Research Article

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One, Two, Three! Can Everybody Hear Me? Acoustics of Roman *Contiones*. Case Studies of the Capitoline Hill and the Temple of Bellona in Rome

https://doi.org/10.1515/opar-2022-0330
received March 27, 2023; accepted August 18, 2023

Abstract: Rhetoric was one of the cornerstones of Roman education and public speaking, the essence of being a Roman politician. The speakers attempted to captivate the audience with their style and convince them of their arguments. Studying the audience is therefore just as important as investigating the speakers and their speeches. The aim of this article is to estimate the number of people who could intelligibly hear a speaker delivering a speech from two speaking platforms located in the city of Rome: the podium of the Temple of Bellona in the Campus Martius (in the Late Republican and Late Augustan periods) and the Capitoline Temple. To do this, we built virtual reconstructions of both venues according to the current state of knowledge about them, taking into account the geometry of the space as well as the materials from which they were built. On the models thus prepared, we carried out acoustic simulations for three different levels of background noise (36, 49, and 55 dBA), resulting in Speech Transmission Index maps. The results became the basis upon which we estimated the size of the maximum potential crowds that could hear speech intelligibly, using two methods based on the behaviour of contemporary crowds. We further compared our results with those of previous studies that concern other speaking platforms in Rome.

Keywords: acoustic simulations, ancient Roman politics, archaeoacoustics, Late Roman Republic, popular assemblies in ancient Rome

Special Issue on Past Sounds: New Perspectives in the Field of Archaeoacoustics, edited by Margarita Díaz-Andreu & Neemias Santos da Rosa.

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1 Introduction

In 63 BCE, in the city of Rome, there was such a violent political demonstration in the theatre[1] that the consul of that year, Marcus Cicero, himself decided to address the people and calm their hateful reaction to the appearance of Lucius Roscius Otho[2] in the venue (Plut. *Vit.Cic.*13.2-4). Otho had infuriated the people when, while holding the office of plebeian tribune 4 years earlier, he had proposed and successfully voted down a law granting 14 rows of seats in the theatre to the members of the equestrian order (cf. Cic.*Corn.*1, ft. 52, *Att.*2.19.3, *Mur.*19.40, *Phil.*2.18.44, Liv.per.99, Hor.*Epod.*4.15-16, *Epist.*1.1.62, Vell.Pat.2.32.3, Ascon.78-79C, Tac.*Ann.*15.32, Iuven.3.159,[3] Maillard, 2018; Pociña Pérez, 1976; Rawson, 1987; Scamuzzi, 1969, 1970). The situation in the theatre was further exacerbated by the fact that the equites naturally applauded Roscius, which led to an exchange of insults between members of the two orders. This threatened to escalate the conflict further. Hence the intervention of the consul.

Unfortunately, the speech he gave to appease the people has not been preserved. However, we know the place from which he spoke: the podium of the Temple of Bellona in the Campus Martius. This choice was probably dictated by the proximity of the theatre, although we do not know exactly where the performances were held. This is the only time when the written sources specifically point us to this place as the speaking venue. However, given that the senate often met in the temple (cf. Bonnefond-Coudry, 1989, pp. 151–160; 47, Table II, pp. 144–145, Table IV, pp. 146–147, Table V) and there was a free space in front of it, we can guess that it was used more often. Especially, the location of the site outside the pomerium (the sacred boundary of the city) allowed politicians who were not formally allowed to be in Rome, such as provincial governors waiting for a triumph, to attend Senate meetings and speak in front of the people (Bonnefond-Coudry, 1989, pp. 143–149, 269–274).

The speaking platform on the podium of the Temple of Bellona was one of several used to address the people. In addition to it, the Republican speaking platform (*rostra vetera*) at the Comitium[4] and the podium of the Temple of Castores in the Forum Romanum were used during the Republican period, as was the podium of the Capitoline temple[5] (Döbler, 1999, pp. 139–140; Pina Polo, 1989, pp. 182–198; esp. 183–184; 1995, pp. 212–213). During the period of civil wars, the Forum Romanum underwent changes that greatly affected the rhetorical landscape of Rome's main square (Coarelli, 1977; 1985, pp. 125–324; Frischer & Massey, 2022; Fuchs, 2021; Sumi, 2005, 2009, 2011). The old Republican platforms were replaced by the *rostra Caesaris* (and later *rostra Augusti*) and the *rostra aedis divi Iulii* (associated with the Temple of Caesar) (Coarelli, 1985, pp. 308–310; Fuchs, 2021, pp. 534–547, Figures 11–13; Pina Polo, 1995, pp. 212–213). During the Imperial period, the number of public speeches to the people declined, but for a long time speaking to the people of Rome remained among the important duties of the emperor and members of the imperial house (Pina Polo, 1989, pp. 171–181).

Many aspects of these speeches, such as their purpose, composition, and crowd constitution, have received the attention of researchers (cf. Bennett, 1995; May, 2002; Vasaly, 1993). However, little has been said so far about another aspect of public speaking in Rome that seems relevant: how many people were able to hear intelligibly what the speaker had to say, how large a proportion of the crowd was likely to hear the speaker (given the total capacity of the venue), and perhaps even – indirectly – how large were the average crowds that attended the *contiones*. Many movies and TV series set in the past present us with visions of venues filled to the brim. This is what the Forum Romanum resembles, for example, in the classic screen adaptations of Shakespeare's *Julius Caesar* from 1953 to 1970, or in more recent years, in the TV series *Domina* (2021). Usually, we do not see anything strange in such scenes; after all, all kinds of public gatherings today look similar. They gather hundreds, thousands, and sometimes even tens of thousands of people. However, there is an important difference between

1 Plutarch does not specify which theater he is referring to. Since there was no permanent stone theater before the construction of Pompey's Theater, he was probably referring to a temporary theater built for games by the aediles. For temporary theatres in Rome, see Sear (2006, pp. 54–57).

2 Possibly the praetor of this year, cf. Broughton (1952, p. 167).

3 All abbreviations of ancient works are from Oxford Classical Dictionary.

4 The open area used for assemblages at the Forum Romanum in Rome and several Roman colonies.

5 According to the catalogue of *contiones* compiled by Pina Polo (1989, pp. 244–345), which lists 375 *contiones* from the Regal and Republican periods and 45 from the Imperial period, the Capitoline Hill (probably the Capitolium itself) was unquestionably used as a speaking platform eight times during the Republican period and twice during the Imperial period.

the two situations of the modern and the ancient. Today, we have artificial sound systems at our disposal. Perhaps the reality of such speeches was best captured by the makers of the *Life of Brian* (1979), who parodied the Sermon on the Mount. On screen, we can see how the people standing at a distance from the speaker not only misheard and distorted his words, but also drowned him out with their constant chatter, or even by asking to repeat what he had said. In academia, the question of potential crowd size has only been addressed so far by Holter, Muth, and Schwesinger (2019) and Kopij and Pilch (2019), in the case of public assemblies held in the Forum Romanum, Fron, Stappmanns, Zhou, and Leistner (2019) in the case of Senate meetings in Curia, and by Boren (2018) in the case of speeches of a military nature taking place just before a battle (in this particular case, before the battles of Dyrrachium and Pharsalos, between armies led by Caesar and Pompey). We will return to a critical discussion of the results of this research and the methodology used and variables considered in Section 4.

The aim of our study is to answer the following questions: how many people could actually hear the speaker intelligibly and what percentage of the crowd had the opportunity to hear the speaker, given the maximum filling of the available space? We base our answers on the results of acoustic simulations for three case studies: the Temple of Bellona (in two periods: ca. 54 BCE and ca. 14 CE) and the Capitoline temple (Figure 1). Furthermore, we intend to compare the acoustic properties of both venues and to consider whether practical factors influenced the choice of speaking platform. We then compare the results with those of other similar studies carried out for *rostra* in the Forum Romanum.

2 Methods

2.1 3D Reconstructions

In order to run the simulations, we built virtual 3D reconstructions of all venues. Doing so, we took into account the state of archaeological and architectural research on both spaces as well as reconstructions

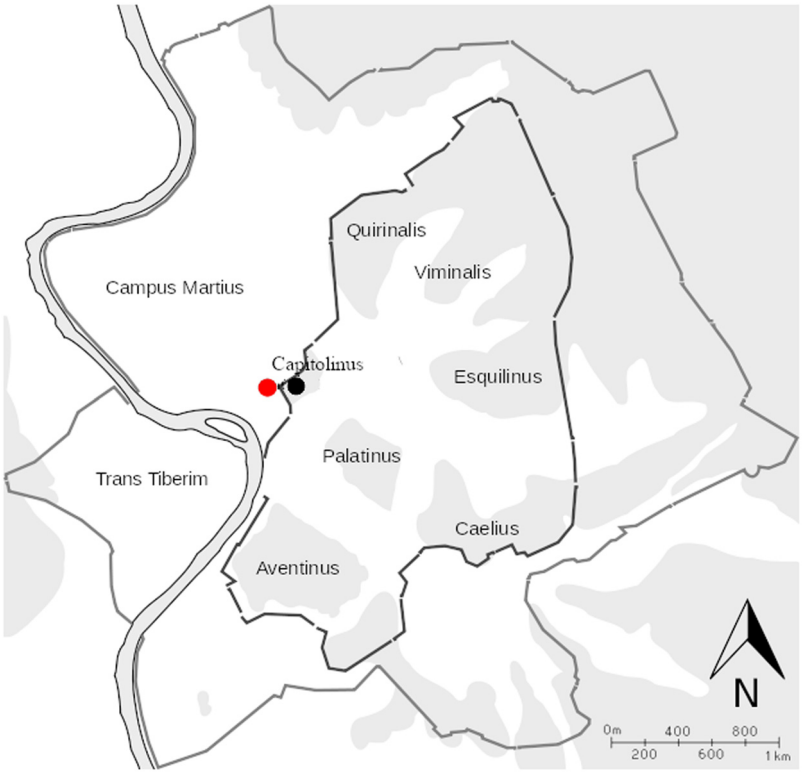

Figure 1: Plan of Rome with marked venues discussed in the article (black dot for Capitolium and red for the Temple of Bellona).

previously suggested in the literature. The reconstructions were built with an accuracy of 0.1 m, because in order to achieve realistic acoustic analysis results, higher accuracy is not needed, and the process would only increase the computational time. Objects close to the sound source were reconstructed with smaller details (where possible). Objects far away from the sound source were reconstructed more roughly. The models were constructed using Blender 2.91, according to the current knowledge of the possible appearance and construction of each structure during the Late Republican and Early Augustan periods. Export of the models to CATT-acoustic was made by plug-in created in authors team.

