ACOUSTICS, PERFORMERS AND AUDIENCES IN MEDIEVAL ENGLISH DRAMA

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1 INTRODUCTION

Although recent years have seen an increase in the number of acoustical studies focusing on historical sites of drama performances,[1] medieval drama acoustics is often omitted from research projects, due to its use of outdoor spaces and temporarily assembled stages. However, historical research has highlighted that medieval drama had the aim of reverencing Christ and communicating religious doctrine,[2] which indicates that the lines delivered and the music performed,[3] would have needed to be as intelligible and engaging as possible so that the Christian message could be transmitted to the audience.

The present paper focuses on the *York Mystery Plays* as a case study due to the importance of aural considerations in the text.[4] The *York Mystery Plays* is a series of 48 plays that narrate events of relevance to the Christian faith and were performed in York (UK) from the XIV to the XVI century. Performances were at predetermined 'stations' (street spaces) on wagons that were designed for the occasion. Previous research by the author explored the use of impulse response measurements as well as computer models to study the acoustics of one of the playing 'stations': Stonegate.[5] Research on medieval Stonegate explored the use of multiple computer models to study the historical unknowns in relation to the architectural characteristics of the space and their impact on acoustics, resulting in four different simulations (Table 1).[6] The author also explored the acoustical impact of two different wagon structures with two different orientations (Table 2) in connection to their incorporation to the simulations of Stonegate.[7] The present paper extends this research project by exploring the variations in performer positions as well as the inclusion of audience areas.

Version of Medieval Stonegate	No. of Building Storeys	Glass/wooden shutters in windows
1	2	Yes
2	2	No
3	3	Yes
4	3	No

Table 1 – Versions of Medieval Stonegate used for computer models

Wagon	Wagon Type	Wagon Orientation
CL-SI	Closed	Side-on
CL-FR	Closed	Front-on
OP-SI	Open	Side-on
OP-FR	Open	Front-on

Table 2 – Versions of wagon structures added to the computer models of Stonegate. Closed wagons are multi-level structures closed on three sides with curtains. Open wagons were simulated as being open on 4 sides with 4 columns supporting a pitched roof. Side-on refers to performing towards one of the sides of the street, whereas front-on refers to performing towards one of the ends of the street.

2 PERFORMERS AND AUDIENCES IN THE *YORK MYSTERY PLAYS*

2.1 Historical Research and Computer Models

Studies on the *York Mystery Plays* are faced with the challenge of working with information that is scarce and open to several interpretations. The use of computer models for acoustics work makes it possible to explore different theories on staging and performance. A topic of discussion in scholarly work on the plays is the position of performers and audiences. Regarding performers, scholars have analyzed 2 main options: at street level, and atop the wagon deck.[8] The acoustic impact of these options was studied through the inclusion of a variety of sound source positions to the computer models (Figure 1) and conducting the comparative analyses listed in Table 3.

