Modelling Processional Movement at Ostia

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Introduction

Ostia hosted a rich religious landscape, its composition ranging from monumental temples to private household altars. Despite the prevalence of religious architecture and dedicatory objects found throughout the ancient city, only minimal attention has been afforded to the topic of processional rituals, which would have brought life to the city's various cults and temples. Most scholarly accounts provide either passing commentary about where processions may have transpired, such as along Ostia's *decumanus,* or address their probable occurrence in conjunction with certain cults.[1] These approaches remain largely a consequence of the nature of the Roman processional record, which favoured literary and iconographic depictions of major processions at Rome to those that occurred in smaller cities around the Empire. While we can infer the presence of processional rituals at cities such as Ostia through the comparative study of the Roman calendar with known Ostian cults that had well identified rituals, the form of processions and their impact within the city remains invisible within the archaeological record.[2]

This paper introduces a novel approach to considering how processions may have navigated Ostia during the late 2nd century CE through the use of an agent-based simulation. The model takes a spectatorship and visibility focused approach to question how different forms of viewership helped to shape possible processional routes through the city. Without some form of visibility, a procession would have been effectively meaningless.[3] Therefore, questioning how spectators engaged in various urban activities shaped routes provides one method of studying a procession's construct. For instance, if passage past shops was significant due to the possibility of granting a procession greater visibility, where might the ritual have travelled? Engaging different audiences would also have depended upon the intended purpose and message of a particular processional ritual.[4] Within the agent-based model, the built environment is used as a proxy for the different types of spectator groups that would have been found within the city. While other urban features such as street width could be used to help inform how processions navigated the city, when a route is otherwise unknown, such measurements alone cannot be used to determine full processional routes. Questioning where processions may have travelled within Ostia's urban fabric ultimately provides new insight into the extent to which Ostian cults effected urban life through virtue of their moving rituals.

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Case Study: The Serapeum

Ostia's Serapeum has been chosen as a case to test the suitability of using agent-based modelling to study processional movement and to determine the extent to which this offers new insight into the nature of the temple's ritual activity. While the small temple, which is located at the western-most edge of the excavated city (fig. 1), has received a significant amount of scholarly attention, its rituals have not received equivalent consideration.[5] As the only presently excavated Egyptian temple within the city, study of its potential processional rituals presents an ideal opportunity to question how the cult was more widely integrated within Ostia's urban landscape. Comparative evidence from across the Roman Empire attests to the practice of various Egyptian processions involving the deity Serapis.[6] Furthermore, the large quantity of evidence relating to Egyptian cults discovered at Ostia provides a strong argument towards the likely presence of processional rituals.[7] Despite the high probability for the occurrence of Egyptian processions at Ostia, existing evidence does not offer any indication into their routes through the cityscape. The methodology introduced in this paper, therefore, provides a new approach to questioning how processions originating at the temple of Serapis may have navigated Ostia's urban landscape during the late 2nd century CE.