The state of research and the later centuries of transformation of the spaces of interest make our proposed reconstructions hypothetical in some details. This particularly concerns the reconstruction of the appearance of the Capitoline Hill, where we can only be fairly certain of the look and geometry of the Temple of Jupiter Optimus Maximus. The remaining buildings are debatable and their reconstructions, and even their spatial interrelations, differ considerably amongst the reconstructions proposed so far. After getting acquainted with the literature and contacting Alberto Danti, who was conducting the excavation from 2000 to 2018, it was decided to reconstruct the Capitoline Hill as it had already been reconstructed in model form in the Museum of Roman Civilisation (Museo della civiltà romana), with slight changes. There is very little certain information, so the reconstructions are mostly based on the experiences and intuitions of the researchers. For this reason, it was concluded that the best solution is to reconstruct the Capitoline Hill as the best-known structure and not to create a completely new version (Figure 2a and b. Bibliography for the reconstruction, see Appendix 1, 3D Virtual Reconstruction, see Appendix 2).[6]

For the Temple of Bellona at Campus Martius, together with the surrounding buildings, we made two reconstructions corresponding to two chronologically close periods. The first corresponds to the state of the Republican period, before the construction of the Theatre of Marcellus began during Caesar's dictatorship in 45 BCE[7] (cf. Suet.*Iul.*44, Cass. Dio 43.49.3) (Figure 2c). The second reflects the geometry of the space after the erection of the aforementioned theatre, which was finally commissioned in 13–11 BCE (Plin.*HN*.8.6 Cass. Dio 54.26.1, Ciancio Rossetto & Pisani Sartorio, 1999, pp. 31–35; Richardson, 1992, pp. 382–383) (Figure 2d). Again, the reconstruction, at least in part, is hypothetical. For, while the dimensions and spatial relationships of the main buildings (the Temple of Bellona itself, the adjacent Temple of Apollo Sosianus, or the Theatre of Marcellus) are not much in doubt, the state of research on the others does not always allow for an accurate reconstruction. In creating ours, we have relied on the results of archaeological research and on previous proposals to reconstruct this location in the period of interest, i.e. ca. 54 BCE and ca. 14 CE (Bibliography for the reconstruction, see Appendix 3, 3D Virtual Reconstruction, see Appendices 4 and 5).

2.2 Acoustic Analysis

We then uploaded the models to CATT-acoustics v9.1f, adding the acoustic properties of the materials used in the built environment of the venues. The most important factor we considered was sound absorption and scattering coefficients, which determine how much of the sound is not reflected by the surface it falls on. Its value, defined for six octave band frequencies between 125 and 4,000 Hz is between 0 and 1 (Tables 1 and 2). Most of the sound absorption coefficients were taken from CATT-acoustics database. Values for people were taken from Boren (2018). Sound scattering coefficients were roughly estimated based on similar materials given in Cox and D'Antonio (2009).

In each case, the place where the speaker stood (assuming he was in the middle of the speaking platform, as close to the front as possible) and the sound power spectrum were defined. Each time we used the sound level and directivity of "human_singer," defined by sound pressure level (SPL) at a distance of 1 m, as presented in Table 3. Sound source was situated 1.5 m above the floor surface.

For each simulation, the sound source generated 500,000 cones (energy particles). The cones travelled in straight lines, bouncing off the surfaces they encountered. Depending on the acoustic properties of the materials the surfaces were made of (or covered with), some of the acoustic energy was absorbed and/or

6 All appendixes are available at: https://doi.org/10.5281/zenodo.7773048.

7 There is still a lively debate over whether Caesar actually started the construction of this theatre, see Tucci (2022).

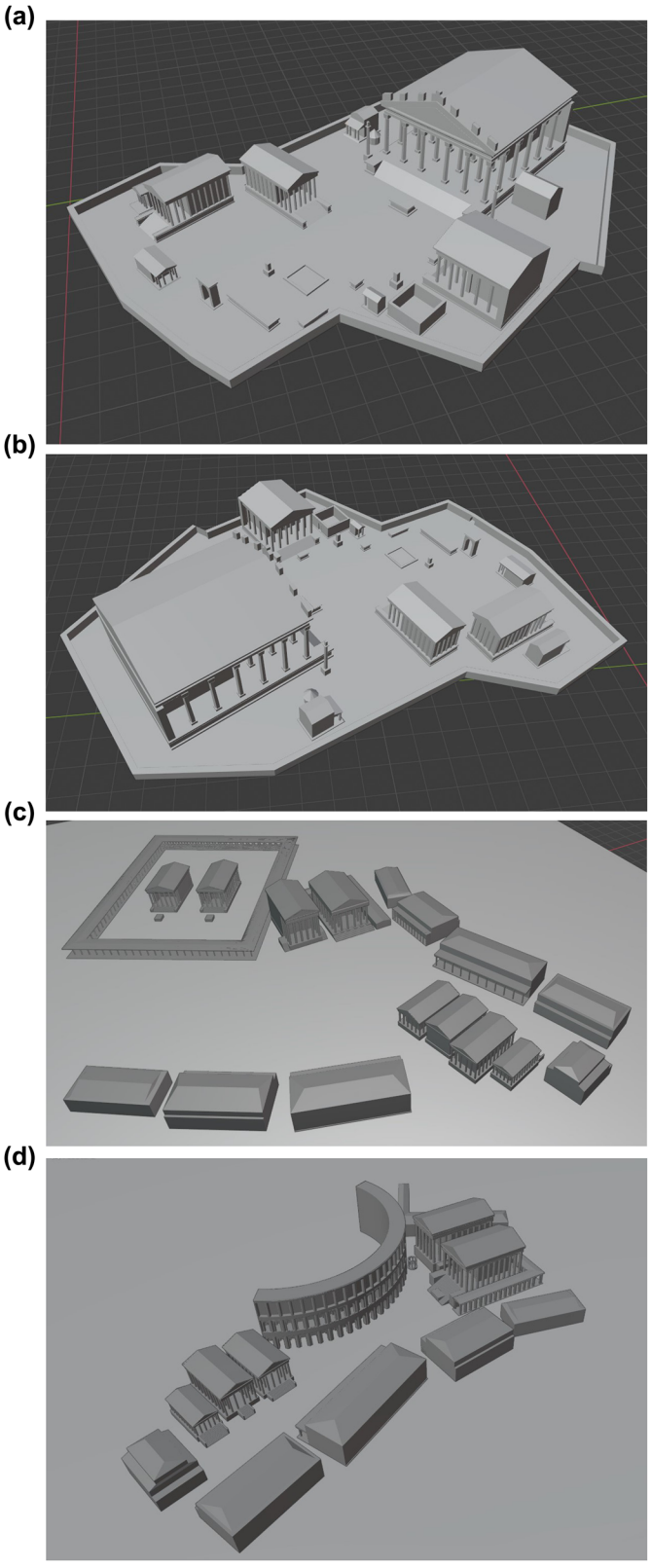

Figure 2: (a) Screenshot of the 3D model of the Capitoline Hill. (b) Screenshot of the 3D model of the Capitoline Hill, alternate view. (c) Screenshot of the 3D model of the Republican period Temple of Bellona with surroundings. (d) Screenshot of the 3D model of the Early Imperial period Temple of Bellona with surroundings.

Table 1: Sound absorption coefficients for materials used in models

	Frequency (Hz)					
Material	**125**	**250**	**500**	**1,000**	**2,000**	**4,000**
Plaster	0.02	0.02	0.03	0.03	0.04	0.05
Terracotta	0.08	0.09	0.12	0.16	0.22	0.24
Bronze	0.01	0.01	0.01	0.01	0.02	0.02
Wood	0.14	0.1	0.06	0.08	0.10	0.10
Marble	0.01	0.01	0.01	0.01	0.02	0.02
Glass	0.35	0.25	0.18	0.1	0.06	0.03
Tuff	0.05	0.05	0.05	0.08	0.14	0.20
People	0.24	0.47	0.94	0.99	0.99	0.99

Table 2: Sound scattering coefficients for materials used in models

	Frequency (Hz)					
Material	**125**	**250**	**500**	**1,000**	**2,000**	**4,000**
Plaster	0.10	0.10	0.10	0.10	0.10	0.10
Terracotta	0.10	0.10	0.10	0.10	0.10	0.10
Bronze	0.10	0.10	0.20	0.20	0.30	0.30
Wood	0.10	0.10	0.10	0.15	0.15	0.20
Marble	0.04	0.04	0.04	0.06	0.06	0.10
Glass	0.05	0.05	0.05	0.05	0.05	0.05
Tuff	0.10	0.10	0.10	0.10	0.10	0.10
People	0.10	0.20	0.30	0.30	0.40	0.50

Table 3: SPL in dBA at 1 m distance from sound source defined for speaker

Frequency (Hz)					
125	**250**	**500**	**1,000**	**2,000**	**4,000**
58	64	70.3	70.7	65.9	59.9

Note: Values are taken from CATT-acoustic database (Dalenbäck, 2019) for loud voice as an average for males and females.

scattered. The map of audience situated 1.5 m above the floor surface recorded the energy and time the cones reached them. Based on the cone registration data, echograms were created for the map of audience in 2 m steps, which then became the basis for determining the acoustic parameters of the venues (Dalenbäck, 1996). TUCT2 ray/cone tracing model was used to perform the calculations.

