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Formant frequencies in Middle Eastern singers

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Abstract

Purpose: This work was conducted to describe the formant frequencies in a group of Middle Eastern singers and to look for the presence of the singer's formant described in operatic singers.
Material: A total of 13 Middle Eastern singers were enrolled in this study. There were 5 men and 8 women.
Method: Descriptive analysis was performed to report the various formants (F1, F2, F3, and F4) in both speaking and singing. The Wilcoxon test was used to compare the means of the formants under both conditions.
Results: For both sexes combined, for the /a/ vowel, F1 singing was significantly lower than F1 speaking ($P = .05$) and F3 singing was significantly higher than F3 speaking ($P = .046$). For the /u/ vowel, only F2 singing was significantly higher than F2 speaking ($P = .012$). For the /i/ vowel, both F2 and F3 singing were significantly lower than F2 and F3 speaking, respectively ($P = .006$ and .012, respectively). There was no clustering of the formants in any of the Middle Eastern sung vowels.
Conclusion: Formant frequencies for the vowels /a/, /i/, and /u/ differ between Middle Eastern singing vs speaking. There is absence of the singer's formant.

1. Introduction

Speech characteristics are intimately related to the shape and configuration of the vocal apparatus. As airstream is chopped into air pulses at the rima glottidis, the resulting sound is filtered into various prominent spectral regions by multiple resonances. The preferred frequencies that radiate with high amplitude are called formant frequencies. These formants characterize our speech in terms of vowel quality. They can be tuned by adjusting the vocal tract shape and length. For instance, lengthening the vocal tract by lowering the larynx or protruding the lips lowers all formant frequencies. On the other hand, constriction of the vocal tract leads to an increase in the formant frequencies [1].

In the description of vocal techniques in singing, one invariably refers to the resonatory aspects of voice production. These can be translated in terms of the lowest 4 to 5 formant frequencies. These formant frequencies vary between speech and singing and between various styles of singing [2-4]. Analyzing the formant frequencies of various styles of singing allows a better understanding of the respective singing technique, information that can be used in vocal pedagogy and in the interpretation of various problems of the singing voice. Middle Eastern singing is unique in its style of music and genre of performance. It is rich in ornaments and much agility is often required by the singers. Invariably, performers add their own improvisation to the piece. Middle Eastern singing is very much understudied, and the current literature lacks reports on acoustic analysis of this style of singing. We have previously reported on the

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Table 1
Formant frequencies F1, F2, F3, and F4 for the speaking and singing voice modes in male subjects

Vowel	Subject	F1				F2				F3				F4			
		Speaking		Singing		Speaking		Singing		Speaking		Singing		Speaking		Singing	
		MV	SD	MV	SD	MV	SD	MV	SD	MV	SD	MV	SD	MV	SD	MV	SD
/a/	S1	790	27.1	680	131	1367	96	1423	143	2711	36	2853	72.3	3738	59.9	3699	62.4
	S2	743	36.1	704	27.1	1336	54.8	1462	68.1	2632	23.5	2829	95.5	3651	85.6	3817	119
	S3	688	47.5	577	13.9	1201	36.1	1201	13.9	2555	85.7	2782	36.1	3485	103	3509	24
	S4	696	59.9	640	103	1217	13.9	1312	54.8	2545	49	2766	36.1	3438	0	3555	1.73
	S5	711	40.9	766	49.4	1327	103.1	1225	54.9	2782	49	2513	627	3477	112.3	3129	639
/u/	S1	466	27.7	427	62.9	980	68.7	964	145	2506	27.1	2545	27.7	3319	62.9	3327	72.3
	S2	419	13.9	466	36.1	1012	27.1	1154	95.8	2426	36.2	2742	83.3	3936	24	3746	47.5
	S3	506	36.1	482	49.4	893	83.3	901	62.6	2458	49.4	2529	27.7	3098	36.1	3240	36.1
	S4	403	62.6	537	95.9	901	82	964	27.7	2348	41	2426	59.9	3169	107	3351	49
	S5	442	13.3	450	85.4	980	13.9	980	49.4	2679	144.3	2505	145	3406	49.6	3414	81.9
/i/	S1	458	59.9	419	36.2	2363	99	2213	49	2995	13.9	2648	49.4	3730	68.7	3620	72.8
	S2	411	36.1	458	36.2	2189	89.9	2110	103	2718	54.8	2632	125	3612	27.7	3627	85.4
	S3	522	71.5	395	68.1	1999	27.1	1873	41	2814	443	2537	144	3604	451	3343	62.6
	S4	466	54.8	537	36.1	2173	54.8	1999	49.4	2805	27.1	2616	89.7	3533	0	3556	125
	S5	442	72.8	490	13.9	2189	54.3	2268	77.2	2829	98.8	2916	62.9	3532	310.1	3691	342

MV, mean value; SD, standard deviation.

laryngeal biomechanics in a group of Middle Eastern singers. Various muscle tension patterns were observed and invariably these reflect this style of singing [5]. The purpose of this study is to describe the formant frequencies in a group of Middle Eastern singers and investigate the presence or absence of the singer's formant usually described in well-trained operatic singers.