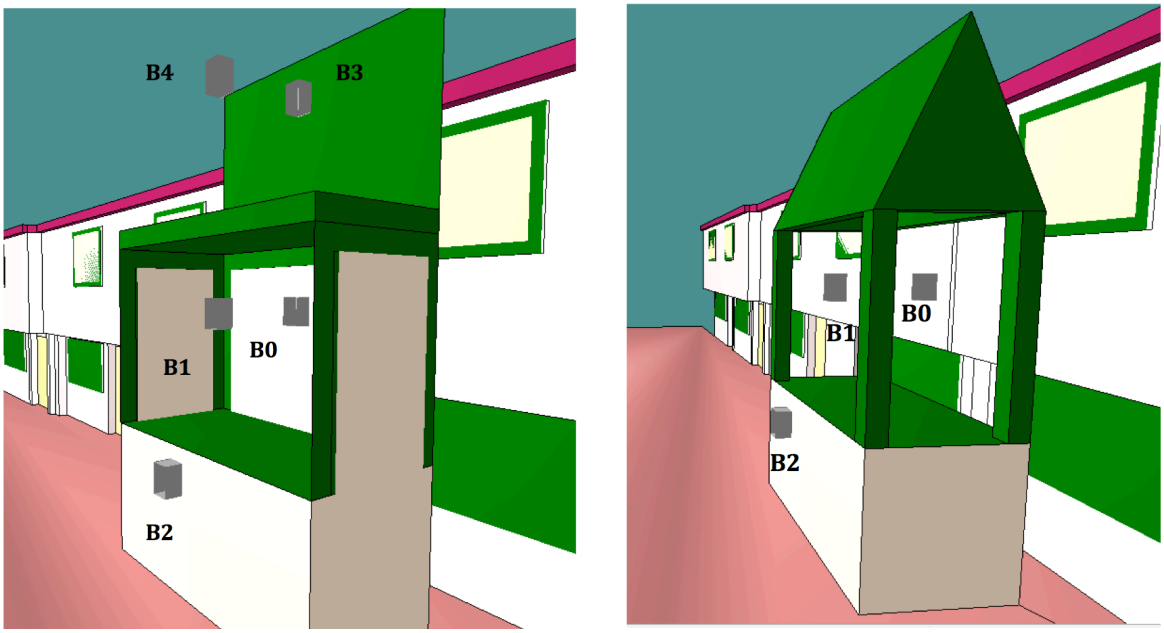

Figure 1 – Closed wagon (left) and open wagon (right) with sounds sources (B0-B5).

Studies have suggested the presence of audiences surrounding the wagons (who would have watched the performance standing and free of charge) as well as paid seated audience positions at scaffolds at the side of the street.[9] Evidence for the use of scaffolds dates from 1417,[10] but there is no documentation indicating how they were constructed or if they were used after this year. It is possible to gain an insight on the characteristics of medieval scaffolds through the observation of Fouquet's painting *The Martyrdom of St Apollonia*,[11] which depicts medieval theatre in the round. Fouquet's depiction shows a kneeling and standing audience at ground level, quite close to the action, while the different scaffolds have floors raised by supporting posts. An upper storey in each structure is formed by the inclusion of frames or rods that support the curtains that enclose the structure at the top, sides and back; the ground level seems to include curtains at the back.

In the acoustical models of this project, the impact of audiences was investigated through the inclusion of three different areas: two areas simulating a standing audience (one at each side of the wagon) and a scaffold area (6m high, 2m deep and 3.66m long) set up against one of the sides of the street with three different levels (Figure 2, Table 4). It should be noted that, due to the very sparse evidence on the appearance and use of scaffolds for the *York Mystery Plays*, the manner in which this was modeled represents only one out of many possible interpretations of their design and implementation. The simulation of the scaffold was only partially based on Fouquet's painting, as the intention was to determine the effect on the acoustics of Stonegate resulting from a structure

that consisted of surfaces with low absorption coefficients. The objective of this decision was to arrive at an understanding of what might have been the highest reverberation times achievable through a modification of the audience area, whilst still using a plausible design. The audience areas were populated with thirty-eight receivers. Ten were located in each standing audience area and six receivers were positioned at each scaffold level.

Sound Sources Comparative Analyses		
Paired Sources	Closed Wagon	Open Wagon
B0-B1	Sources atop the lower wagon deck, which represents Earth. B0 towards the back, B1 towards the front	
B0-B2	Source towards the back of the lower wagon deck (B0), another at street level (B2)	
B1-B2	Source towards the front of the lower wagon deck (B1), another at street level (B2)	
B3-B4	Sources atop the upper wagon deck, which represents Heaven. B3 towards the back, B4 towards the front	
B2-B3	A source at street level (B2), another one towards the back of the Heaven deck (B3)	
B2-B4	A source at street level (B2), another one towards the front of the Heaven deck (B4)	
B0-B3	Sources towards the back of the wagon structure, one atop the Earth deck (B0) another atop the Heaven deck (B3)	
B1-B4	Sources towards the front of the wagon structure, one atop the Earth deck (B1) another atop the Heaven deck (B4)	

Table 3 – Sound sources and comparative analyses for each wagon structure.