The most important acoustic parameter for determining speech audibility is the Speech Transmission Index (STI), which takes into account the reverberation time, the level of speech, and the level of background noise. According to IEC 60268-16 international standard (International Electrotechnical Commission 2020), STI between 0.00 and 0.30 is bad, 0.30–0.45 is poor, 0.45–0.60 is fair, 0.60–0.75 is good, and 0.75–1.00 is excellent. In our simulations, we determined the STI for all areas of a given venue not occupied by other buildings. It was assumed that in areas with STI above 0.45 (fair and better), the speech is intelligible and good enough. Values indicating "poor" intelligibility (0.30–0.45) were disregarded, because the low STI values can be attributed to a low and fluctuating signal-to-noise ratio. In addition, Galbrun and Kitapci (2016) proved that for languages other than English, intelligibility is lower for the same STI value (especially below 0.45). In order to compare

Table 4: SPL of background noise defined for STI calculations (Vassilantonopoulos & Mourjopoulos, 2003)

	Frequency (Hz)						
Background noise level	**125**	**250**	**500**	**1,000**	**2,000**	**4,000**	**Total (dBA)**
LLAN (dB)	45	38	32	28	25	23	36
TAN (dB)	40	46	49	42	38	34	49
RAN (dB)	46	52	55	48	44	40	55

results with Boren (2018), results for poor intelligibility were also given. To simulate different scenarios, we assumed three different background noise levels: "low-level ambient noise" (36 dBA,[8] LLAN), "typical audience noise" (49 dBA, TAN), and "raised audience noise" (55 dBA, RAN) (*cf.* Table 4). LLAN is typical of silent crowds not moving much. TAN characterises the modern theatre audience, which behaves quietly. RAN instead can be compared to the background noise in the centres of modern cities, where there is no traffic.

The most realistic scenario for the centre of ancient Rome seems to be the RAN scenario, but in reality, the level of background noise for the public assemblies of interest probably fluctuated between the TAN and RAN scenarios, sometimes probably even exceeding them (*cf.* i.e. Plut.*Vit*.*Pomp*.25.6[9]).

2.3 Crowd Size Estimation

Today, the estimation of crowd sizes is automated and based on the analysis of images, usually taken from the air (Ma, Li, Huang, & Tian, 2004; Marana, 1997; Marana, Velastin, Costa, & Lotufo, 1998; Yin, Velastin, & Davies, 1996). However, taking into account the fact that we do not have pictures of ancient assemblies, and that those presented in iconographic sources have only a symbolic dimension (Aldrete, 1999, pp. 47–49, 93–95, Figures 16–18; Hülsen, 1906, pp. 97–102, Figures 44–45; Torelli, 1993, pp. 77–79), we were forced to develop our own method based on observations of the behaviour of modern crowds (Kopij & Pilch, 2019). According to them, the average person occupies approximately 0.2 m^2. Consequently, each square metre should be able to accommodate a maximum of five people. In reality, this limit is sometimes exceeded, but only for a short time and in exceptional circumstances. The stress of such crowding causes the crowd to thin out, if possible (Still, 2014, pp. 43–44). The usual crowd density for public appearances similar to those analysed by us is, however, between one and four persons per square metre. Based on these observations, we can assume different crowd density scenarios by multiplying the crowd density factor (between one and five people per square metre) with the areas obtained from the acoustic analysis. It is worth noting, however, that today the density of a crowd is rarely constant within it. It is usually denser closer to the speaker, and the ratio decreases with distance (Still, 2014, p. 36). To make our calculations more realistic, we therefore decided to estimate the crowd size by taking into account the density moderated by the hearing zones resulting from the acoustic analysis. Thus, we assume that the crowd density in the excellent STI zone, was five persons per square metre, in the good STI zone, four persons per square metre, and in the fair STI zone, three persons per square metre (Kopij & Pilch, 2019).

8 dBA or A-weighted decibel corresponds to the relative loudness of sounds as perceived by the human ear. The human ear's sensitivity to different frequencies of sound varies, which means that on the standard decibel (dB) scale, lower and higher frequencies are assigned comparatively lower weight.

9 Interestingly, the hero of the anecdote quoted by Plutarch is the same Roscius mentioned in the introduction of the article. According to the ancient biographer, the noise at the assembly was so great that Roscius' speech could not be heard. Not discouraged by this, the tribune conveyed his position on the issue under discussion (supposedly with success) by means of hand gestures.

Table 5: Results for the "Podium scenario" of the Capitoline Hill

Intelligibility of speech	STI range	Area in m^2	Density (mean) in persons per m^2	Results with mean density in no. of persons	Density (moderated) in persons per m^2	Results with moderated density in no. of persons
Background noise: RAN (55 dBA)						
Excellent	0.75–1.00	4	3	12	5	20
Good	0.60–0.75	4	3	12	4	16
Fair	0.45–0.60	52	3	156	3	156
Poor	0.30–0.45	260	3		2	
Bad	0.00–0.30	4,652	3		1	
	Sum			**180**		**192**
Background noise: TAN (49 dBA)						
Excellent	0.75–1.00	4	3	12	5	20
Good	0.60–0.75	52	3	156	4	208
Fair	0.45–0.60	292	3	876	3	876
Poor	0.30–0.45	1,180	3		2	
Bad	0.00–0.30	3,444	3		1	
	Sum			**1,044**		**1,104**
Background noise: LLAN (36 dBA)						
Excellent	0.75–1.00	120	3	360	5	600
Good	0.60–0.75	916	3	2,748	4	3,664
Fair	0.45–0.60	1,856	3	5,568	3	5,568
Poor	0.30–0.45	1,088	3		2	
Bad	0.00–0.30	992	3		1	
	Sum			**8,676**		**9,832**

3 Results

In the case of the Capitoline Hill, we unfortunately do not have more detailed information on the location of the speaker and his orientation. For, in the case of this temple, we know nothing about the existence of a clearly marked *rostra*. Biliński (1961, p. 269) postulated that during Tiberius Gracchus' attempt for re-election as tribune, he was positioned atop the podium of the Capitoline temple, potentially on a platform specifically arranged for the occasion. However, Ulrich speculated that the temporary platform could have been situated in front of the temple or integrated into the podium itself (Ulrich, 1994, pp. 64–66). Similarly, Taylor considered the latter possibility as the more likely scenario (Taylor, 1966, p. 20). Consequently, we run simulations for two scenarios. First, we assumed that the speaker was standing at the top of the stairs leading to the temple's podium ("Podium scenario"). He was speaking facing a potential crowd gathered at the foot of the temple (and partly on its steps). It is possible, however, that the speaker may have been speaking from the monumental altar located in front of the temple facing the Forum Romanum ("Altar scenario").

Our simulations for the "Podium scenario" show that for the RAN background noise level of the (55 dBA), the group of people who could hear the speaker intelligibly does not exceed 200 participants. This is approximately 180 people for the average crowd density factor, and 192 people for the density moderated by STI zones. The number of individuals who could hear the speaker intelligibly increases to approximately 1,044 and 1,104 in the TAN setting (49 dBA). In the least-probable LLAN setting (36 dBA), the speaker's words could be understood by roughly 8,676 and 9,832 individuals. The results are summarised in Table 5 and Figures 3–5 (cf. Appendices 6–8).

Figure 3: STI map for the "Podium scenario" of the Capitolium at RAN.

Figure 4: STI map for the "Podium scenario" of the Capitolium at TAN.

