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THE BILABIAL NASAL IN ENGLISH AND GREEK

[ΛΕΥΚΗ ΣΕΛΙΔΑ]

1. INTRODUCTION

A theory of speech production based on the notion of universally possible sentence needs support from experimental data which do not only confirm the presence of intrinsic allophones but also increase their number so that the language universal basis is strengthened.

This paper is concerned with an experiment involving a contrastive investigation of the English and Greek bilabial nasals. The parameters include surface electromyography associated with muscle orbicularis oris contraction for lip closure, nose-out and mouth-out airflow. The third of these parameters is only used as a confirmation of the accuracy of the second since nose-out and mouth-out airflow are inversely correlated (Figure 1).

The aim of the investigation is to provide experimental and comparative data on the lowering and raising of the velum in time in conjuction with the emg activity from m. orbicularis oris during the production of the bilabial nasal in English and Greek. Thus airflow provides information on articulatory movement whereas m. orbicularis oris is examined for emg activity before, during and after the closure.

It is hoped that the present combined study of movement and motor commands will provide data towards a better understanding of the velar mechanism.

2. METHOD

Bipolar surface electrode emg was used to examine contraction of m. orbicularis oris. The two electrodes were attached to the upper lip at the vermillion border and just to the left of the midline. The electrodes were platinum cupped types approximately 3-4 mm in diameter, filled with electrode jelly and fixed with Blenderm tape onto a slightly abraded skin surface. The signals were recorded on an Ampex SP300 tape-recorder (frequency response 0-2.5 kHz) operating in the FM mode at a tape speed of 38 cm/s.

Nose-out and mouth-out airflow measurements were obtained through a Fr'o'kjaer-Jensen Electro Aerometer (frequency response: DC-10 kHz).

The resultant signals were recorded on DM channels together with a reference oral microphone signal (correctly equalised, frequency response 45 Hz —20 kHz±3 dB).

On playback the signals were processed as follows:

a. emg signals were, first, high-pass filtered at 27 Hz to remove most of any low-frequency electrode movement and then, rectified and 'smoothed' using a low-pass filter operating at an effective integration time of 22 ms.

b. airflow signals were low-pass filtered at an effective integration time of 22 ms.

c. audio signals were not processed; they only served as reference.

