Mapping the Domestic Landscape: GIS, Visibility and the Pompeian House

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Abstract. Previous research on Roman domestic architecture has failed to clarify the functional aspects of ancient Roman houses by focusing solely upon typological and historical-cultural explanation of house form and development. This paper presents the initial results of a three-year project that sought to rectify this oversight through the application of computerised analyses including small-scale use of GIS, to a sample of sixty-five houses from Pompeii. In particular, these analyses consider the spatio-visual effects of architecture and develop methods for the scientific study of phenomenological effects created by the built environment. By examining the way that the ancient Roman built landscape was structured with regard to phenomenology it is possible to identify the social, political and economic needs of house owners. Detailed results are presented for one house from the sample.

1. Introduction

The study of the 'Roman house' has been a subject of research almost from the beginning of the study of ancient Rome itself, and has always played a significant role in the topic of Roman architecture. Excavation has uncovered numerous examples from sites across the Mediterranean and beyond, and much has been written explaining the forms and daily life of the Roman house, particularly in relation to the ancient sources (Laurence and Wallace-Hadrill 1997; Gros 2001; Ellis 2000; Hales 2003; Laurence 1997; McKay 1975; Richardson 1988; De Albentiis 1990; Barton 1996; Boëthius and Ward-Perkins 1970 et al.). However, there is no work that has sufficiently explained the functioning of the 'Roman house' and the reasoning behind its forms. This paper presents research that has been carried out over the past three years in an attempt to fill this gap by an examination of a sample of Pompeian houses. It consists of new, computerised methods of analysis that have been developed in order to examine the ways that Pompeian houses function to pattern social interaction taking place within them. These analyses were developed through a combination of the use of commercial GIS software and purpose built scripting to enable the examination of the small scale built landscape created by Roman houses.

2. A History of Research on the Roman House

The traditional approach to understanding the 'Roman house' is a view particularly derived from the remains present in Campania, and the towns destroyed by Vesuvius in AD 79. Although this has prejudiced our understanding of Roman housing towards the evidence found at Pompeii and Herculaneum, the fact remains that these sites present a greater amount of information on daily life during the Roman Empire than most other sites combined. For this reason the present study has examined evidence from these areas as a test of new analyses before moving on a larger sample.

The development of the Roman house has generally been explained as the result of an evolutionary, cultural-historical process in which a hypothetical 'Italic house' is seen to have developed through adoption of various 'foreign' features, particularly those from the Greek east (Maiuri 1978; Gros 2001; Barton 1996; DeVos and DeVos 1994). Paired with this approach has been that of typology, the mapping of names derived from Vitruvius, Varro and other ancient authors onto the various floor plans revealed through excavation, as though calling a room a cubiculum, ala, or exedra was a sufficient explanation of its role in the daily life of that house (Mau 1900; Overbeck 1884).

I consider this form of explanation to be insufficient. The remains of an ancient house are a cultural artefact, a product of the patterns of daily life and a meaningful indicator of what was important to the ancients who occupied it. We must examine the daily functioning of the Roman house in order to understand the reasons behind its forms and the priorities of its inhabitants. At first glance, the primary function of a house seems to be for purposes of shelter. However, this fails to address the reasons for the division of space found in the domestic buildings of many cultures (Hillier and Hanson 1984). Anthropological accounts of the house and post-structural discussion of habitus and enstructuration suggest that the house's most important function is actually to provide an arena for social action: an appropriate locus for human activity (Lévi-Strauss 1963; Bourdieu 1973; 1977; Giddens 1984; Rapoport 1969; 1990; Dobres and Robb 2000). Each social interchange that takes place within the spaces created by a house is patterned by those spaces and their phenomenology, and we can safely assume that each house owner will logically arrange space within their houses to suit the social needs of the inhabitants with regards to society, economy and power. This is most certainly true of the Roman house, whose prominent role in the social, political and economic life of its owner has long been identified (Wallace-Hadrill 1994; Clarke 1991).