	Frequency							
	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz	16kHz
Wooden Surfaces								
Absorption	11%	7%	3%	1%	1%	2%	3%	4%
Scattering	10%	10%	10%	10%	10%	10%	10%	10%
Standing Audience								
Absorption	26%	46%	87%	99%	99%	99%	99%	99%
Scattering	30%	40%	50%	60%	70%	70%	70%	70%
Seated Audience (on wooden chairs)								
Absorption	24%	40%	78%	98%	96%	87%	78%	69%
Scattering	30%	40%	50%	60%	70%	70%	70%	70%

Table 4 – Absorption and Scattering values used for the audience areas expressed in percentages (%). Values sourced from the Surface Properties Library in CATT-A.

2.2 Analysis of Results

This section analyses the impact of different performer positions and audience areas added to the simulations of sixteenth-century Stonegate that also include wagon structures. Results were studied in terms of reverberation time (T_{30}), clarity (C_{50}, C_{80}) and Apparent Source Width ($IACC_{E3}$). Differences between the results derived from the various virtual models studied were considered significant when measuring 1JND or above. A summarized version of the results can be seen in Tables 5-8.

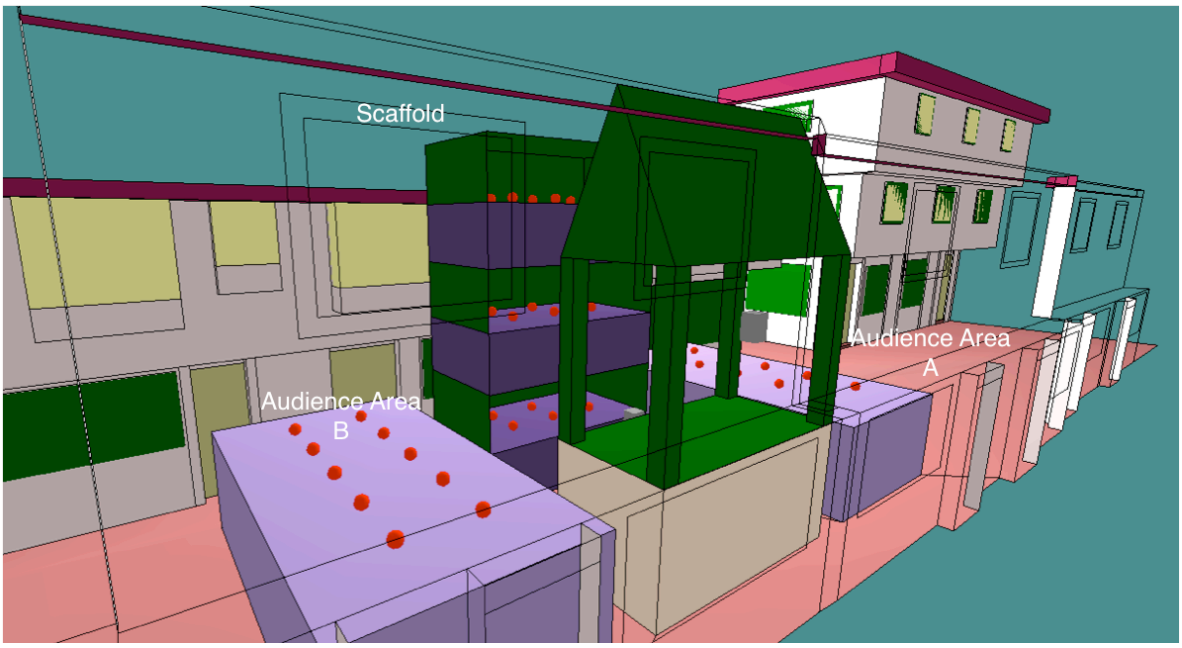

Figure 2 – Model of Stonegate with an open wagon and audience areas. The purple boxes represent standing audiences. The spheres represent individual listener positions.