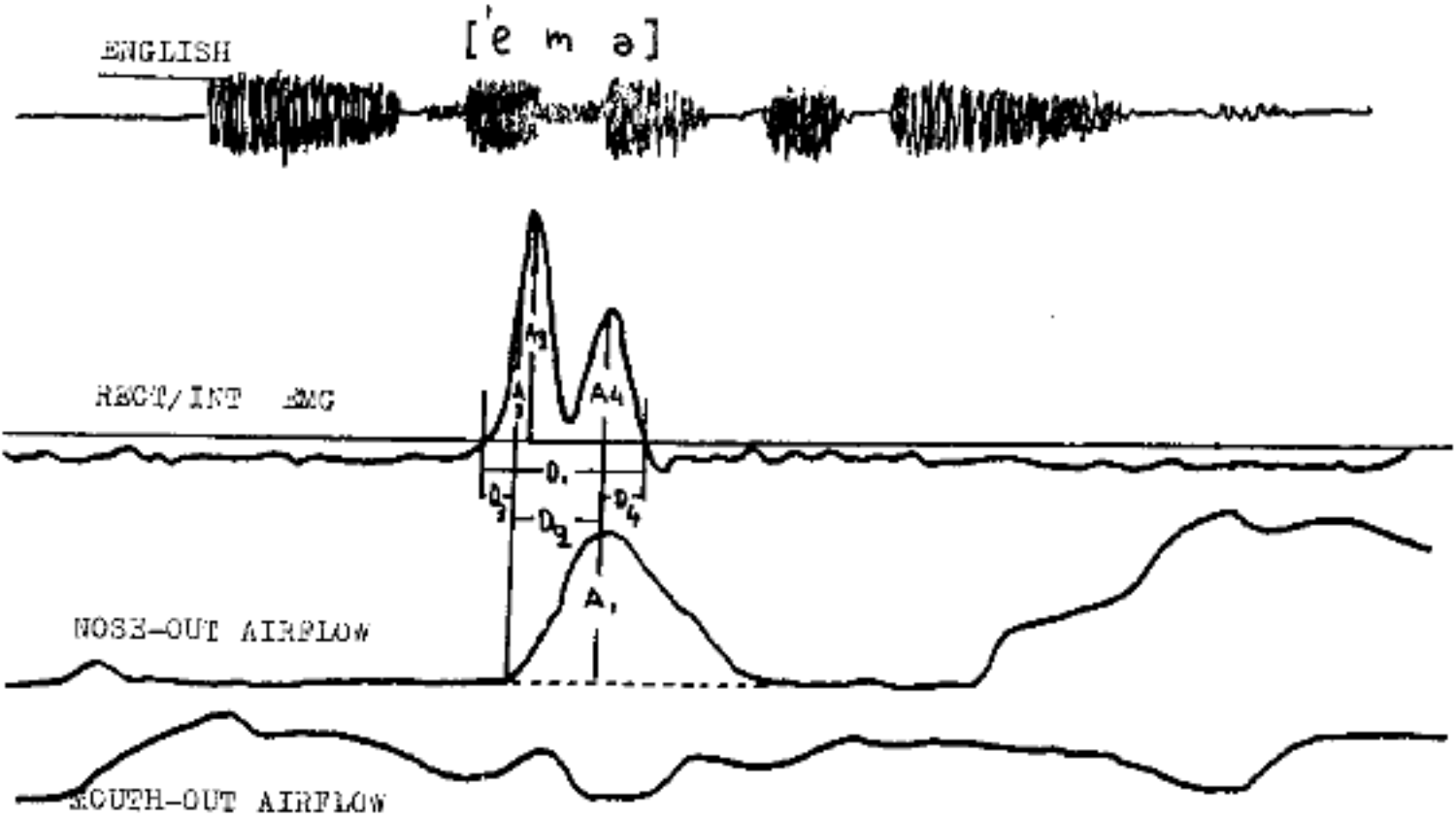
All signals were recorded simultaneously on an ink-jet recorder, an Elema-Schönander Mingograf, running at 100 mm/s (frequency response 0-700 Hz ± 3dB, chart speed accuracy 5%).