3. Method: How to Measure It?

By measuring the phenomenological effects created by the physical arrangement of space, it is possible to study the ways that particular houses function and by extension the social priorities of the owners of those houses. Though a through examination of phenomenological effects of architecture would also take into account all aspects of human experience within the built environment, it is logical to assume that the two most important are visibility and access. The spaces created by architecture will either encourage or occlude line of sight in purposefully designed ways. At the same time buildings also intentionally modify the possibilities for actors' movement, isolating some areas and making others central to the system.

3.1 Access and Movement

Considerable work has been done on the quantitative analysis of access and movement, which formed the central component of Hillier and Hanson's influential publication in 1984 (Grahame 1997; 2000; Blanton 1994; Jiang and Claramunt 2002). Their analyses derive from the initial creation of j-graph – a schematic representation of the spaces of a house by 'nodes', with lines connecting them in which each 'node' represents a single convex space within the building.

A range of graph theory indices can be calculated from the j-graph, the most useful of which for the examination of interior space is called Real Relative Asymmetry. (RRA) This involves calculating a value for each node that is the distance between that node and every other node in the system, summed, and then divided by the number of nodes within the system minus one.

This index is significant because it measures the degree of centrality (i.e. integration) for each space in the traffic flow of a building. Areas of high asymmetry are isolated from the

major pathways in the structure, and will therefore receive very little traffic, whilst areas of lower asymmetry make up traffic throughways. The traffic flow within the built environment reveals much about the daily movement of actors within the system and the ease with which certain rooms were accessed. However, what makes this index especially interesting is that asymmetry can also measure social interaction (Hiller and Hanson, 1984). Two actors in the same system have a high chance of 'bumping into' each other whilst carrying out their daily tasks in areas of low asymmetry since they are statistically more likely to be passing through such a location at any one time, while actors in areas of high asymmetry are unlikely to encounter others so long as they remain there.

While the procedure for the calculation of RRA indices is straightforward, it is fraught with the potential for making mistakes because the process involves counting the steps between nodes in a j-graph, once for each node in the system. In order to be able to perform this analysis on a large number of houses, it was beneficial to automate the procedure by means of a script written in Perl. The script uses as input a file that contains a schematic representation of the spatial relationships between nodes in the form of binary pairs (e.g. A-B, B-A for a connection between rooms A and B). This file is processed and used to calculate all of the basic spatial syntax analyses defined by Hillier and Hanson as useful for the study of interior space, including real relative asymmetry. This reduces a process that could previously take hours to accomplish into one that takes only a few seconds to complete. Furthermore, mistakes can be easily rectified by changes to the original input file.

However, while RRA presents a useful rough measure of the role played by each room or space within the house structure, the index and its means of calculation generate a number of inaccuracies. Because the actual shape of each 'space' is not represented in the j-graph (i.e. a large thin room and a small fat room are represented by identical nodes) the way in which rooms are interconnected does not factor into RRA analysis. Equally, the decision about which spaces in the structure qualify to be represented by individual nodes is left entirely to the discretion of the individual researcher. This can be a particularly difficult problem when dealing with the often oddly shaped rooms found in Pompeian houses. In order to resolve these problems, my research has developed an analysis called 'extended' Real Relative Asymmetry (eRRA). This process begins by overlaying a grid of equally sized squares onto the floor plan for a building. Squares that fall within the space occupied by the walls are ignored, while those within rooms are examined as the internal space of the building. A node is assigned for each of these squares, and a line connects nodes that share a side. Thereafter, relative asymmetry can be calculated following the same process used for RRA.

As the number of nodes in even a relatively small building tends to be quite large, this procedure would be very time consuming to achieve by hand. I have therefore also computerised this process by means of a Perl script. The

Fig. 1. The j-graph and corresponding floor plan for a Pompeian house (I, 7, 2).

easiest way to produce a floor plan of a house divided by grid is in the form of a digital image – by definition a grid of