2. Material and method

A total of 13 Middle Eastern singers who have had training in the Middle Eastern singing style or had been in the profession for at least 2 years were recruited for this study. There were 5 men and 8 women. In the male group the mean age was 36.8 years (range, 26-49 years). In the female

Table 2
Formant frequencies F1, F2, F3, and F4 for the speaking and singing voice mode in female subjects

Vowel	Subject	F1				F2				F3				F4			
		Speaking		Singing		Speaking		Singing		Speaking		Singing		Speaking		Singing	
		MV	SD	MV	SD	MV	SD	MV	SD	MV	SD	MV	SD	MV	SD	MV	SD
/a/	S1	767	54.8	869	89.7	1288	27.1	1478	27.7	2885	83.3	3169	107	3715	72.8	3960	23.5
	S2	830	85.6	933	68.1	1454	49.4	1383	27.7	2964	85.4	3209	72.3	3920	89.9	4078	62.6
	S3	1004	36.1	772	30.1	1620	13.9	1367	72.3	2995	119	3011	144	3912	24	3857	36.2
	S4	862	89.7	727	36.1	1391	99	1217	36.7	3162	175	3074	36.1	3833	191	3548	13.3
	S5	933	76.6	782	71.5	1462	68.1	1296	36.1	2964	23.5	3161	76	3959	41	3999	95.8
	S6	846	49.4	885	36.2	1407	49.6	1399	82	2979	59.9	3146	49.4	3928	36.7	4055	41
	S7	893	96	814	68.7	1533	89.7	1517	62.9	3027	49.4	3019	68.7	4015	27.7	4094	76
	S8	1059	36.1	940	59.9	1439	35.6	1351	23.5	2908	76.6	2932	83.3	3888	47.5	3936	142
/u/	S1	458	27.1	348	13.9	996	62.9	996	85.6	2814	135	2932	49	3793	125	3975	13.3
	S2	450	47.5	403	24	956	36.2	1036	27.1	2869	85.6	2956	89.9	4094	13.9	3952	36.2
	S3	371	13.3	356	23.5	877	47.5	846	49.4	2624	76	2624	143	3952	154	3849	68.1
	S4	403	132	474	148	1004	27.7	933	95.9	2790	54.3	2616	355	3699	23.5	3414	155
	S5	561	27.7	585	13.9	1138	47	1067	24	2774	103	2711	179	3857	76	3572	154
	S6	474	41	459	54.8	964	59.9	1099	36.1	2877	83.3	2908	155	3849	107	3762	95.8
	S7	577	76.2	569	47	1312	322	1754	62.9	2505	363	2837	49.6	3856	61	3810	49.4
	S8	530	54.8	498	0	964	54.8	980	83.3	2529	130	2885	72.8	3738	167	3904	36.1
/i/	S1	514	13.9	435	59.5	2671	13.9	2695	13.9	3256	59.4	3398	36.2	4055	41	4094	89.9
	S2	441	54	395	27.7	2561	85	2371	188	3390	47.5	2916	23.5	4157	36.7	4062	49.4
	S3	387	13.9	348	13.9	2505	167	2521	171	3398	72.8	3311	157	4110	36.1	4062	193
	S4	348	13.9	413	39.4	2545	36.1	2395	62.9	3130	0	3106	41	3841	41	3770	62.6
	S5	395	59.4	482	76.2	2679	85.6	2395	41	3454	76	3240	426	4070	36.1	4039	36.1
	S6	324	59.4	522	0	2727	62.9	2584	62.9	3248	85.4	3130	185	4078	62.6	4054	94.5
	S7	545	23.5	466	98.4	2916	23.5	2490	188	3414	109	2988	171	4086	49	3881	27.1
	S8	498	62.6	625	54.8	2584	94.5	2482	36.2	3533	207	3082	171	4141	122	4078	62.6

MV, mean value; SD, standard deviation.