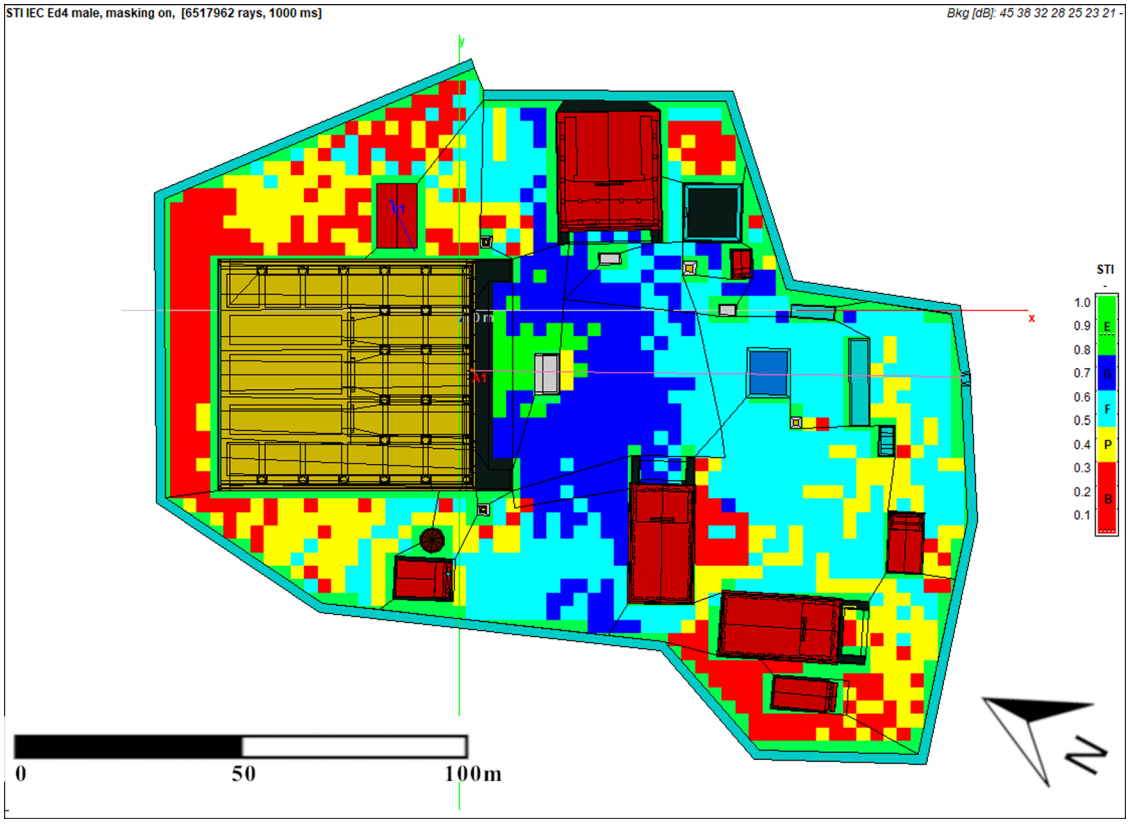

Figure 5: STI map for the "Podium scenario" of the Capitolium at LLAN.

Table 6: Results for the "Altar scenario" of the Capitoline Hill

Intelligibility of speech	STI range	Area in m^2	Density (mean) in persons per m^2	Results with mean density in no. of persons	Density (moderated) in persons per m^2	Results with moderated density in no. of persons
Background noise: RAN (55 dBA)						
Excellent	0.75–1.00	4	3	12	5	20
Good	0.60–0.75	24	3	72	4	96
Fair	0.45–0.60	132	3	396	3	396
Poor	0.30–0.45	496	3		2	
Bad	0.00–0.30	4,316	3		1	
		Sum		**480**		**512**
Background noise: TAN (49 dBA)						
Excellent	0.75–1.00	32	3	96	5	160
Good	0.60–0.75	144	3	432	4	576
Fair	0.45–0.60	508	3	1,524	3	1,524
Poor	0.30–0.45	1,076	3		2	
Bad	0.00–0.30	3,212	3		1	
		Sum		**2,052**		**2,260**
Background noise: LLAN (36 dBA)						
Excellent	0.75–1.00	320	3	960	5	1,600
Good	0.60–0.75	948	3	2,844	4	3,792
Fair	0.45–0.60	1,724	3	5,172	3	5,172
Poor	0.30–0.45	988	3		2	
Bad	0.00–0.30	992	3		1	
		Sum		**8,976**		**10,564**

Figure 6: STI map for the "Altar scenario" of the Capitolium at RAN.

The simulations for the "Altar scenario" instead indicate that for the background noise level of the RAN (55 dBA), the group of people who could hear the speaker intelligibly was much greater reaching approximately 500 participants. This is approximately 480 people for the average crowd density factor, and 512 people for the density factor moderated by the STI zones. In the TAN setup (49 dBA), these figures rise to approximately 2,052 and 2,260 people, respectively. In the least-realistic LLAN setting (36 dBA), the speaker could be intelligibly heard by approximately 8,976 and 10,564 people, respectively. The results are summarised in Table 6 and Figures 6–8 (cf. Appendices 9–11).

In the case of the Temple of Bellona, we can assume that the speaker was standing on its podium, speaking towards the square in front of the temple. The area of this square was significantly reduced with the construction of the Theatre of Marcellus. Our simulations for the Republican period for the RAN setup indicate that a speaker delivering from that location was heard intelligibly by approximately 384 people, when we assume the average crowd density, and 428 people for the moderated density. In the TAN setting, these numbers rise to approximately 1,500 and 1,668 people, respectively. And for the LLAN setup, there are approximately 13,344 and 14,580 potential listeners. The results are summarised in Table 7 and Figures 9–11 (cf. Appendices 12–14).

The change in the geometry of the space associated with the construction of the Theatre of Marcellus significantly affected the size of the potential crowd that could gather in front of the temple and the acoustic properties of the space. For the RAN setup, the number of people who could hear the speaker intelligibly was approximately 264 for the average density and 288 for moderated density. In the TAN scenario, these numbers increase to approximately 1,344 and 1,432 people, respectively. And for the LLAN setting, they were approximately 7,092 and 7,688 people, respectively. The results are summarised in Table 8 and Figures 12–14 (cf. Appendices 15–17).

Figure 7: STI map for the “Altar scenario” of the Capitolium at TAN.

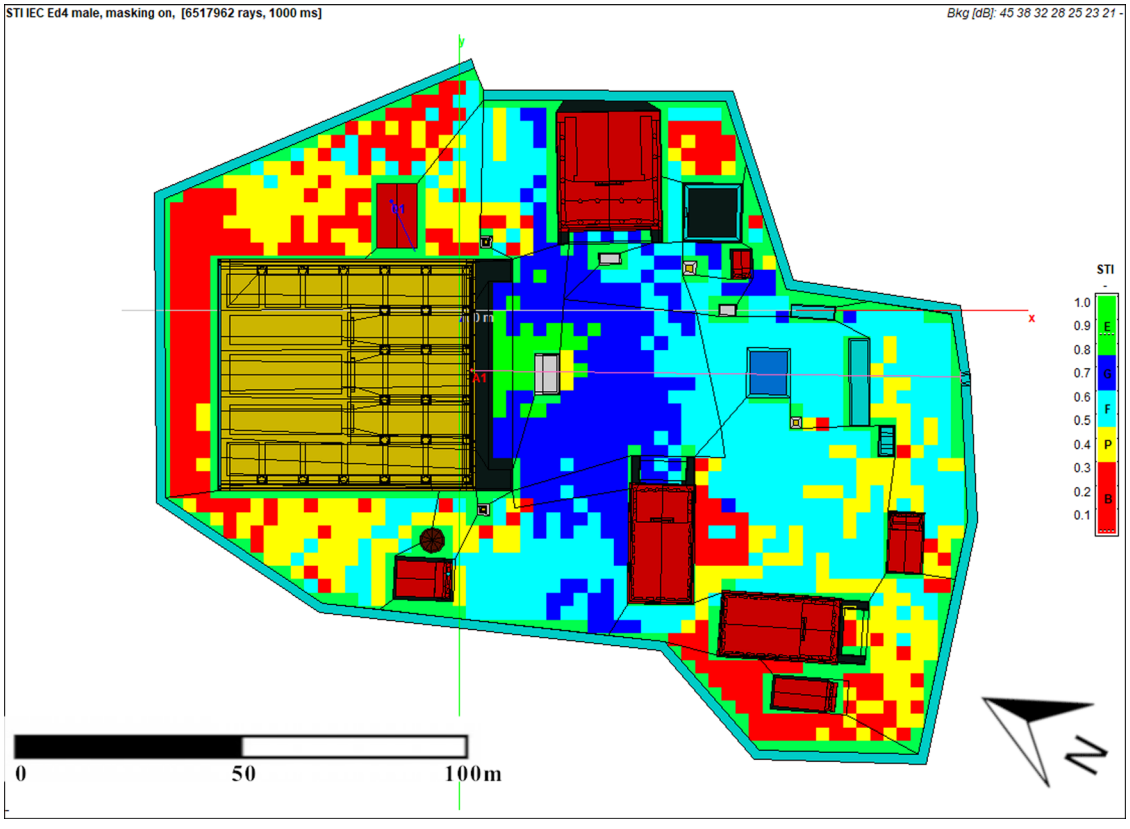

Figure 8: STI map for the “Altar scenario” of the Capitolium at LLAN.

Table 7: Results for the Temple of Bellona in the Late Republican Period

Intelligibility of speech	STI range	Area in m^2	Density (mean) in persons per m^2	Results with mean density in no. of persons	Density (moderated) in persons per m^2	Results with moderated density in no. of persons
Background noise: RAN (55 dBA)						
Excellent	0.75–1.00	8	3	24	5	40
Good	0.60–0.75	28	3	84	4	112
Fair	0.45–0.60	92	3	276	3	276
Poor	0.30–0.45	352	3		2	
Bad	0.00–0.30	219,996	3		1	
		Sum		**384**		**428**
Background noise: TAN (49 dBA)						
Excellent	0.75–1.00	32	3	96	5	160
Good	0.60–0.75	104	3	312	4	416
Fair	0.45–0.60	364	3	1,062	3	1,092
Poor	0.30–0.45	1,240	3		2	
Bad	0.00–0.30	218,736	3		1	
		Sum		**1,500**		**1,668**
Background noise: LLAN (36 dBA)						
Excellent	0.75–1.00	260	3	780	5	1,300
Good	0.60–0.75	716	3	2,148	4	2,864
Fair	0.45–0.60	3,472	3	10,416	3	10,416
Poor	0.30–0.45	10,300	3		2	
Bad	0.00–0.30	205,728	3		1	
		Sum		**13,344**		**14,580**

Figure 9: STI map for the Temple of Bellona in Late Republican period at RAN.