2.2.1 Performer Positions

This section explores the variations in the results for the different acoustical parameters produced by changes to sound source positions in computer models that do not include audience areas. Thereby determining the existence of more suitable positions for performers. The comparisons of the different pairs of sources listed in Table 3 demonstrates that significant differences in reverberation time, clarity and Apparent Source Width (ASW) can be found as a consequence of changes to the source position. The extent to which results are affected by these changes is dependent upon the simulation studied, the sources being considered as well as the frequency bands analyzed.

When comparing two sound sources located on the main wagon deck (B0 and B1), it was observed that a performer situated towards the front would result in longer reverberation times, which would be an asset for the performance of plainchant items, while still maintaining high clarity, which is essential for speech intelligibility. The choice between a performer situated towards the back of the wagon deck (B0) or one at street level (B2) does not pose any challenges in connection to the reverberation time, which is not clearly correlated to either of the sources. However, the location at street level does have an impact on clarity results, which are higher for this position and, when using a side-on wagon, this sound source also results in a larger ASW. The comparison between a performer, who is located towards the front of the wagon deck (B1) and one located at street level (B2), demonstrated that a higher reverberation time is attained with the use of the position atop the wagon deck. Although clarity is lower for this position it still provides very high levels and the ASW is larger for source B1 when a front-on wagon is used but lower when a side-on wagon is employed. The comparison of two performer positions atop the upper wagon deck, which represents heaven, (B3 and B4), showed that this difference has little impact on the reverberation time or clarity parameters. The only clear tendency is for $IACC_{E3}$ where source B4 is connected to an increase in ASW. The analysis of the positions atop the heaven deck (B3 and B4) and that at street level (B2) demonstrated that the positions atop the upper deck resulted in a higher reverberation time, lower clarity and a decrease in $IACC_{E3}$ if used in a front-on orientation, all attributes that are more suitable for the performance of music items. When comparing the positions at the deck representing heaven (B3 and B4) and those positions representing the earth (B0 and B1) a similar tendency was

observed, with values for the upper deck showing an increase in reverberation time, a larger ASW when used in a front-on orientation and lower clarity values.

		CL-SI				CL-FR			
	Range	T_{30}	C_{50}	C_{80}	$IACC_{E3}$	T_{30}	C_{50}	C_{80}	$IACC_{E3}$
B0	Min.	0.26s	5.16dB	8.34dB	0.38	0.26s	2.6dB	7.18dB	0.4
	Max.	0.78s	18.63dB	25.5dB	0.66	0.69s	19.62dB	25.61dB	0.55
B1	Min.	0.29s	3.28dB	6.25dB	0.3	0.26s	2.7dB	7.02dB	0.27
	Max.	0.79s	15.58dB	22.41dB	0.73	0.75s	16.68dB	23.15dB	0.49
B2	Min.	0.28s	7.44dB	9.63dB	0.28	0.26s	5.71dB	8.88dB	0.39
	Max.	0.83s	15.39dB	20.91dB	0.68	0.72s	19.16dB	25.23dB	0.63
B3	Min.	0.27s	0.42dB	3.84dB	0.49	0.25s	3.44dB	6.98dB	0.23
	Max.	0.83s	16.34dB	23.26dB	0.76	0.77s	14.14dB	21.2dB	0.36
B4	Min.	0.29s	3.1dB	5.53dB	0.3	0.27s	4.81dB	7.91dB	0.24
	Max.	0.84s	14.38dB	21.86dB	0.74	0.72s	12.89dB	19.95dB	0.36

Table 5 – Range of results recorded for the closed wagons for Stonegate 1-4.

		OP-SI				OP-FR			
	Range	T_{30}	C_{50}	C_{80}	$IACC_{E3}$	T_{30}	C_{50}	C_{80}	$IACC_{E3}$
B0	Min.	0.27s	2.88dB	5.94dB	0.38	0.25s	4.52dB	7.94dB	0.2
	Max.	0.77s	15.53dB	23.03dB	0.68	0.74s	19.06dB	23.69dB	0.38
B1	Min.	0.3s	4.9dB	8.11dB	0.38	0.28s	6.05dB	9.49dB	0.24
	Max.	0.79s	15.28dB	22.59dB	0.72	0.75s	18.18dB	24.24dB	0.53
B2	Min.	0.28s	4.19dB	7.97dB	0.27	0.25s	6.54dB	10.58dB	0.43
	Max.	0.77s	16.31dB	22.27dB	0.66	0.74s	20.24dB	26.68dB	0.66

Table 6 – Range of results recorded for the open wagons for Stonegate 1-4.