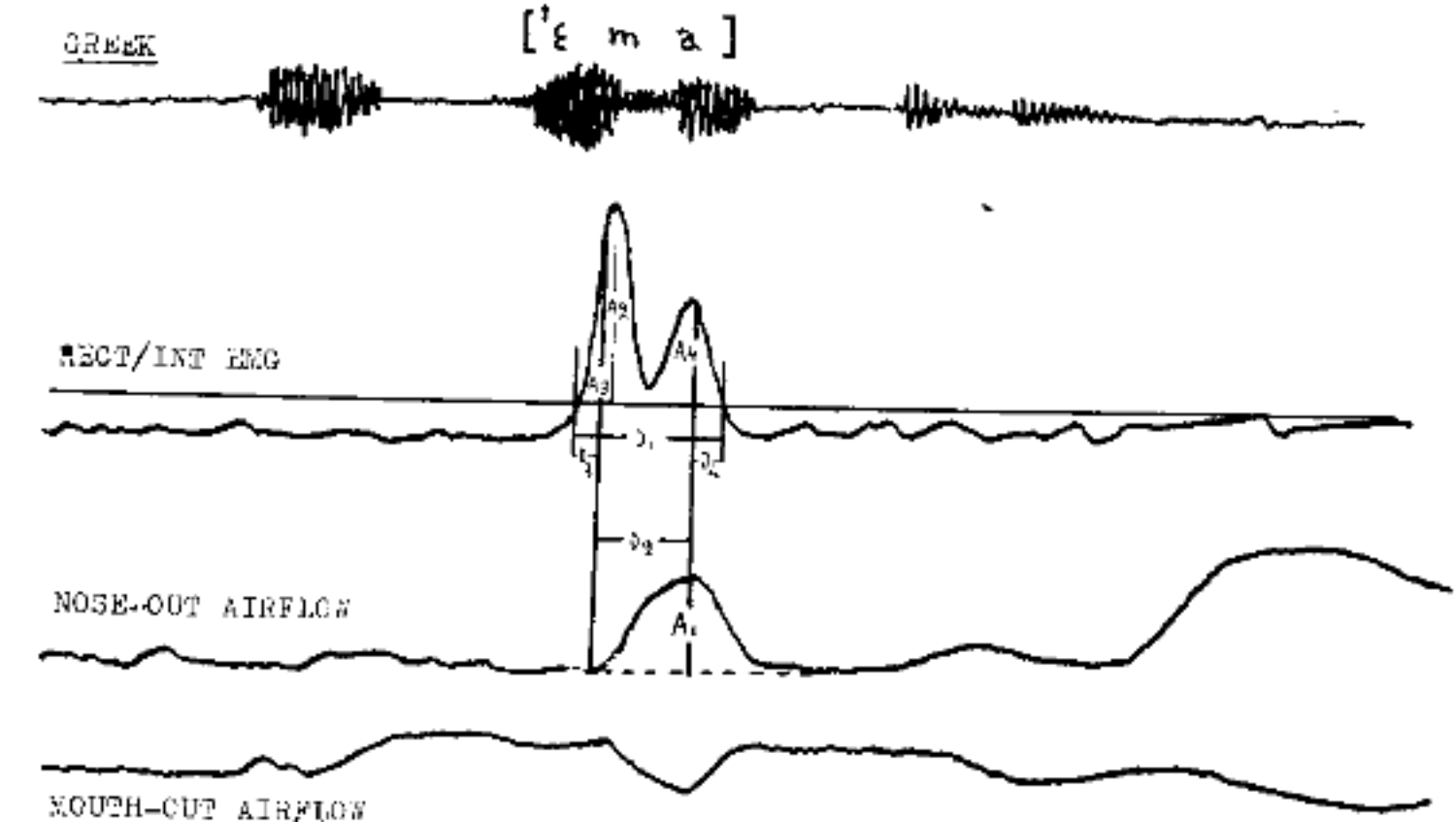
The English and Greek bilabial nasals were preceded by a stressed front vowel and followed by an unstressed mid-central vowel. Thus the two utterances were /ˈema/ for English and /ˈɛma/ for Greek and the frames were 'say ——— again' and 'pès —— ksanà'. Each test utterance was repeated thirty five times by one male native speaker of each language.

A full statement of the measurements of twenty nine utterances in each language taken in arbitrary linear units follows Figure 1 in Tables (a) and (b).

Figure 1: see following page

Audio, rectified/integrated emg from orbicularis oris, nose-out and mouth-out airflow of typical examples of /ˈemə, ˈɛma/.
A_1: peak nose-out airflow at moment of raising of velum
A_2: peak amplitude of emg
A_3: amplitude of emg at moment of lowering of velum
A_4: amplitude of emg at moment of raising of velum
D_1: duration of emg
D_2: duration of closure
D_3: duration of emg before closure
D_4: duration of emg after closure


ENGLISH
['e m ə]
RECT/INT EMG
NOSE-OUT AIRFLOW
MOUTH-OUT AIRFLOW


GREEK
['ɛ m a]
RECT/INT EMG
NOSE-OUT AIRFLOW
MOUTH-OUT AIRFLOW

(a) raw data from /'emə/

	A_1	A_2	A_3	A_4	D_1	D_2	D_3	D_4
1.	18	17	10	9	25	12	5	8
2.	17	19	7	13	34	13	10	11
3.	19	24	24	10	25	10	4	11
4.	17	19	11	11	26	13	6	7
5.	20	27	10	13	23	13	2	8
6.	19	17	7	7	24	15	2	7
7.	19	29	5	7	22	16	2	4
8.	19	25	12	14	31	17	3	11
9.	18	21	5	10	27	11	2	14
10.	19	32	12	13	23	16	2	5
11.	20	25	7	10	29	16	5	8
12.	19	36	7	20	28	15	6	7
13.	19	28	14	10	32	18	10	4
14.	19	30	13	11	27	17	6	4
15.	19	31	13	15	28	15	5	8
16.	20	20	18	16	29	12	8	9
17.	20	35	15	19	30	16	5	9
18.	20	18	5	6	24	15	3	6
19.	21	20	—	7	27	11	3	13
20.	22	19	—	14	28	14	4	10
21.	19	26	5	8	23	14	4	5
22.	22	20	11	20	31	14	7	10
23.	21	26	10	11	25	12	3	10
24.	19	21	7	11	26	15	3	8
25.	19	20	10	11	24	13	6	5
26.	18	25	15	6	24	16	3	5
27.	18	17	11	7	24	15	4	5
28.	16	16	—	12	27	15	4	8
29.	17	15	7	6	25	11	3	11