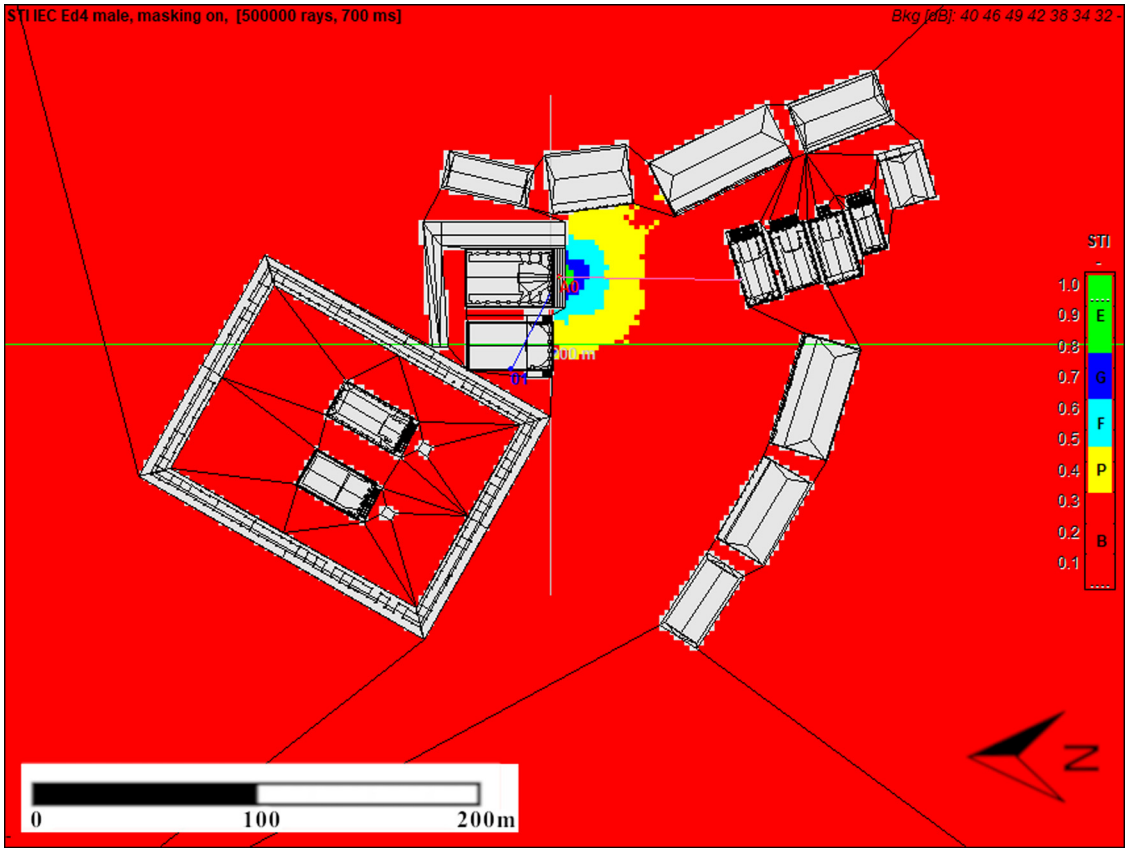

Figure 10: STI map for the Temple of Bellona in Late Republican period at TAN.

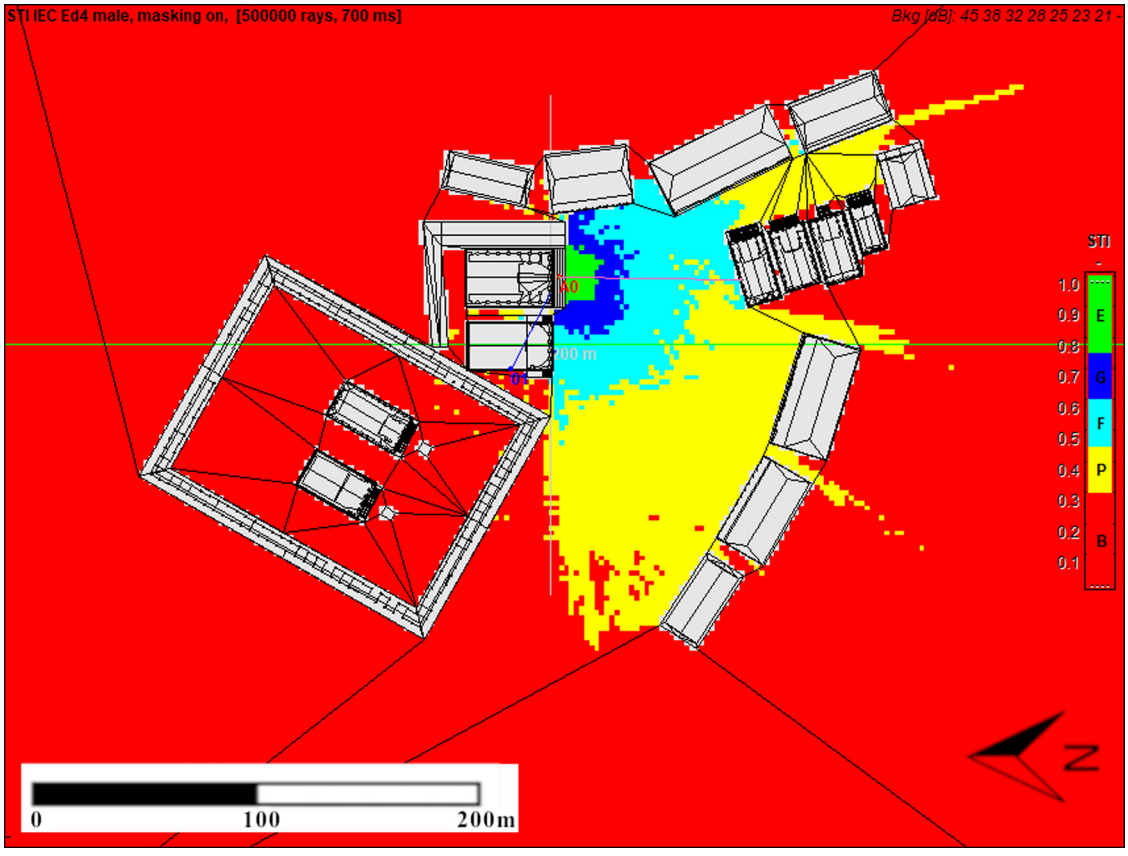

Figure 11: STI map for the Temple of Bellona in Late Republican period at LLAN.

Table 8: Results for the Temple of Bellona in the Early Imperial Period

Intelligibility of speech	STI range	Area in m^2	Density (mean) in persons per m^2	Results with mean density in no. of persons	Density (moderated) in persons per m^2	Results with moderated density in no. of persons
Background noise: RAN (55 dBA)						
Excellent	0.75–1.00	0	3	0	5	0
Good	0.60–0.75	24	3	72	4	96
Fair	0.45–0.60	64	3	192	3	192
Poor	0.30–0.45	412	3		2	
Bad	0.00–0.30	226,772	3		1	
		Sum		**264**		**288**
Background noise: TAN (49 dBA)						
Excellent	0.75–1.00	12	3	36	5	60
Good	0.60–0.75	64	3	192	4	256
Fair	0.45–0.60	372	3	1,116	3	1,116
Poor	0.30–0.45	964	3		2	
Bad	0.00–0.30	225,860	3		1	
		Sum		**1,344**		**1,432**
Background noise: LLAN (36 dBA)						
Excellent	0.75–1.00	64	3	192	5	320
Good	0.60–0.75	468	3	1,404	4	1,872
Fair	0.45–0.60	1,832	3	5,496	3	5,496
Poor	0.30–0.45	3,044	3		2	
Bad	0.00–0.30	221,864	3		1	
		Sum		**7,092**		**7,688**

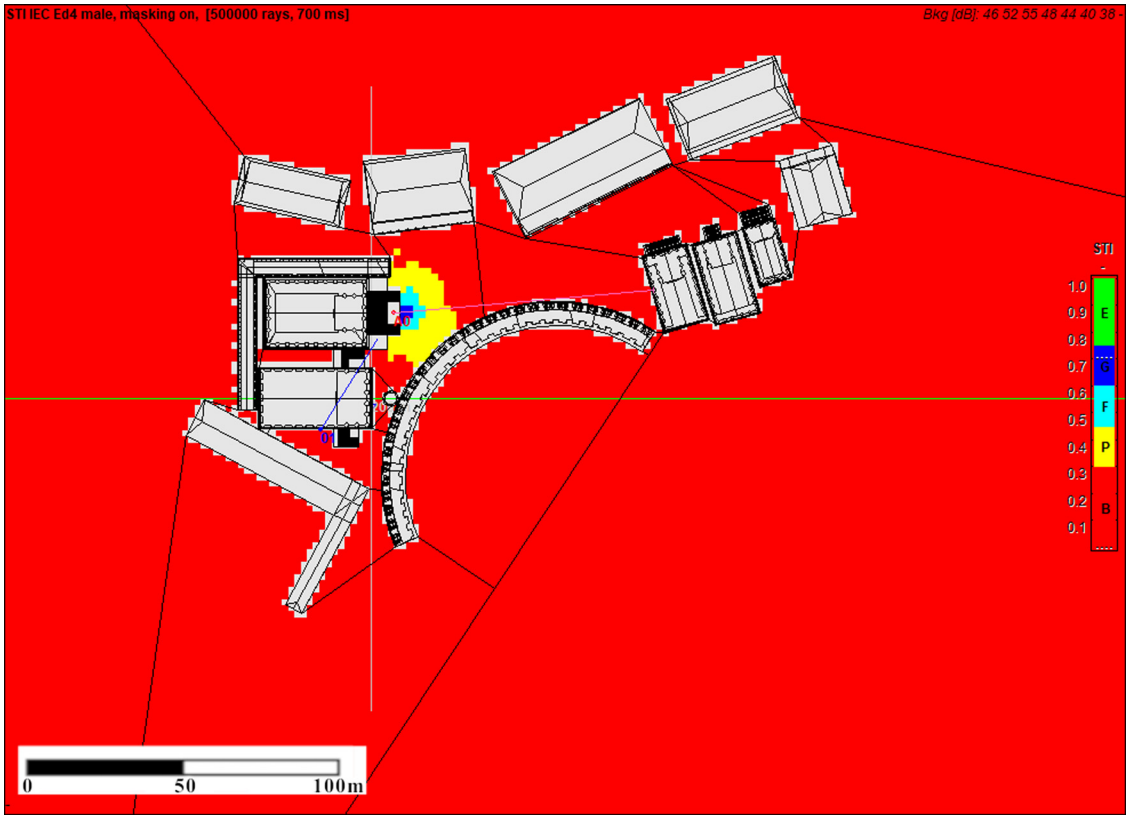

Figure 12: STI map for the Temple of Bellona in Late Augustan period at RAN.