2.2.2 Audience Areas

The results were studied by dividing them into five different areas (Figure 2): standing audience area A, standing audience area B and the three different scaffold levels. The analysis of the results was carried out considering the mean values across all receiver positions but considering source positions separately. Results have been considered in connection to the minimum and maximum values calculated for each parameter.

Although some general tendencies can be observed in connection to the correlation between audience areas and the highest/lowest values for each parameter, the abundance of differences across simulations is also evident. When considering the CL-SI wagon the highest reverberation times were found at the standing audience areas (Stonegate 1 and 3), the second level of the scaffold (Stonegate 2) and the top level of the scaffold (Stonegate 2-4). The lowest reverberation times are connected to the use of the first (Stonegate 3) and the second level of the scaffold (Stonegate 1-4). The study of the CL-FR simulation indicates that the highest T_{30} values are related to audience area B (Stonegate 1), the second level of the scaffold (Stonegate 2-4) and the third level (Stonegate 4). The shortest reverberation times can be observed at the first and third levels of the scaffold for Stonegate 1, only the first level for Stonegate 2 and 4 and the audience area A for Stonegate 3. The computer models with open wagons demonstrate the correlation between the use of the top level of the scaffold and a longer reverberation time. Stonegate 1 and 2 combined with the OP-SI simulation have their shortest T_{30} at the first level of the scaffold and Stonegate 3 and 4, both at the first and second levels. The shortest reverberation time for the OP-FR model is connected to the use of levels one and two of the scaffold (Stonegate 1), the first level as well as audience area B (Stonegate 2), only the second level of the scaffold (Stonegate 3) and only the first (Stonegate 4).

Regarding results for clarity, when considering the CL-SI model the highest values were found at the middle (Stonegate 3-4) and the top level of the scaffold (Stonegate 1-4), whereas the lowest values were related to audience area A (Stonegate 1, 3 and 4), audience area B (Stonegate 2 and 3) and the first level of the scaffold (Stonegate 2). When examining C_{50} and C_{80} results for the front-on wagons it was observed that audience area B, which is located facing the sound sources presented the highest clarity values. The lowest values for the CL-FR simulation were found in area A (Stonegate 1, 3 and 4) and at the second level of the scaffold (Stonegate 2). In the case of the OP-FR model the lowest values of C_{50} and C_{80} are in audience area A (Stonegate 1 and 3), the second level of the scaffold (Stonegate 2) as well as the top level (Stonegate 2 and 4). The results recorded for the OP-SI design demonstrated that the highest clarity is achieved at the first level of the scaffold, when considering Stonegate 1, 3 and 4, whereas the lowest values are connected to the use of the standing audience area B in Stonegate 1-4 as well as in A in the case of Stonegate 3.

The data corresponding to $IACC_{E3}$ shows that, when studying the simulations including the CL-SI, CL-FR and OP-SI wagons, the listener positions representing the standing audiences have the largest ASW whereas the positions in the scaffold area correspond to a smaller ASW. The simulations including the OP-FR wagon indicate that the largest ASW corresponds to the positions A (Stonegate 1 and 3) and at the second level of the scaffold (Stonegate 2 and 4), whereas the smallest ASW is related to the use of the top level of the scaffold (Stonegate 1) and audience area B (Stonegate 2-4).