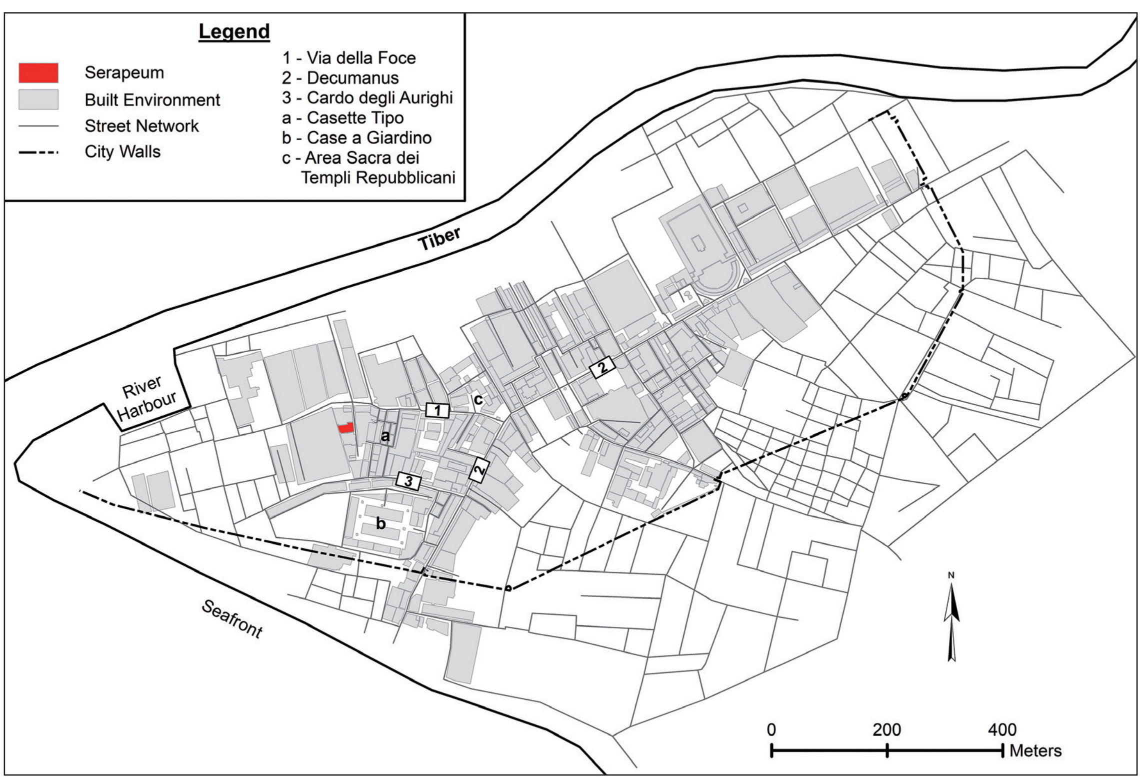

Fig. 1: Map showing the location of the Serapeum within Ostia with relevant buildings and streets noted.

Methodology

Agent-based modelling is applied to question how processions may have navigated Ostia's cityscape following the passage of buildings with different functions. An agent-based model is a simulation tool that allows the user to create a 'real-world' environment in order to study the behaviours and interactions that arise between agents within the model.[8] The results of a simulation can help us to understand how behaviours arise from various decisions. More significantly, for the present study it provides a formalised method of visualising the complex dynamics that contributed to the manifestation of a processional route. The simulation outcomes, when analysed in light of the archaeological record, provide a way of moving beyond written theories about the probable presence of processions at Ostia to studying their action within the city.

There are a variety of different platforms that support agent-based simulations. The present model was developed in NetLogo, which is fully programable in addition to having the capability of incorporating geographic information system (GIS) spatial data.[9] The spatial environment of NetLogo consists of individual cells called patches, and, while stationary, they can hold different types of information in addition to having the ability to interact with the agents that pass over them. Within the model, agents are coded to follow pre-determined rules that determine how they interact with other agents within the simulation as well as the underlying spatial environment. These coded interactions are repeated for a certain amount of time, after which the results of the model can be exported and analysed.

Model Overview

The model comprises an underlying spatial environment and three types of agents. In order to create the model's background simulation environment, GIS shapefiles specific to Ostia's built environment, street network, and individual building classifications are imported into NetLogo.[10] The landscape consists of 700-cells by 400-cells. The model's resolution corresponds to each cell measuring approximately 1 meter. The environment consists of seven different components: Ostia's unexcavated cityscape (grey), streets (black), commercial spaces (green), production spaces (orange), residential spaces (yellow), public spaces (blue), and religious spaces (pink) (fig. 2).[11]

This spatial environment has different parameters that dictate how agents can act and where they can move. Pedestrian movement associated with the procession, which is influenced by the various building classifications, can only occur along the city's street network, therefore ensuring that agents do not enter buildings. Each of the individual building classification categories can be attributed with a different 'influence' value that ranges from 1–5, which determines how desirable it is to the passing procession.