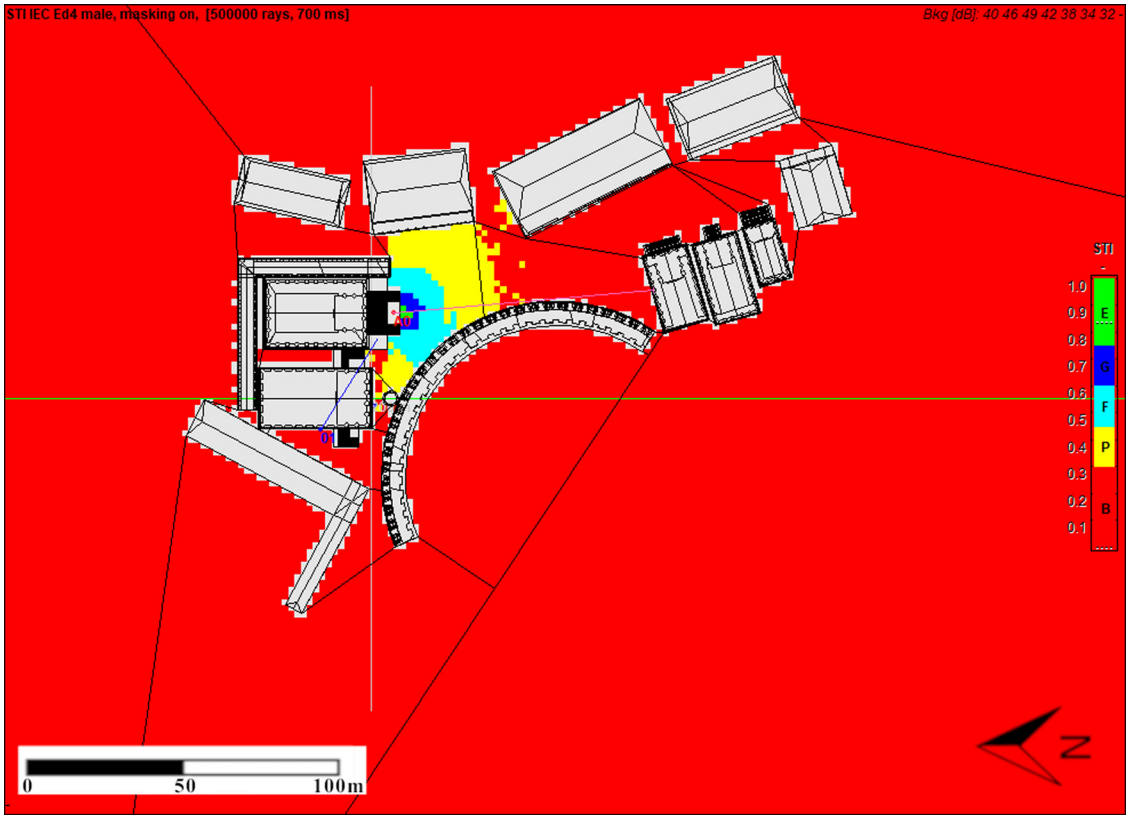

Figure 13: STI map for the Temple of Bellona in Late Augustan period at TAN.

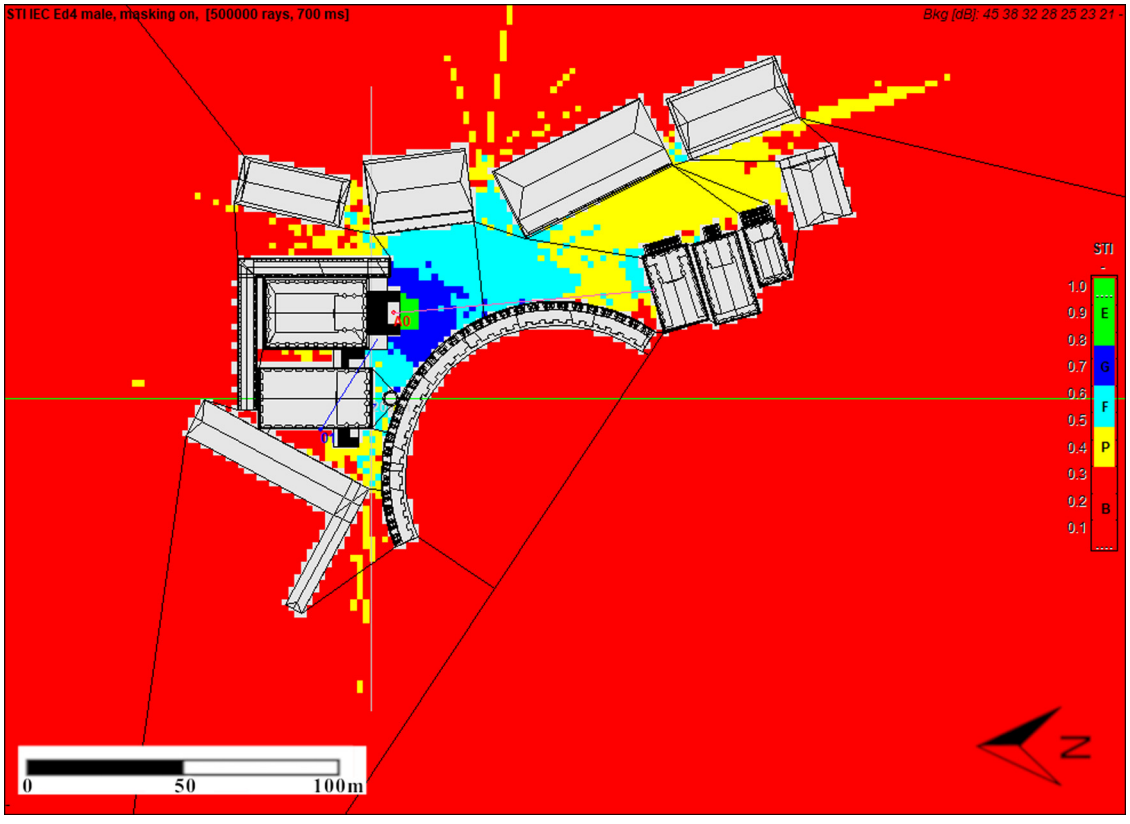

Figure 14: STI map for the Temple of Bellona in Late Augustan period at LLAN.

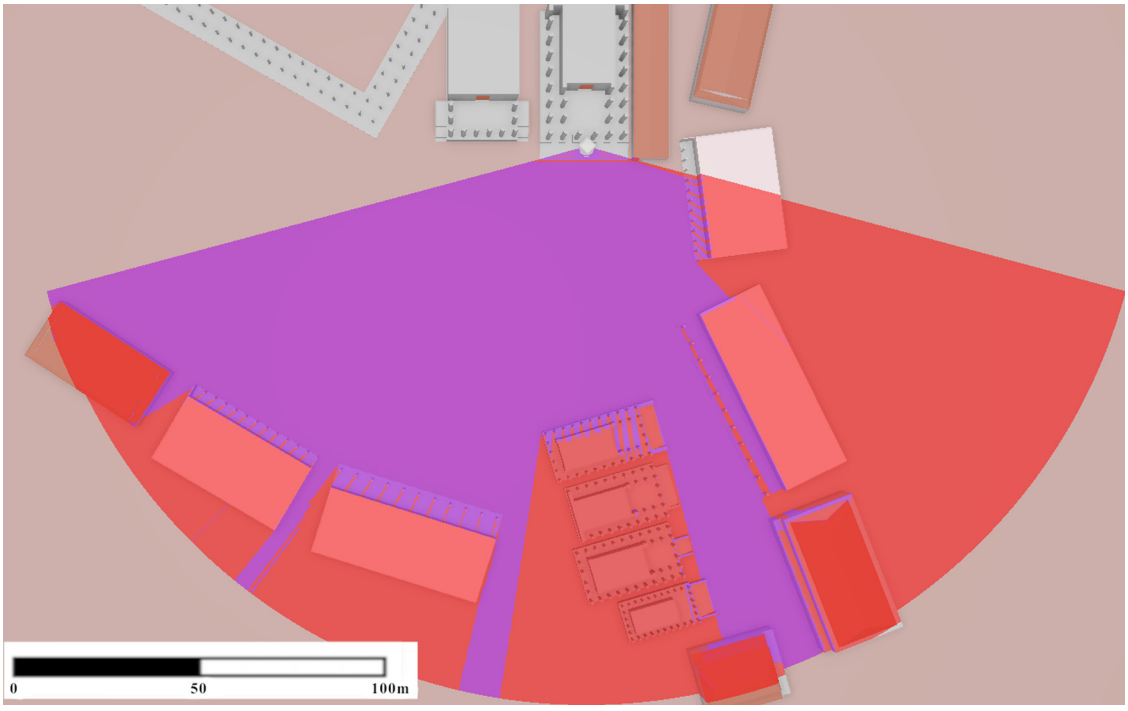

Figure 15: Viewshed analysis for a speaker standing at the podium of Late Republican Temple of Bellona.