(b) raw data from /'ɛma/

	A_1	A_2	A_3	A_4	D_1	D_2	D_3	D_4
1.	6	21	17	5	16	8	6	2
2.	4	17	7	7	19	8	7	3
3.	4	15	7	10	18	10	6	2
4.	10	18	17	10	22	14	5	3
5.	7	33	31	10	23	12	5	5
6.	4	23	16	7	20	9	6	5
7.	8	18	17	13	19	10	5	3
8.	10	16	14	6	20	10	6	4
9.	10	26	15	6	18	9	6	3
10.	10	29	24	9	20	8	6	5
11.	9	22	16	11	24	10	10	4
12.	7	22	21	10	20	10	6	3
13.	4	20	15	4	20	10	6	4
14.	5	20	14	6	20	9	7	4
15.	9	18	12	4	20	10	6	5
16.	4	17	16	8	20	10	5	5
17.	4	37	20	8	19	8	7	4
18.	5	19	8	7	19	8	7	4
19.	4	22	12	10	19	8	7	5
20.	10	21	19	16	20	11	6	3
21.	6	24	19	12	22	10	8	4
22.	5	41	22	5	22	10	8	5
23.	10	20	13	11	21	13	5	3
24.	6	24	16	8	21	10	6	5
25.	6	20	10	5	23	10	6	7
26.	4	20	6	16	24	10	8	5
27.	6	19	10	10	23	11	6	5
28.	4	31	25	9	22	9	6	6
29.	5	27	17	8	19	9	5	5

3. RESULTS AND DISCUSSION

A number of hypotheses test similarity, correlation and stability among the available quantified parameters through comparisons of means ($\bar{x}$), standard deviation (s), Mann-Whitney tests (U), Spearman rank correlation coefficient (r_s), t-tests and Pearson's coefficient of variation (v).

Hypothesis 1: There is no significant difference in peak amplitude reached by the emg signal associated with orbicularis oris contraction for the bilabial nasal between English and Greek.

Result:

	mean peak amplitude		
	x	s	v
English:	23.37	5.71	24.46
Greek:	22.75	6.14	26.97
U=385.9	z=.538		

At a level of .01 for a one-tailed probability the hypothesis is confirmed. The finding is significant because it contributes towards the increase of intrinsic allophones which support the universal base hypothesis.

Hypothesis 2: Peak nose-out airflow during the production of the bilabial nasal is higher for English than for Greek.

Result:

	mean peak nose-out airflow		
	$\bar{x}$	s	v
English:	19.06	1.38	7.27
Greek:	6.41	2.31	36.04
U=0	(z=6.53)		

The confirmation of the second hypothesis which leads to a perfect discrimination of the bilabial in the two languages can be interpreted in either of two ways: (a) The observed values point towards an extrinsic articulatory quality which may progressively be defined as specific of Greek (cf. similar findings concerning fricatives in Greek (Panagopoulos 1975)). Such a thesis would imply that articulatory load is more evenly distributed in Greek than in English. (b) The observed values are the result of an artefact. Such an explanation is assisted by the comparatively high figure of (v) computed for Greek.

Hypothesis 3: There is close correlation between mean peak amplitude of emg from muscle orbicularis oris and mean peak nose-out airflow in English and Greek /m/.

Result:

English:	r_s =.349	t=1.93
Greek:	r_s =.010	t= .05

For a one-tailed test at .01 level of significance the hypothesis is rejected.

The result is in accordance with absence of similar correlation in plosives

(PANAGOPOULOS 1974) and with the fact that positive results would have correlated energy through different parameters which never coincide in time.