Fig. 2: Plan of Ostia shown in NetLogo's spatial grid. The different colours correspond to different building classification categories, the extended cityscape, and the city's streets. Each colour has different functions and rules that have to be followed by the agents (see text).

The model includes three different types of agents. First is the processional leader, whose goal is to determine a certain path through the urban environment that passes the highest influence value buildings while staying on the streets and not running into other agents. The second type of agents are urbanites, which wander along Ostia's streets but have no specific goal except to avoid running into other agents and to move randomly along the city's streets. The third type of agents are the observers. If observers are within a certain radius of the processional leader, they will stop for a set amount of time to "watch" the procession before continuing onwards. Like the processional leader and the urbanites, these agents are confined to moving along the street network and avoiding obstacles. The total number of urbanities and observers can be adjusted within the model. The introduction of agents into the model in addition to the processional leader serves to account for some of the possible movement dynamics that occurred along Ostia's streets. A procession, regardless of its form, would not have travelled along a completely empty street. Introducing urbanites and observers into the present model, therefore, serves to begin presenting a more realistic consideration of processional movement by making the processional leader react and move in relation to other agents within the street.

Model Experiments

The agent-based model is used to study the routes taken by a hypothetical circular procession which begins and concludes at the Temple of Serapis. Five different experiments are undertaken within this framework to test how different building classification categories affect movement patterns. The first test consisted of an unweighted model, where all building categories were weighted with a value of 1. This provided a general baseline for analysing subsequent simulations in light of the degree to which processional routes were determined by passing different building classification categories versus the shape of the built landscape. The next four models were run by separately weighting the commercial, residential, public, and religious building classification categories.[12]

Since each simulation run results in a different outcome, multiple simulations have to be undertaken for each parameter (e.g. building weight) in order to assess the degree of variation in the results. For the present model, ten simulation runs were found to adequately capture the possible variation of movement along different city streets. The results of each weighted simulation are presented using a colour gradient relating to the similarity of passing along a specific street during each of the ten runs.

Implementation of ABM and Results

Within each simulation, the route is determined by the processional leader following a movement algorithm that determines which nearby buildings have the highest influence value, walking to the edge of that building while avoiding other pedestrians, and then choosing the next building to move towards. The processional leader keeps track of where it has previously travelled, thereby ensuring that it does not travel in circles or stay in one place within the model. This movement procedure is repeated for a predetermined amount of time, at which point, the processional leader determines the best route to return to the starting temple. Each simulation is run for a total of 1,000-ticks, which equates to the procession traveling along a distance of 1,000 meters.

Prior to presenting the results of the four different weighted simulations, figure 3 shows the outcome of the unweighted simulation. The pathways are shown on a colour gradient of the streets most likely to be used during ten different simulation runs. Streets that are used during each of the ten runs are displayed in red, and streets used only once or twice are shown in green. Since all the buildings are provided with the same influence value, the resulting route is reflective of how the built landscape and street design structures movement patterns within the model. The route visualisation shows that the majority of movement occurs along the streets directly west of the Serapeum.

Figure 4 shows the results of the four different weighted simulations. Like in figure 3, the results are presented on a colour gradient of how often a street is traversed during ten different simulation runs. The routes weighted by commercial spaces (fig. 4a)