4 Discussion

First, comparing the simulation outcomes for the two scenarios involving the placement of the speaker at the Capitoline temple area, it was observed that speaking from the altar located in front of the temple had a significant advantage in terms of reaching a larger audience who could clearly comprehend the speech, as opposed to speaking from the temple stairs.[10] In addition to the acoustic properties of the space, this is related to the fact that people can gather around the speaker and not just in front of him. When considering the RAN setup, the estimated audience size in front of the temple was only around 37% of the potential attendees who could have gathered around the altar and heard the speaker's words distinctly (approximately 180–192 vs 480–512 attendees, respectively). In the case of the TAN setting, the percentage difference is smaller, as it turns out that the crowd is approximately 1,044–1,104 people for a speaker delivering his speech from the temple steps and 2,052–2,260 for a speaker delivering the speech from the altar. Although speaking from the altar was possible (after all, it was a location for other public rituals), the results imply that future reconstructions of the Capitoline temple from this era should consider the option of a speaking platform incorporated into the temple steps which has already been considered by Biliński (1961, p. 269), Taylor (1966, p. 20), and Ulrich (1994, pp. 64–66), but has not been included in any reconstruction to date. It is important to mention, nonetheless, that no iconographic source provides evidence of the existence of such a platform at that site.

Before comparing the results of the acoustic simulations for the two phases of the Temple of Bellona, it is worth looking at how the total available space in front of the temple in both periods – which could theoretically be occupied by assembly participants – has changed. The visibility analysis[11] shows that the area available during the Republican period was approximately 12,500 m^2, whereas the construction of the Theatre of Marcellus reduced it to less than a third of this value, i.e., approximately 4,000 m^2 (*cf.* Figures 15

10 Further, when we speak of the maximum crowd size, crowd(s), or potential "capacity" we will always mean "the maximum number of people who could intelligibly hear the speaker" unless we make it clear that we are referring to something else.

11 The visibility analysis was carried out in ArcGIS Pro 2.9.0 using the Viewshed analysis within the Exploratory 3D Analysis. The parameters used in the analysis are included in Appendix 18.

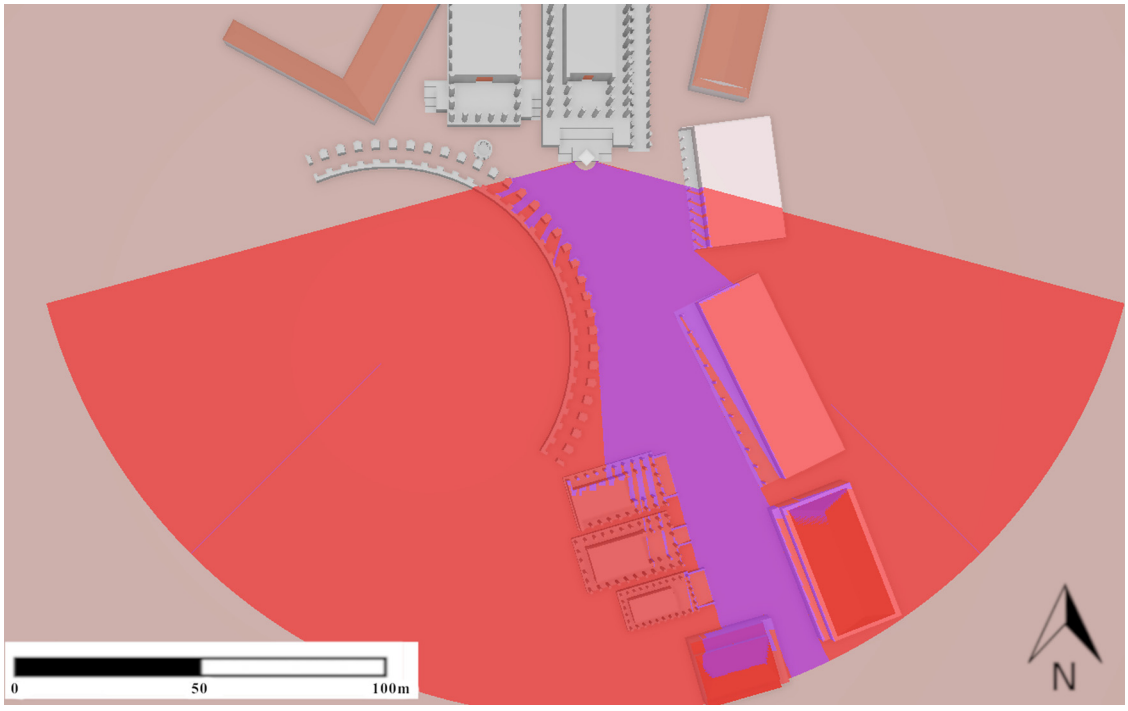

Figure 16: Viewshed analysis for a speaker standing at the podium of Late Augustan Temple of Bellona.

and 16). Although the areas where speech was intelligibly heard cover much smaller areas, the changes in the built environment – most notably the rebuilding of the temple itself and the construction of the Theatre of Marcellus – also negatively affected the size of the potential crowds.

In the RAN scenario during the Republican period, intelligible speech could only be heard by approximately between 384 and 428 people, depending on how the crowd size was estimated. In the early Imperial period, these potential crowd sizes reduced to approximately between 264 and 288. Although these figures are generally not impressively high, they represent a sizable reduction of more than 30%.

When we consider the TAN scenario in the Republican period, the ancient rhetors' speeches would have been heard intelligibly by approximately between 1,500 and 1,668 people, depending on how the crowd size is estimated, and in the Imperial period approximately between 1,344 and 1,432 people. This represents a reduction of approximately 10–15% between the Republican and Imperial periods.

In the least-likely scenario of the LLAN, during the Republican period, speeches delivered from the podium of the Temple of Bellona could be heard by approximately between 13,344 and 14,580 people, depending on how the crowd size is estimated. In the Imperial period, this figure drops to approximately between 7,092 and 7,688 people. Only in this case does the construction of the Theatre of Marcellus directly affects the size of the potential crowd, rather than by changing the acoustic properties of the space in front of the temple. The reduction in crowd size during the Imperial period relative to the Republican period in this scenario is almost 50%.

We can now compare these results with the acoustic simulation outcomes for the Capitolium. To begin with, it should be highlighted that the "Podium scenario" for the Capitoline temple has a lower potential maximum crowd size compared to the temple of Bellona in its both phases. According to the simulation results, the estimated maximum crowd in front of the Capitoline temple is over 50% smaller than that in front of the temple of Bellona for the RAN setup in the Republican period (approximately 215 people less), and over 30% smaller in the Imperial period (approximately 90 people less). At the TAN setting, the disparities are less pronounced, with the maximum crowd in front of the Capitoline temple being around 33% smaller than in front of the Bellona temple during the Republican period (approximately 500 participants less) and less than 25% smaller during the Imperial period (approximately 315 people less). When comparing the results for the

Table 9: Results from Holter et al., 2019

Venue	*Rostra* (*Comitium*)		*Rostra* (Forum)		Temple of Castores	
	Area in m^2	Crowd size	Area in m^2	Crowd size	Area in m^2	Crowd size
Zone 1[1]	2,650	10,600	2,300	9,200	2,950	11,800
Zone 2[2]	4,750	19,000	4,790	19,160	5,900	23,600

[1]The authors describe the zone as, "the space in which a listener would have been able to understand very well." [2]The authors describe the zone as, "the space in which the listener would still be able to understand, albeit only with intense concentration."

Bellona temple with the "Altar scenario" of the Capitoline temple, an inverse relationship between maximum crowd sizes can be observed. In the Republican period, at the RAN setting, the crowd in front of the Bellona temple was approximately 20% smaller (approximately 100 people less), while in the Imperial period it was approximately 45% smaller (approximately 225 people less). On the other hand, for the TAN setup, the crowd in front of the Bellona shrine was slightly more than 25% smaller (approximately 560 persons less) during the Republican period and one third smaller (approximately 700 persons less) during the Imperial period.

We can also cross-reference our results with other studies of this type for other venues in ancient Rome. To date, the results of two such studies have been published. The first investigated the maximum number of people who could hear intelligible speeches delivered from the *rostra vetera* towards the *Comitium* and towards the open space of the Forum Romanum as well as the Temple of Castores in the Late Republican period (Holter et al., 2019). Although the study was carried out for a similar period, the results are difficult to compare directly, as the authors of the study did not express variables such as the SPL of the source and, above all, background noise by numbers. For the latter variable, it was only indicated that the source was a recording from St Peter's Square in the Vatican during the Sunday Angelus prayer of the Pope (which is a good idea; it is unfortunate that the authors did not express this numerically). The only variable expressed numerically was a crowd density of four people per square metre. The results are summarised in Table 9.