		CL-SI				CL-FR			
	Range	T_{30}	C_{50}	C_{80}	$IACC_{E3}$	T_{30}	C_{50}	C_{80}	$IACC_{E3}$
A	Min.	0.29s	-0.6dB	2.09dB	0.16	0.3s	-1.68dB	1.63dB	0.17
	Max.	1.6s	21.72dB	26.32dB	0.83	1.15s	23.19dB	27.45dB	0.71
B	Min.	0.26s	2.23dB	4.47dB	0.15	0.29s	3.26dB	5.86dB	0.14
	Max.	1.26s	20.15dB	24.73dB	0.83	1.28s	23.43dB	29.39dB	1
L1	Min.	0.22s	2.4dB	5.1dB	0.32	0.22s	1.89dB	4.05dB	0.32
	Max.	2.04s	24.8dB	31.11dB	0.88	1.68s	19.4dB	24.46dB	0.87
L2	Min.	0.21s	3.91dB	8.52dB	0.36	0.29s	0.38dB	4.29dB	0.21
	Max.	1.86s	22.62dB	29.96dB	0.94	1.51s	17.71dB	23.84dB	0.85
L3	Min.	0.29s	4.55dB	9.08dB	0.39	0.32s	-1.34dB	2.11dB	0.2
	Max.	1.52s	24.84dB	30.26dB	0.93	1.1s	19.23dB	24.72dB	0.91

Table 7 – Results recorded for the closed wagons, divided into Audience Area A and B, Scaffold Levels 1-3.

		OP-SI				OP-FR			
	Range	T_{30}	C_{50}	C_{80}	$IACC_{E3}$	T_{30}	C_{50}	C_{80}	$IACC_{E3}$
A	Min.	0.31s	3.31dB	6.95dB	0.13	0.32s	0.78dB	4.73dB	0.2
	Max.	1.39s	18.46dB	23.28dB	0.82	1.25s	18.58dB	22.41dB	0.66
B	Min.	0.29s	3.9dB	7.06dB	0.19	0.29s	6.27dB	9.17dB	0.22
	Max.	1.29s	16.69dB	21.77dB	0.65	1.15s	22.70dB	28.28dB	1
L1	Min.	0.23s	6.96dB	10.52dB	0.3	0.25s	4.19dB	7.61dB	0.24
	Max.	1.66s	23.51dB	29.85dB	0.86	1.45s	19.62dB	25.81dB	0.79
L2	Min.	0.26s	5.78dB	10.63dB	0.44	0.32s	1.94dB	5.21dB	0.17
	Max.	1.39s	18.94dB	25.67dB	0.86	1.3s	14.92dB	20.07dB	0.73
L3	Min.	0.24s	3.94dB	8.87dB	0.47	0.31s	2.51dB	5.16dB	0.3
	Max.	1.47s	21.43dB	29.98dB	0.92	1.49s	15.35dB	21.7dB	0.86

Table 8 – Results recorded for the open wagons, divided into Audience Area A and B, Scaffold Levels 1-3.

3 CONCLUSIONS

The analysis of the acoustics of Stonegate and the wagon structures in relation to the different performer and audience positions demonstrated that such changes have a significant acoustical impact, although in the case of audience positions this seems to be largely affected by the type of street space and wagon modeled. Regarding the performer positions a finding of particular significance is the increase in reverberation time and ASW as well as the decrease in clarity recorded for the positions atop the wagon deck representing Heaven. The presence of acoustical conditions that are more favorable for music in those particular positions indicates that the upper wagon decks might have presented both a good visual and acoustic spot in which to locate the singers, which in many plays would have represented angels.

The introduction of audience areas to Stonegate had a positive acoustical effect; the reverberation time increased, in relation to the second and third levels of the scaffolds, making the space more suitable for vocal performances. Moreover, it is interesting to explore how different acoustical characteristics can be associated with different audience areas. Seated audiences, who would have paid for their seats, seem to have been at positions where the reverberation time is higher while still retaining high levels of clarity. These characteristics seem to indicate that paying audiences had better seats for both the spoken and sung extracts. However, when considering the ASW it is standing audiences that would have enjoyed better positions.

The results presented do not have the aim of providing absolute answers to questions on the relationship between staging techniques and acoustics but on the contrary is focused on the relative values that result from comparing different configurations and analyzing the relevance of these in the context of the performance. This study provides an initial insight into the relationship between acoustics, performer and audience positions and further work will be conducted in order to strengthen the findings here presented.

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