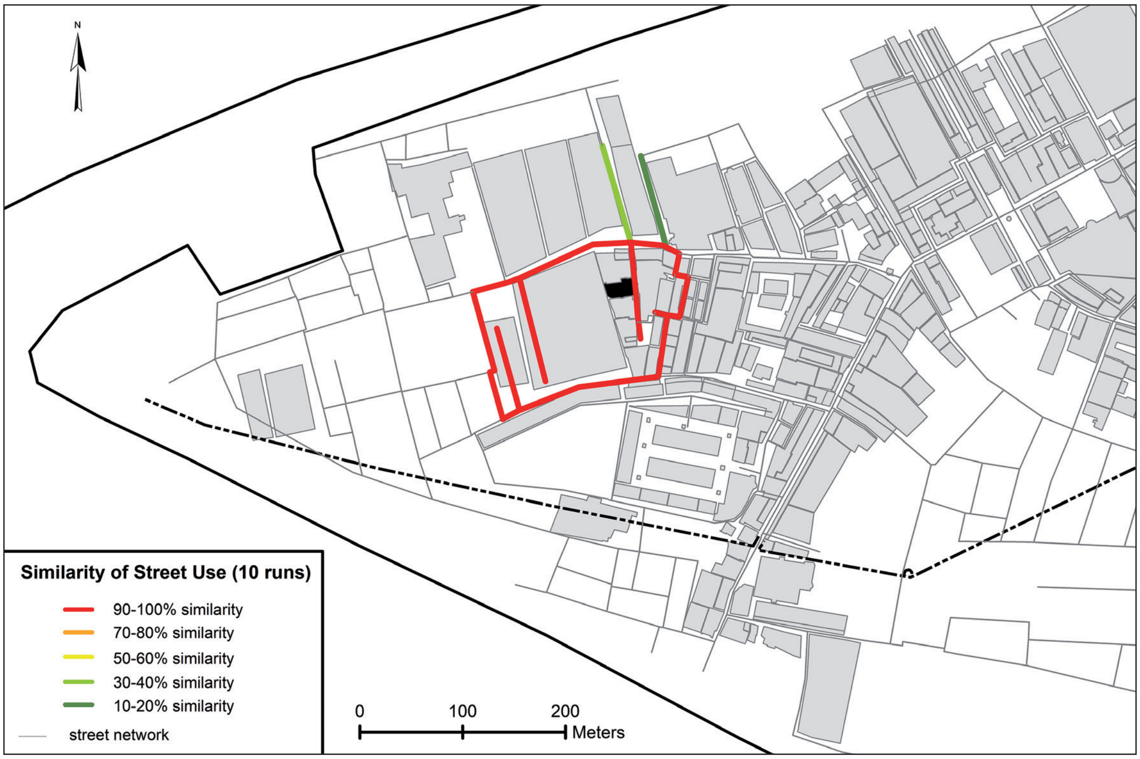

Fig. 3: Results of ten unweighted simulation runs beginning and ending at the Serapeum. The Serapeum is shown in black. The similarity of street passage is represented on a colour gradient from red to green.

travel north-west of the temple, passing several of the city's large warehouse structures. Routes weighted by residential space follow two distinct pathways (fig. 4b). The first travels east along the Via della Foce in the direction of the *forum.* The second major area of movement travels in a southern direction, passing along the streets bordering the Cassette Tipo apartments before continuing towards the Cardo degli Aurighi and past the large residential complex, the Case a Giardino. Processional routes informed by traveling past public spaces (fig. 4c) are shown to travel almost exclusively along Ostia's Via della Foce. This is unsurprising considering that the majority of public spaces are easily accessible from the city's main thoroughfares. Religious weighted routes (fig. 4d) are shown to move along Ostia's major street, the Via della Foce, with short detours past several of the religious structures located north of the Serapeum such as the Republican sacred area.