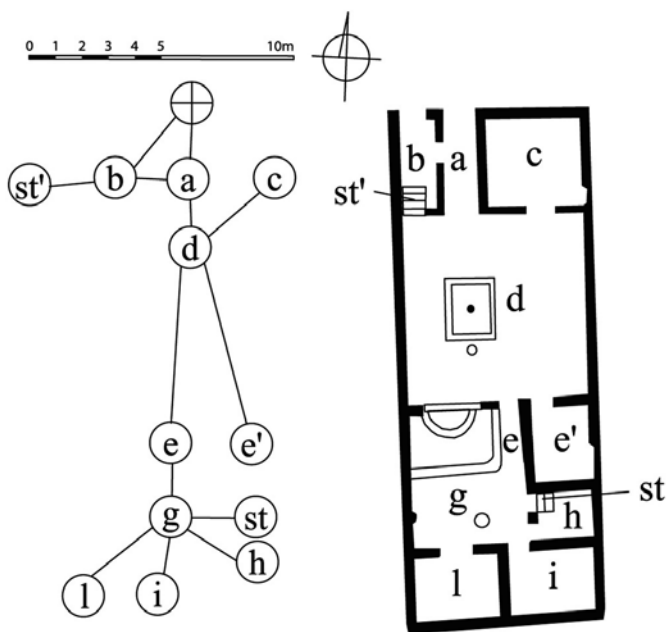squares. Pixels of a certain colour can represent open space while those of another signify walls. Because images from Pompeian houses were also likely to contain information about windows and other details, additional colours were permitted in order to represent impassable objects that were not actually walls. The GIF file format was chosen for the processing because of its simplicity.

The Perl script written for this analysis makes use of a free image-processing plug-in called ImageMagick, (http://www.imagemagick.org/) to dissect the image into a grid of values that are loaded into an array in memory. For each pixel, the distance to each other in the system is calculated via a recursive process similar to that used by image processing programs to 'flood fill' areas of colour. This means that solid objects cause obstructions in the pathway followed by the calculation, just as they do for actors within a building. Once these values have been determined, they are summed and divided by the total number of pixels representing interior space, minus one – just as in the production of RRA values. This process continues until the eRRA value for each pixel has been calculated, and thereafter the stored eRRA index for each pixel is used to create a new image, in which intensity of colour represents the degree of asymmetry at that point. A text file is also produced in which the value of each pixel is recorded in tabular form. Close examination of the output of eRRA analysis reveals that in each area, those pixels located in the centre are more easily accessible than those in the corners or on the edges. This fits exactly with the human experience of architecture, and is indicative of the degree of detail revealed by eRRA analysis.

The Perl script is entirely scaleable, so that in theory images of very high resolutions could be processed. However there are limitations enforced by processor speeds and the extremely large number of calculations necessary for large images. It was found that the most effective size for the GIF input images was approximately 150 pixels by 200 pixels. Even at this resolution, such an image could require approximately 20 hours of processing time, depending on the amount of open space within the structure. This is because each of the 30,000 pixels in an image of this resolution must receive a value that is calculated by performing 29,999

measurements, resulting in 899,970,000 individual processes. Even running on a relatively high-end system (Athlon 2GHz, 256 MB RAM) processing the files for this research required several weeks of constant processing time.

3.2 Analyzing Visibility

Unlike access and social syntax, the study of visibility has only recently come into vogue, particularly with the Bartlett school of Architecture (Beatriz Arruda de Campos 1999; Turner and Penn 1999; Desyllas and Duxbury 2001). While previous work has been useful for my research, it has been necessary to develop a range of new analyses and unique approaches to the subject of visibility, a topic that presents unique and difficult challenges to the researcher.

The most straightforward characterisation of the visual experience of an actor within the built environment is the 'point viewshed' (Hanson 1998). Rays may be traced from a single point, and the area represented by the field of vision of an actor is shaded to represent visible areas. This type of representation suffers from the significant limitation that the rays are traced from a single location and while therefore being very good at representing the view from a particular point; it will only be accurate if an actor remains stationary and rotates in place. Clearly, this is not a very realistic representation of how people move within architecture, nor does it present a general measure of the visual effects presented by the built landscape. If the hypothetical actor is permitted to move freely within the architecture, however, the sum of viewsheds taken from every conceivable position will present a situation where there is no part of the building that is not visible at one moment or another – in other words, total visibility. This too, fails to present an accurate measure of visual phenomenology within architecture.

Fig. 2. An example of eRRA analysis, the grey square is the starting point for this iteration.