Hypothesis 4: There is a relative stability in the duration of the closure of the lips during /m/ in both languages.

Results: closure duration

	$\bar{x}$	s	v
English:	14.13	2.02	14.35
Greek:	9.79	1.42	14.53

The hypothesis is confirmed. However, the observed values are less stable than those found for closure duration in bilabial plosives (PANAGOPOULOS 1974) but consistent with the remarkable degree of stability normally associated with this parameter.

Hypothesis 5: The amplitude of emg from m. orbicularis oris for lip closure for English and Greek /m/ is stable.

Results: mean amplitude at moment of lowering of velum

	$\bar{x}$	s	v
English:	10.42	4.40	42.25
Greek:	15.72	5.61	35.73

The present figures viewed against the v-values computed for peak amplitude reject the hypothesis. Before this hypothesis is discussed it may be convenient to examine the following:

Hypothesis 6: There is close correlation between mean amplitude of emg from m. orbicularis oris at the moment of raising of the velum and nose-out airflow.

Results: mean amplitude at moment of raising of velum

	$\bar{x}$	s	v
English:	11.27	3.94	35
	peak nose-out airflow		
	19.06	1.38	7.27
	$r_s = .334$		$t = 1.84$
	mean amplitude at moment of raising of velum		
Greek:	8.65	3.07	35.54
	peak nose-out airflow		
	6.41	2.31	36.04
	$r_s = .180$		$t = .950$

For a one-tailed test at a level of .01 the hypothesis is rejected.

Along a time axis emg naturally comes first followed by the beginning of the lowering of the velum which, in English, is in turn *followed* closely by the setting of the closure of the lips. Thus a slight anticipatory release of the velopharyngeal contact is constantly present in English whereas in Greek the lowering of the velum and the setting of the closure of the lips coincide in time. The anticipatory movement observed in English is considered to be of extrinsic nature. The release stage of the emg gesture is disturbed by the onset of the following 'allophone'.

Hypothesis 7: The duration of orbicularis oris contraction before lip closure is the same for both English and Greek bilabial nasals.

Results: duration of emg before closure

	$\bar{x}$	s	v
English:	4.48	2.17	48.52
Greek:	6.31	1.11	17.70

U=391 z=.450

At a level of .01 for a one-tailed test the hypothesis is confirmed. The result suggests that emg amplitude is not to be directly correlated to emg duration (see also hypotheses 5 and 6). Greek is considerably more stable than English and in this respect the results are comparable to those for plosives (PANAGOPOULOS 1974); once again Greek shows less pre-closure emg variation than English. In the present results the same tendency appears in the case of emg after closure, i.e.

duration of emg after closure

	$\bar{x}$	s	v
English:	7.96	2.69	33.86
Greek:	4.17	1.14	27.48

The usual aspect of emg investigation, that is, high variability due to lack of effective muscular coordination to achieve precision in the repetition of a gesture is not particularly prominent in the present results, at least in the case of overall muscular activity:

duration of emg

	x	s	v
English:	26.58	2.97	11.19
Greek:	20.27	1.83	9.05

But it is much higher in the quantified measurements.

Although the original optimism about the usefulness of emg activity in

the study of speech (BASMAJIAN 1962, COOPER 1965) has been followed by scepticism (MANSELL 1970, 1971) electromyography, whose variability is part of the overall variability and redundancy which are typical of bio-electric signals and therefore, of speech, is in the unique position to allow a close readout of speech activity in the central processor with reasonable selection possibilities which are not available at present in either electroencephalography or speech oriented open brain surgery.

4. SUMMARY AND CONCLUSION

The English and Greek bilabial nasals have been examined comparatively along quantified parameters of surface electromyography from muscle orbicularis oris and nose-out airflow.

Similarities which are statistically significant are treated as intrinsic allophones. Thus peak amplitude emg as well as the temporal delay between the arrival of the emg signal and the velopharyngeal lowering are considered to be intrinsic.

But findings such as absence of correlation between peak amplitude emg and airflow, the comparatively greater stability observed in Greek and the anticipatory lowering of the velum in English but not in Greek point towards different patterns of behaviour which are too systematic to be due to peripheral constraints and are, therefore, treated as extrinsic allophones.*

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