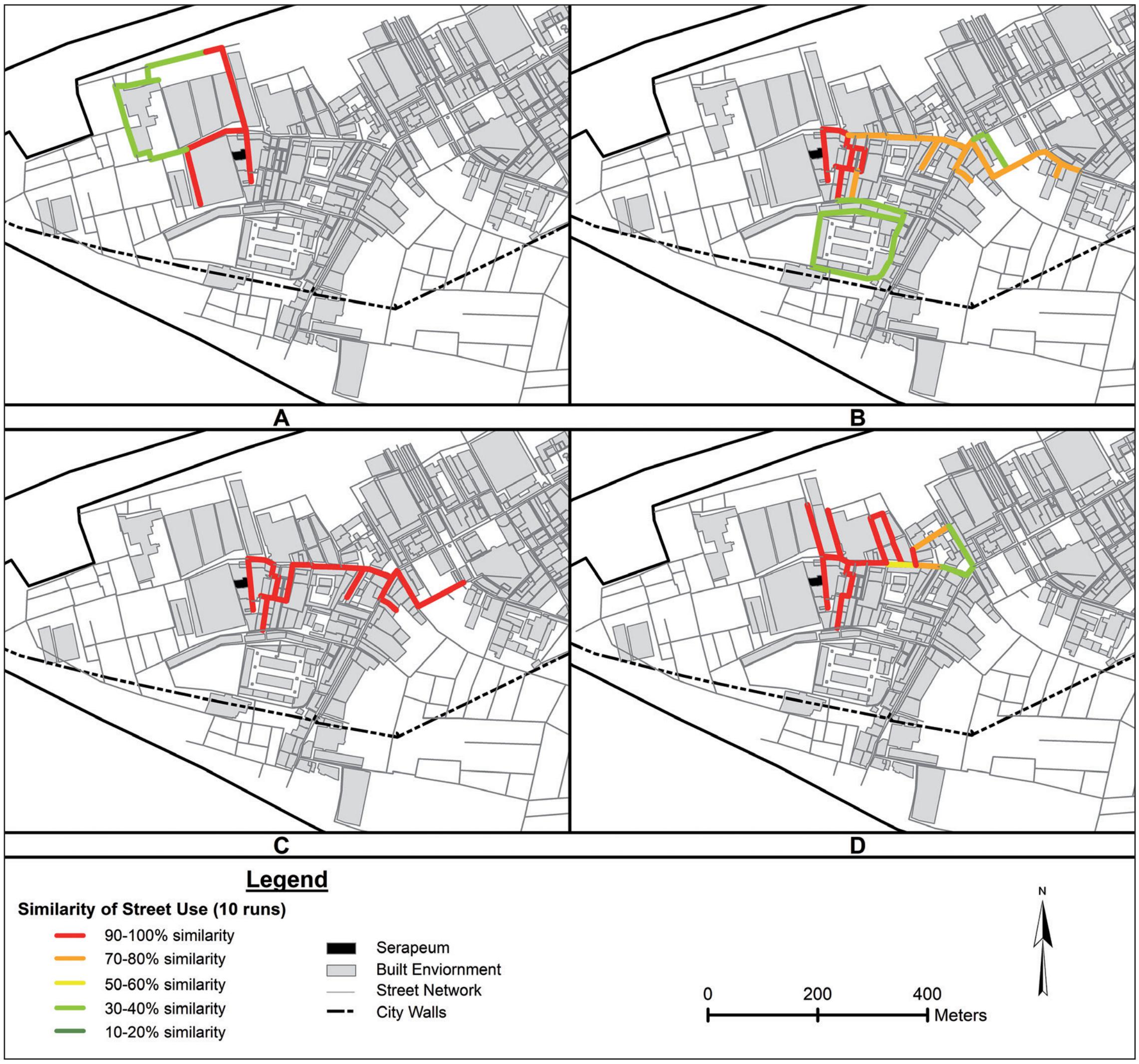

Fig. 4: Results of the four different weighted simulations: A – commercial weighted; B – residential weighted; C – public weighted; D – religious weighted. The similarity of passage along streets within each simulation is shown on a colour gradient from red to green.