Fig. 3. The final result of eRRA analysis for the Casa di Trebius Valens (III, 2, 1).

The factor that is missing from this calculation is the introduction of time. As the actor moves within a building, individual views exist only momentarily, but certain features will remain visible longer than others. If it were possible to calculate a point viewshed from every location and then layer them, so that the number of overlapping viewsheds represented the length of effective visibility, this would present an excellent index of the visual experience of the built environment. While it is not possible to calculate a viewshed from every location, a compromise may be reached by placing a grid of equally spaced points across the floor plan, such that it approximates the free movement of an actor within the built landscape.

It was found that the best way to produce this type of analysis was to use software designed for the creation of Geographical Information Systems (GIS). My research used ArcGIS 8, but other types of GIS software such as GRASS or ArcView would have produced similar results. Because GIS software is designed for the purpose of examining large-scale spatial information that normally is on the scale of cities or continents, my research faced a diverse range of challenges and demanded different requirements than most GIS projects. Some research on small-scale GIS has suggested that inaccuracies can be introduced by dealing with information at its true scale (Merlo, 2004; personal communication). Nevertheless, the GIS system used to process the Pompeian houses in this research was set to the appropriate scale. Because the house plans were on the scale of metres, it was entirely unnecessary to perform many of the tasks that are crucial to large-scale GIS projects, but this actually caused more trouble than might have been expected. Difficulties were encountered because the information brought into the system did not have defined projections, and it proved impossible to set up the GIS so that the map projection, global information or coordinate system of the maps was unimportant.

Maps were introduced into the GIS by means of a process that began with the digitisation of house plans in AutoCAD 2002 and Adobe Illustrator 9 into a vectorised format. The DXF file (Drawing eXchange Format) formed the basic file from which all later files were derived, including the GIF files used by the eRRA analysis explained above. Once the DXF file had been set to the correct scale it was used to generate a 16-bit Windows bitmap (BMP) file at a resolution of 508 pixels per inch. This unusual resolution was found to produce an image at the resolution of 20 pixels per metre, and was felt to be a reasonable degree of resolution for visibility processing. In a manner similar to that used by the eRRA Perl script, the different colours of the image were used by the GIS software to represent different elevations, so that black pixels were the walls, white the surrounding space, and blue details, windows and other features that would not block visibility. This BMP file was used as the input for the creation of a 'grid coverage' within ArcGIS 8. Once the coverage had been created it was necessary to set it to the correct scale, as the high resolution of the BMP image generated unexpected results. Thereafter the grid was re-classed so that the correct values were associated with the cells of the grid. This was a rather different system from that encountered by most GIS projects because the landscape to be examined was created by hand

rather than from satellite information or pre-existing geographical information. Theoretically, it would have been possible to create much more detailed elevation models of the houses, including the heights of window sills and various rooms. However, such information was not available for this research, and would have required new surveys of the studied houses. Only three different elevations played a role in this GIS: walls were classed at 10,000 metres, open space was classed at zero, and features such as windows or details that did not block visibility were given the NoData value so that they did not interfere with the creation of viewsheds.

Once in the GIS, a grid of points spaced at five metre intervals was placed across the interior of the house and additional points were placed in rooms that were missed by this grid. Viewsheds were calculated from each point and the layered results produced what could be called a grid viewshed or visibility map: representing the general visual effect of the built environment and characterising the experience of an actor moving through the architecture.

