms there is contact in the rear part of the pseudopalate but no complete closure. A close inspection of these palatograms reveals a slight difference from the contact patterns we observed in the tutorial for the vowels (and velar stops). In the vocalic articulations, this speaker has contact patterns in which the lateral contact extends farther forward at the edges of the pseudopalate than it does more medially. In this sentence, such a pattern can be seen, for example, at time .48s and .72s. However, the same pattern of lateral bracing is *not* apparent in this sentence for the articulation occurring before time point H (i.e. at time points .98s and 1.00s). We may not be able to strongly support a candidate, but if we are willing to rule out the typical vowel articulations due to the difference in the lateral bracing pattern, one other medium

amplitude periodic choice presents itself—[ɹ]. In the tutorial (in Figure 3, left), we see a contact pattern for [ɹ] that is comparable to that found in our target interval. We will list [ɹ] below, along with a high front vowel in case we are in error.

ɟ	i	.l	ɑ	k'	t	.b	ʌ	ɹ	ɹ
	ɪ		o			v			i
			aɪ			f			

The interval from H to I should be relatively easy. Notice that we have a voiceless closure in the waveform accompanied by a velar closure in the palatograms (frames 1.08s and 1.12s). This closure is released articulatorily at time point I where we also see a release in the waveform. We propose:

ɟ	i	.l	ɑ	k'	t	.b	ʌ	ɹ	ɹ	k
	ɪ		o			v				i
			aɪ			f				

For the interval from I to J we see a short medium amplitude periodic signal in the waveform and a vocalic contact pattern in the palatograms (e.g. at time 1.20s). Due to the mediolateral and anterior extent of contact (see the vowel examples in the tutorial), we propose a mid front vowel.

ɟ	i	.l	ɑ	k'	t	.b	ʌ	ɹ	ɹ	k	e
	ɪ		o			v				i	
			aɪ			f					

From time points J through K we again have a voiceless stop in the waveform and a velar closure evidenced in the palatograms. We propose:

ɟ	i	.l	ɑ	k'	t	.b	ʌ	ɹ	ɹ	k	ε	k
	ɪ		o			v				i		
			aɪ			f						

Following the closure we have a short, medium amplitude, periodic interval in the waveform, roughly at time point K. In the palatograms we see extensive contact, both on the sides and up into the dome of the palate. This strongly suggests a high front vowel. We propose:

ɟ	i	.l	ɑ	k'	t	.b	ʌ	ɹ	ɹ	k	ε	k	i
	ɪ		o			v				i			
			aɪ			f							

From interval L through the end, we see in the waveform a low energy, aperiodic signal which is quite long. We must turn to the palatograms for further information. At

time point L (1.48s) we see the formation of a channel at the front of the palate. At times 1.52s through 1.64s the channel is quite narrow and all the way at the front of the palate. We note also the extensive lateral bracing. The narrowness and anterior formation of the channel, along with the large amount of lateral bracing all suggest an [s] or [z] in sentence final position. We propose then:

f	i	.	l	ɑ	k'	t	.	b	ʌ	r	ɹ	k	ɛ	k	i	s
	ɪ			o				v			i					z
			ai			f										

2. The "mystery" sentence

At this point we turn to our "top-down" skills to finally decipher the sentence:

f	i	.	l	ɑ	k'	t	.	b	ʌ	r	ɹ	k	ɛ	k	i	s
	ɪ			o				v			i					z
			ai			f										
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		

(Numbers are included here and below so as to facilitate reference in the text.)

Let's refer back to the hints we were given. The sentence includes four words, one bilabial stop, a diphthong, two liquids, and the final phone devoiced. The bilabial stop must be that at position 7, so we can exclude the fricatives previously included there.

f	i	.	l	ɑ	k'	t	.	b	ʌ	r	ɹ	k	ɛ	k	i	s
	ɪ			o				v			i					z
			ai			f										
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		

The only candidate diphthong is the one proposed at position 4. We select it.

f	i	.	l	ai	k'	t	.	b	ʌ	r	ɹ	k	ɛ	k	i	s
	ɪ							v			i					z
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		

One of the liquids is present at position 3, the other must be the [ɹ] at position 10.

f	i	.	l	ai	k'	t	.	b	ʌ	r	ɹ	k	ɛ	k	i	s
	ɪ							v								z

We were also told in the hints presented with the "mystery" palatogram that the sentence final phone is devoiced. That leaves us with:

ʃ	i	.	l	aɪ	kʰ	t	.	b	ʌ	r	ɪ	k	ɛ	k	i	z̥
	ɪ															

We have already postulated two syllable boundaries. If these are in fact word boundaries for the first two of the four words, we have deciphered the first half of the sentence!

ʃ	i	.	l	aɪ	kʰ	t	.	b	ʌ	r	ɪ	k	ɛ	k	i	z̥
	ɪ															
She				liked												

We can finish using top-down knowledge. The placement of the final word boundary before the first of the two [k]'s near the end of the sentence yields:

ʃ	i	.	l	aɪ	kʰ	t	.	b	ʌ	r	ɪ	.	k	ɛ	k	i	z̥
	ɪ																
She				liked				butter									

Since no word suggests itself it seems that we were probably incorrect as to the penultimate vowel, although determining the exact quality of this vowel would require listening or spectral analysis. However, even with an unidentified vowel in the first syllable of this word, we can easily reconstruct:

ʃ	i	.	l	aɪ	kʰ	t	.	b	ʌ	r	ɪ	.	k	V	k	i	z̥
	ɪ																
She				liked				butter				cookies.					

Congratulations!

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Reference

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