Discussion

The results of the various weighted processional routes show distinct variation in movement passage when compared to the unweighted simulation. Figure 5 shows a combined illustration presenting how the four different weighted movement routes encompass distinct areas of the cityscape. Commercial and residential weighted routes are focused to areas north-west and south-west of the Serapeum respectively. Public and religious weighted routes, alternatively, both travel towards the centre of the city. The results,

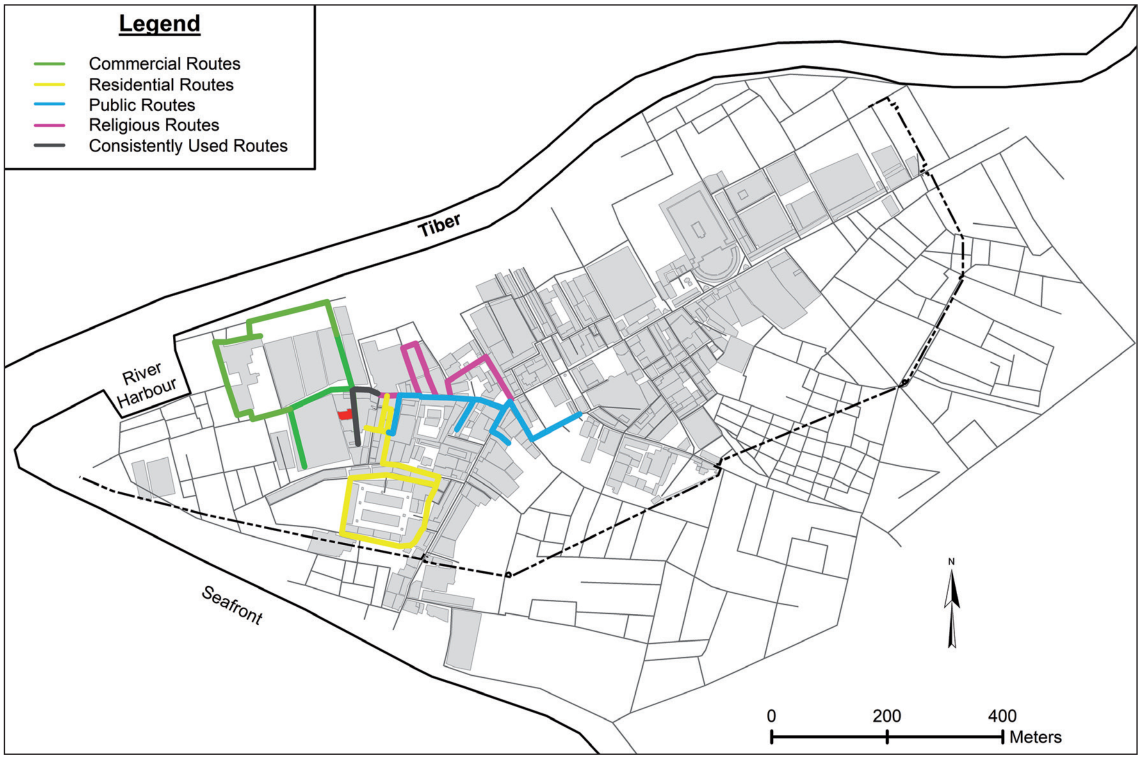

Fig. 5: Summary of the possible movement routes weighted by the four different building classification categories. The Serapeum is shown in red.

apart from highlighting the variation in potential movement passage, also show the extent to which processions allowed the rituals of the Serapeum to extend beyond the temple's precinct to encompass a portion of the Ostian cityscape.

The potential areas of movement in part served to highlight the cult's existence within the community. This would have been particularly significant since the temple's spatial location along a dead-end street did not favour unintentional interaction. A small brick panel showing a depiction of the bull Apis was located along the Via della Foce, possibly acting as a signpost for the temple's location.[13] Given the marker's size, however, prior knowledge of the temple would probably still have been necessary. Processional rituals therefore acted as a marker of both the cult's presence within the city as well as informing the surrounding population about the cult via its ritual practices.