The differences in results are striking and can in no way be explained by variations in space geometry alone. They must result primarily from the use of different values of variables, above all SPL and background noise level. A comparison with our results (Table 10) shows that Holter et al. used a very low background noise value. Even with its value at the LLAN setup – which we believe is unrealistic – only the results for the Republican phase of the venue in front of the Temple of Bellona fall within a range containing similar values. Using the same crowd density factor, its "capacity" could have reached approximately 17,792 people. In that case, the Capitolium with a "capacity" of approximately 11,024 people would, in turn, fall within the lower limits of the ranges proposed by Holter et al. All this indicates, in our opinion, that these results need to be verified, as they are overestimated due to the assumption of unrealistic background noise levels.

It is easier to compare our results with those of our preliminary study of the Forum Romanum (Kopij & Pilch, 2019) because everything was expressed in numbers in the same way (*cf*. Table 11). This study included the *rostra Augusti* and the podium of the Temple of Castores after the removal of the Temple of Deified Caesar (*aedes divi Iulii*). The biggest methodological problem with the study, which was primarily to test the method, is

Table 10: Our results with the density of crowd = 4 persons/m^2

Venue	Bellona (Republican)		Bellona (Imperial)		Capitolium (Podium)		Capitolium (Altar)	
STI	Area in m^2	Crowd size	Area in m^2	Crowd size	Area in m^2	Crowd size	Area in m^2	Crowd size
Excellent	260	1,040	64	256	120	480	320	1,280
Good	716	2,864	468	1,872	916	3,664	948	3,792
Fair	3,472	13,888	1,832	7,328	1,856	7,424	1,724	6,896
Sum	**4,448**	**17,792**	**2,364**	**9,456**	**2,892**	**11,568**	**2,992**	**11,968**

Table 11: Results from Kopij & Pilch, 2019

	55 dBA		49 dBA		36 dBA	
	Rostra	**Temple of Castor**	**Rostra**	**Temple of Castor**	**Rostra**	**Temple of Castor**
Mean density[1]	336	357	1,323	1,284	6,651	5,929
Moderated density[2]	351	375	1,423	1,383		

[1]Three persons per square meter.
[2]Five, four, or three persons per square meter, depending on the STI value.

Table 12: Summary of crowd sizes for the RAN setup (55 dBA) ranked from largest to smallest

	Mean density	**Moderate density**
(a) Late Republican period		
Capitolium (altar)	480	512
Bellona (Republican)	384	428
Castores	357	375
Capitolium (podium)	180	192
(b) Early Imperial period		
Capitolium (altar)	480	512
Rostra Augusti	336	351
Bellona (Imperial)	264	288
Capitolium (podium)	180	192

that a slightly modified model of the Forum from the Late Roman period (ca. 320 CE) was used. This, in turn, differed in many details from the periods of the Late Republic and Early Empire that interested us most.

It is particularly notable that in the Late Republican Period both the venue at the altar of the Capitoline temple and the venue at the temple of Bellona performed better in terms of maximising the size of the crowd than the Temple of Castores, a popular speaking venue located in the Forum Romanum (cf. Table 12(a)). The worst performer in this respect is the podium of the Capitolium. Unfortunately, at the moment, we do not yet have our own simulation results for the Republican *rostra vetera*, and a direct comparison of the results with those of Holter et al. (2019) is not possible due to methodological differences. In the future, we intend to fill in these gaps in order to get a complete picture of the rhetorical landscape of the ancient city of Rome.

With regards to the Early Imperial period, the results so far show that the "Altar scenario" of the Capitolium had the greatest potential, followed by the *rostra Augusti* and the Temple of Bellona. Again, the podium of the Capitolium is the worst performer in this comparison (*cf.* Table 12(b)).

Table 13: Summary of crowd sizes for the TAN setup (49 dBA) ranked from largest to smallest

	Mean density	**Moderate density**
(a) Late Republican period		
Capitolium (altar)	2,052	2,260
Bellona (Republican)	1,500	1,668
Castores	1,284	1,383
Capitolium (podium)	1,044	1,104
(b) Early Imperial period		
Capitolium (altar)	2,052	2,260
Bellona (Imperial)	1,344	1,432
Rostra Augusti	1,323	1,423
Capitolium (podium)	1,044	1,104

Table 14: Summary of crowd sizes for the LLAN setup (36 dBA) ranked from largest to smallest

	Mean density	Moderate density
(a) Late Republican period		
Bellona (Republican)	13,344	14,580
Capitolium (altar)	8,976	10,564
Capitolium (podium)	8,676	9,832
Castores	5,929	not determined
(b) Early Imperial period		
Capitolium (altar)	8,976	10,564
Capitolium (podium)	8,676	9,832
Bellona (Imperial)	7,092	7,688
Rostra Augusti	6,651	not determined

For the Late Republican period, the same ranking also holds for the lower level of background noise, i.e., TAN (*cf.* Table 13(a)). Again, it can be concluded that the Altar area in front of the Capitoline temple provided the greatest "capacity." Interestingly, despite the erection of the Theatre of Marcellus, in the Early Imperial period the "capacity" of the venue in front of the temple of Bellona slightly exceeded the *rostra Augusti*, which must be considered the "nominal" rostra of this period in Rome (*cf.* Table 13(b)). The difference is, however, very small, leading to the conclusion that both venues had a similar capacity to maximise the people who could intelligibly hear the speeches delivered there.

Only for what we consider to be a least-realistic LLAN setup does the platforms located on the Capitoline Hill perform better. It ranks in terms of potential "capacity" behind the Temple of Bellona in the Republican period, and in the early Imperial period, it accommodates the largest number of people able to intelligibly hear the speakers of all the cases analysed. Interestingly, the worst performer in this respect is the *rostra Augusti* (*cf.* Table 14).

Arguably, only greater differences in the ability to maximise a crowd that could intelligibly hear public speeches were noticeable to the ancient Romans. The question is whether the difference of approximately 200 such people, as in the case of the Late Republican temple of Bellona and the temple of Castores for the TAN setup, was enough for them to notice the difference. If so, the speakers were free to consciously decide where they wanted to speak so as to achieve their objectives. This does not necessarily mean that they always chose venues that maximised the number of people who could intelligibly hear them. It is possible that sometimes the total capacity of the venue may have been more important to them, even if the vast majority of those gathered could not hear clearly what they were saying. In other cases, the venue may have been determined by other, less practical reasons, such as the nature of the issue raised by the speech, the proximity of other events (as in the case of the theatrical performance cited in the introduction), or yet other issues, such as the level of security in the case of Brutus' speech after Caesar's assassination (cf. Lendon, 2022, pp. 29–50). Only a full reconstruction of the rhetorical landscape of the ancient city of Rome will perhaps allow us to say how important the issue of audibility of speech was.

5 Summary

Speaking before the people was an important part of ancient Roman public life, especially during the Republican period. Although its importance declined during the Imperial period, public speaking remained an essential part of the duties of emperors and members of the imperial house. The aim of this article was to answer the question of how many people could intelligibly hear speeches delivered in two venues: the Capitoline Hill (for two scenarios for the positioning of the speaker) and in front of the Temple of Bellona in the Campus Martius in Rome (in this case, in two close historical periods: at the end of the Republic and in the late Augustan period). Carrying out acoustic simulations led us to answers that allowed us to compare

venues in terms of acoustic properties, looking for the one that maximised the number of people who could intelligibly hear speeches being given. Our findings indicate that, except for the LLAN (36 dBA), the speaking from the stairs in front of the Capitoline temple provided the worst acoustic conditions for maximising the audience size that can intelligibly hear the speaker. While historical sources do not explicitly mention the speaker's position, it is likely that speakers used a platform that was integrated into the temple's podium (as was the case with other *templa rostrata*), rather than the altar in front (which compares best according to our results). Hence, our results support the researchers who postulated the existence of such a platform, which has so far not been considered in reconstructions.

The location in front of the temple of Bellona is superior in terms of maximising the crowd to the steps of the Capitoline temple, but inferior to the altar situated in front of it. Later developments, particularly the erection of the Theatre of Marcellus in front of the temple, which reduced the total area available in front of it, worsened the acoustic properties, thus reducing the number of people who could potentially hear the speeches. Also, comparisons with studies of other speaking venues – the Republican *rostra vetera* and the Temple of Castores, both at the Forum Romanum – indicate that Temple of Bellona as well as the altar in front of the Capitolium had better acoustic properties. In this case, however, the results presented here should be considered preliminary as there are methodological limitations in the studies used for comparison. Properly positioning all the rostra by the maximum number of people who could intelligibly hear speakers can only be achieved by conducting simulations for historically accurate reconstructions of the Forum Romanum and the use of a comparable methodology.

Funding information: This research was funded by a grant from the National Science Centre, Poland entitled *One, two, three! Can everyone hear me? Can everyone see me? – Acoustics and proxemics of Roman 'contiones'* (project number 2019/35/D/HS3/00105). The Open access status of this article has received funding from the European Research Council under the European Union's Horizon 2020 research and innovation programme (2018–2024), grant agreement no. 787842.

Author contributions: K.K.: conceptualisation, methodology, design of the study, supervision, analysis (visibility analysis), writing – original draft preparation, and funding acquisition. A.P.: methodology, design of the study, analysis (acoustic simulations, crowd size calculations), visualisation, and writing – review and editing. M.D.: investigation (data collection for building model of the Capitolium), resources (building the 3D reconstruction of the Capitolium), and writing – review and editing. Sz.P.: investigation (data collection for building models of the Temple of Bellona), resources (building the 3D reconstruction of the Temple of Bellona), and writing – review and editing.

Conflict of interest: Authors state no conflict of interest.

Data availability statement: All data generated or analysed during this study are included in this published article and its supplementary files available at Zenodo https://doi.org/10.5281/zenodo.7773048.

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