4. Results – The Casa di Trebius Valens

The sample chosen for this research involves sixty-five houses from those excavated at Pompeii, including each house from seven complete insulae, regardless of the size, shape or publication quality of the house (Regio I, Ins. 6, 7, 10 and 13, Regio II, Ins. 2, Regio VI, Ins. 10 and 16). This
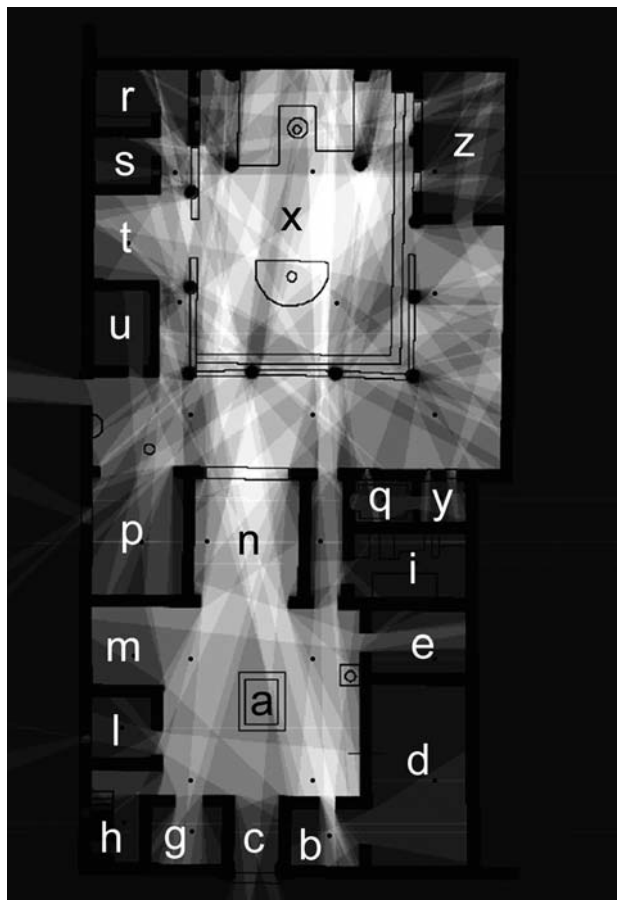

Fig. 4. The visibility map for the Casa di Trebius Valens (III, 2, 1) – light areas are highly visible while dark areas are not.

provides a good sample of the variety of houses present at the site. The sample also contains the more famous houses discussed by Allison (1992) and Franklin (2001) in their works on Pompeian archaeology and philology, as the level of detail, both in finds and decorative information in these houses is unparalleled. While significant concerns revolve around the applicability of Pompeian evidence to the study of Roman houses, the sample nevertheless presents the single greatest source in terms of detail of information attesting to daily life in Roman times. Even if the result of this research is an explanation of the functional nature of Pompeian houses, it will have made a great step forward towards understanding similar roles for houses of the Roman period found elsewhere in the Empire.

There is not room to discuss all of the houses in detail here, but the Casa di Trebius Valens, located in Regio III, insula 2, doorway 1 presents an example of the results of the analyses presented above. This relatively humble house is located about two thirds of the way down the via dell'Abbondanza, and in the recent past was famous for having a large number of electoral programmata on its First Style facade (Spinazzola 1953; De Vos and De Vos 1994). Unfortunately these were lost when front of the house was destroyed by Allied bombing in 1943. The combination of these electoral messages and graffiti from one of the rooms surrounding the atrium (l) have attributed it to the younger Trebius Valens, probably the son of a quinquennial duovir of the same name, who was running for the position of aedile just prior to the eruption (Franklin 2001; Della Corte 1954; Castrén 1975; contra: Mouritsen 1988). The distribution of finds and decor within the house may indicate that it was under restoration or even near abandonment in AD 79 (Allison 1992), but the fine Third Style decoration found throughout the house indicates that it once had a prominent role in the social and political life of its owner, although it should be pointed out that it is possible that this was not, in fact, Trebius Valens.

The house centres on a modest Tuscan atrium (a) with a relatively large peristyle beyond it. Upon excavation the atrium was found covered in coarse white plaster, possibly awaiting further decoration or in a downgraded state of use. It is surrounded by a range of small rooms included one with remnants of fine Second Style painting (l), an ala (m) and a large rectangular room (d) both of which preserved high-quality Third Style painting. On the north side of the atrium there is a similarly decorated tablinum (n), with Dionysiac decoration, that was provided with a large window to the garden peristyle beyond. On the east there was a narrow corridor (f) that connected to a large kitchen (i) before leading to the south portico of the peristyle. Other rooms around the atrium included a small, undecorated room (g), a stairway leading to the upper stories (h) and a simply adorned room (e) from which was discovered a box containing a number of luxury items (Spano 1915, 1916; Allison 1992).