The way in which a procession interacted with the surrounding cityscape helped to articulate its reception. As a procession travelled through different areas of Ostia's cityscape, different social groups would be engaged as temporary participants by the cult. Depending upon the intended message of the ritual, various movement areas become more or less probable. In terms of the cult's trade connections, it seems plausible that travel past the city's many large commercial structures would highlight this engagement.[14] An alternative focus may have been to interact with a large proportion of residential spaces. The area surrounding the Serapeum has previously been interpreted as a space with a high proponent of eastern immigrants and cultic followers.[15] A procession that followed a residential weighted route would inevitably serve as a way to strengthen the identity of Ostia's Egyptian community. In such an instance, the processional rituals there not only served as an expression of devotion to the god, but also as an overt visual display of their connection to the cultic community of Serapis. While the simulation results provide possible visualisations of processional routes, these routes need to be further analysed in relation to both our understanding of the cult's social composition and existing archaeological evidence.

Conclusions

Previous studies of Roman processions have either assumed the occurrence of processions within cities or have constructed hypothetical models about how processions travelled along certain major streets. However, approaches such as these do not address the larger question about how routes were fabricated within individual cities and therefore how they can be more fully studied. The simulation introduced in this paper has attempted to move beyond hypothesizing about the probable existence of processional rituals occurring at Ostia to visualising how they were structured by the built environment and corresponding spectator activities, and therefore, how they may have navigated the city.

Different simulation experiments were used to investigate the extent to which processional routes were structured by the model's various building classification categories. The results of the Serapeum's processional simulations clearly show that distinct areas of movement occur in relation to passing different building categories. Interpretation of the most probable areas of movement subsequently need to be interpreted in light of existing archaeological evidence and our understanding about the particulars of Serapis' rituals. This can be accomplished through considering the function and connection of the buildings passed to the Serapeum. More importantly, the community engaged with the cult of Serapis needs to be accounted for in any evaluation of potential routes.

Although we must remain aware that the parameters used to run the model are not the only factors affecting the route of a procession, this approach has presented a first attempt at considering how processional rituals can be studied at Ostia using the Serapeum as a case study. Furthermore, this model provides the foundation for undertaking more complex studies of processional movement. In particular, future research avenues need to account for factors such as how different numbers of processional followers or the nature of ritual artefacts affect routes, or how street width impacts a procession's navigation through the city.

Notes

[1] For commentary about possible streets that hosted processional routes, see Bruun 2009; DeLaine 2008. For the practice of cultic processions, see Turcan 1996, 55; Rieger 2004.
[2] Taylor 1912; Squarciapino 1962; Rüpke 2011; Salzman 1990.
[3] Scheid 1998; Huet 2015.
[4] Rüpke 2012.
[5] Calza 1953; Bloch 1959; Mar 2001; Mols 2007. Only limited attention has been provided to considering the particulars of the cult's ritual practices, see Meiggs 1973, 367–368.
[6] Salzman 1990, 171; Alvar 2008; Abdelwahed 2016.
[7] Taylor 1912; Squarciapino 1962; Mar 2001.
[8] For an overview of simulations used within archaeological research, see Lake 2014; Wurzer et al. 2015.
[9] Wilensky 1999.
[10] All shapefiles were created in ArcGIS 10.3. Building classifications primarily follow the interpretations of Calza 1953; Packer 1971; Meiggs 1973; Hermansen 1982; Boersma 1985; Pavolini 2006. The commercial structures known through geophysical survey located within the western unexcavated area of Ostia have additionally been included within the model (Martin et al. 2002). The identification of the extended street network follow the works of Heinzelmann 1998/1999; Martin et al. 2000; Stöger 2011.
[11] The ABM model and code can be found at <https://github.com/K-A-Crawford/ABM-Processional-Leader> (22. 06. 2020).
[12] Production spaces have not been included as a category since there are no identified production buildings located within the immediate area of the Serapeum. Therefore, any simulation weighted by this classification will have the same results as the unweighted simulation.
[13] Mar 2001, 67. 233.
[14] Keay 2010.
[15] Taylor 1912; Meiggs 1973.

Image Credits

All figures by author.

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