An archaeoacoustic study of the Ħal Saflieni Hypogeum on Malta

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The remarkable subterranean architecture of the Ħal Saflieni Hypogeum on Malta has generated many claims about its dramatic acoustic effects, but previous studies have lacked rigour. A systematic, methodical approach has now been applied to measure the acoustic properties of the site, and to test earlier assertions. The results confirm some, but not all, prior observations, and demonstrate how a sound-based approach can contribute to an understanding of the archaeological context. It is argued that for the people who created the Hypogeum, the acoustics must have had particular significance and ritual power.

Table S1. Examples of acoustic metrics, just noticeable difference (JND) and typical range.

Metric	JND	Typical range
G	1dB	−2 to +10dB
EDT/T20/T30	5%	1s to 3s
C80	1dB	−5 to +5dB
Definition, D50	0.005	0.3 to 0.7

Table S2. Loudness at different receiver positions.

Source position	Measurement position	SPL(A)
S1	M1	42.4
S1	M 2	46.7
S1	M 3	47.9
S1	M 4	49.6

Table S3. SPL(A) for source positions moving away from the niche in the wall of the Oracle Chamber for two microphone positions.

Source position	SPL(A) at M3	SPL(A) at M4
S3	44.2	48.7
S1	47.9	49.6
S4	45.1	43.8

Table S4. STI(Female) and STI(Male) results for all source and receiver positions.

Source	Receiver	STI(Female)	STI(Male)	Difference
S1	M1	0.55	0.52	+0.03
S1	M2	0.30	0.38	+0.01
S1	M3	0.30	0.32	−0.02
S1	M4	0.34	0.34	+0.00
S2 (to niche)	M1	0.58	0.56	+0.02

S2	M1	0.56	0.53	+0.03
S2 (to niche)	M2	0.39	0.38	+0.01
S2	M2	0.40	0.38	+0.02
S3	M3	0.48	0.45	+0.03
S3	M4	0.31	0.30	+0.01

Table S5. Articulation loss of consonants in the Oracle Chamber.

Source position	Measurement position	Articulation loss
S1	M1	11.1
S1	M2	21.8
S1	M3	33.7
S1	M4	25.6

Table S6. Model ranges of articulation loss of consonants.

$AL_{cons} \leq \_3\%$ ideal intelligibility

$AL_{cons} = 3$ to 8% very good intelligibility

$AL_{cons} = 8$ to 11% good intelligibility

$AL_{cons} > 11$ to 20% poor intelligibility

$AL_{cons} > 20\%$ worthless intelligibility (limit value 15%)

Table S7. Bass ratio BR(SPL) for source position 1 with various receiver positions.

Source position	Measurement position	Bass ratio
S1	M1	4.6
S1	M2	6.3
S1	M3	15.1
S1	M4	124

Table S8. Acoustic metrics at different octaves: S1 M4.

	63	125	250	500	1000	2000	4000	8000
EDT	13.01	5.45	4.78	3.40	2.48	2.20	1.70	2.71
T(20)	14.62	7.32	4.87	3.46	2.66	2.13	1.79	–
D(50)	0.05	0.07	0.08	0.14	0.22	0.25	0.33	0.40
C(7)	−20.80	−21.20	−19.80	−17.00	−12.9	−13.1	−11.4	−6.30
C(50)	−12.70	−11.20	−10.40	−7.80	−5.40	−4.70	−3.10	−1.80
C(80)	−10.50	−9.80	−7.80	−50	−2.70	−1.80	−0.10	2.00

Table S9. Clarity minimum values.

C(7)	Directness/nearness of musical sources	−10 to −15db
C(50)	Clarity (speech)	> −2dB (>3dB is good)
C(80)	Clarity (music) - classical music	> −1.6dB

| C(80) | Clarity (music) - romantic music | > -4.6dB |
| C(80) | Clarity (music) - sacral music | > -5dB |