The peristyle to north was decorated with vegetal designs on a low socle and a masonry triclinium bench for dining stood at the north wall, covered with a pergola. To the east there was a large room that looked onto the garden (z) and on the west were several service and storage rooms (r, s, t) and a decorated exedra (t). A further triclinium or oecus (reception room) (p)

faced northward towards the peristyle. Adjoining to the southeast corner of the peristyle was a tiny bath suite (y, q) that was decorated in the Second Style and was clearly out of use at the time of the eruption. Pipes between this room and the kitchen had once provided hot water for the bath.

Examination of the eRRA analysis and visibility map analyses performed for the Casa di Trebius Valens identifies the south wing of the peristyle and the corridor (f) connecting that area to the atrium as the most central locations within the house. On the other hand, the triclinium at the back of the peristyle and the large room (d) on the east of the atrium are isolated from the system of movement. From its decoration and shape this room could be a winter triclinium, and its isolation may therefore result from a desire for greater warmth. The visibility map for this house demonstrates that the areas that received visual focus for long periods of time were the garden area of the peristyle, the tablinum, and to a much lesser degree, the atrium. The rooms around the atrium were rendered surprisingly invisible relative to these spaces, as are the service and storage rooms to the west of the peristyle.

What meaning do these observations have for the pheno-menology of the house with regards to actors within the house? Following Wallace-Hadrill's (1984) discussion of the roles of public and private within Campanian houses, it could be assumed that those areas most remote from the front entrance would be the most private. However, the visibility map indicates that the triclinium and garden area of the house, while both removed from the front door and from the house as a whole, actually receives the heaviest visual focus. That this vista was important to the owner can be further supported by the fact that the large window at the back of the tablinum frames the view, almost as though it were a picture on the wall.

Visitors would have first entered the atrium, where their focus would have immediately been turned toward the more inaccessible regions of the house. The division between those who were permitted to enter further and those who may not must have reinforced their relative statuses vis-à-vis the house owner, ultimately supporting him as the arbiter and controller of access.

On the other hand, the rooms around the atrium, which, due to their proximity to the front door, one might expect to be relatively public spaces, are rendered both visually and pragmatically remote. This is despite the fact that some preserve fine wall painting. Clearly, the decoration was not intended for the purposes of elite display, unless it was to a rather restricted audience. Other rooms, such as that provided with a stairway (h) and the service rooms to the north (r, s, t) receive an equally low degree of visual focus. Perhaps it was not desirable that the activities associated with these rooms should be seen.

On the other hand, the room that contained a collection of luxury goods (e) was both visually removed and simultaneously attached to the main thoroughfare of the house – corridor f. The excavators identified it as a master bedroom, a conclusion that may be supported by its phenomenological characteristics. From this location the owner of the house could have monitored activity within the house while remaining somewhat secluded from that activity.

However, the most revealing spatio-visual effects revolve around the kitchen (i) and bath suite (q, y). While eRRA indicates that the kitchen is quite integrated into the house system – a situation that would be perfect for its role in the provision of cooked food to the various dining rooms of the house. Notably, a small side door opens to the west of the peristyle giving nearly immediate access from the kitchen that must have also assisted in supplying food to be prepared. At the same time it is also virtually invisible from elsewhere in the building so that slaves working in these areas would not have interfered with the more refined activities of the house owner.

The bath suite on the other hand is both removed from the house system and invisible – an expression of Roman privacy that is much more convincing than anything observed by other research. These complicated arrangements indicate that a much wider variety of spatio-visual considerations, functional priorities and requirements were involved in the structuring of a Pompeian house than has previously been identified.

5. Conclusions and Future Directions

The discussion of the dynamics present in individual houses is merely the first step in this research. Patterns such as those observed in the Casa di Trebius Valens will have much greater significance when categorized across the entire sample, amongst a variety of house sizes and forms. Nevertheless, even in this brief discussion it has been possible to present a more detailed and functional account of a Pompeian house than has been achieved by previous research. The future goals of this project include the addition of other phenomenological analyses and documentation of larger trends within the priorities and motivations of Pompeian house owners.

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