Mapping the Senses: Perceptual and Social Aspects of Late Antique Liturgy in San Vitale, Ravenna

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This paper aims to make a conceptual and methodological contribution to the spatial analysis of past architectural spaces, by suggesting some new methods for the investigation of human sensory engagement with the built environment. The Late Antique church of San Vitale at Ravenna is used as a case study to demonstrate the potential of the proposed techniques to illuminate social aspects of past built spaces.

Keywords: sensory analysis, visibility, audibility, 3D modelling, GIS, Space Syntax, San Vitale.

1. Introduction: Aims

"*Rituals and games…rely upon controlled environments and the material culture that is appropriate to them. Furnishings in formal situations are designed to facilitate communication based upon assumptions about human relationships. Thus, churches, courtrooms, theatres, parade squares, classrooms, seminars, and the like all have "basic" patterns that reflect the relations among interacting members who are senders, receivers and observers.*" MCFEAT (1974: 85)

Human perception and communication in ritual spaces often reflect important aspects of social organization and cultural behaviour (TAFT, 1998; MOORE, 1996; CLARK, 2007). This paper aims to make a conceptual and methodological contribution to the spatial analysis of past architectural spaces, by suggesting some new directions in the investigation of human sensory engagement with the built environment. More specifically, by seeking to explore aspects of human perception and communication in a ritual space, San Vitale in Ravenna (548 A.D.), investigates two main issues. Firstly, in which ways patterns of visibility and inter-visibility among the clergy and male and female members of a congregation could best be described and analyzed. Secondly, it examines how these patterns could be associated and intertwine with other aspects of human communication during the liturgy such as speech and singing.

To approach the above issues this research uses established 2D methods of spatial analysis in built spaces, such as isovist and visibility graph analysis (TURNER *et al*., 2001), while at the same time proposing some new analytical approaches that are built upon more recent developments in the areas of visibility mapping and sensory catchment analysis. It applies visibility analysis in 3D spaces (PALIOU, 2009) in order to examine the visual experience of congregation members situated in the second storey (*matroneum*) of San Vitale in a way that is not possible using 2D analysis. Although visibility analysis in 3D spaces is not introduced here for the first time, results are discussed in an interpretive framework more closely associated with Space Syntax methodologies (HILLIER and HANSON, 1984; TURNER *et al*., 2001) than earlier applications of this method (PALIOU *et al.* 2011; PALIOU, 2011). Furthermore, this work suggests a new approach to analysing human perception in a built environment, seeking to integrate visibility and audibility data (the latter produced by TRONCHIN *et al*., 2007, and described in detail by KNIGHT, 2010). This approach stems from criticisms raised in the field of archaeological and anthropological theory concerning the prioritization of vision over the other senses in archaeological analysis, and responds to calls urging for it to be "folded back in the mix of the sensorium" (FRIEMAN and GILLINGS, 2007). The creation of scalar fields that integrate visual and acoustic data is attempted here for the first time in order to explore the potential of spatial distribution maps that more effectively describe human perception as a synergy of the senses, rather than merely as discrete visual or aural engagement with the built environment. Ultimately, the aim of this work is to investigate the ways in which the observed spatial patterns may reveal social aspects of sixth century liturgical practice, and more specifically those associated with inter-relationships between male and female members of the congregation and the clergy.

2. Spatial organisation of the congregation in Late Antique ecclesiastic space

The design, survey, and construction of San Vitale was initiated by Bishop Ecclesius in 526 A.D., immediately following his journey to Constantinople with Pope John I in 525 A.D., and while Ravenna was still under Ostrogothic Arian rule. This octagonal two-storey domed church, which remains extant, was completed and dedicated by Bishop Maximian in 548 following the capitulation of Ravenna to Constantinople in 540 A.D. Evidence suggests conceptual trade influenced the centrally planned churches of San Vitale at Ravenna, SS Sergius and Bacchus and Hagia Sophia at Constantinople (KRAUTHEIMER, 1986; DEICHMANN, 1989; GROSSMANN, 1973; KNIGHT, 2010). San Vitale's famous mosaics of Justinian and Theodora attest to a strong relationship between the Ravennate and Constantinopolitan Orthodox communities.

A few primary sources give some detail of how Nicene liturgical rites were spatially organised during the sixth century in centrally planned churches in Constantinople (Paulus Silentiarius, John Rufus of Maïouma, Evagrius Scholasticus, Procopius). These texts indicate the spatial separation of male and female members in the Constantinopolitan congregations, a phenomenon that has been discussed in detail by MAINSTONE (1988) and TAFT (1998). For Ravenna we are reliant only on Agnellus (DELYANNIS, 2004; 2010) and therefore, any assessment of how the congregation was spatially organised (and on what occasions) in the sixth century Orthodox Ravenna Rite, should be made by analysing the relevant ecclesiastical architecture. Although the relationship between the Orthodox communities of the two imperial capitals may have been reflexive and substantial, understanding that of Ravenna requires an appreciation of the differences and similarities of the architectural details of San Vitale. For example, San Vitale does not have several of the features (*solea, ambo, loges*), which operated as reasons behind much of the congregational spatial organisation characteristic of Constantinople. On the other hand, one important commonality is the presence, in centrally planned congregational churches at Ravenna and Constantinople, of a second storey gallery named in the sources as *matroneum* / *gynaecium*, the place of the women. This suggests that male and female participants were allocated different areas within San Vitale, as is also the case at Constantinople.

If the analogy between the spatial organisation of the congregation in the Ravennate and Constantinopolitan Orthodox communities is further extended according to what is known from sixth century written sources (TAFT, 1998: 87), it is also possible, that during the celebration of the Eucharist some women may have been situated at the side galleries flanking the main nave. The latter seems to have been allocated to men (TAFT, 1998: 87), while on some occasions men may have also participated in the liturgy from one of the ground floor side aisles (left or right ambulatory), when not occupied by women. Finally, the sanctuary would have been exclusively used by the clergy (cf. TAFT, 1998: 29).

It can be safely assumed that the allocation of specific areas within the church to the congregation during the sixth century would have been made preferentially rather than randomly (cf. CLARK, 2007: 86; MOORE, 1996), and in accordance with the local rite, reflecting aspects of religious behaviour and social order. The motives behind the spatial separation of male and female participants can be further illuminated by examining aspects of co-presence between congregational members during the liturgy, as well as visual and acoustic access to the performed rituals.

3. Visibility analysis

Although originally developed in the field of urban planning, computational methods belonging to the set of techniques known as space syntax, such as isovist (BENEDIKT, 1979) and visibility graph analysis (TURNER *et al.*, 2001), have recently been used in archaeological research to examine the visual and social structure of past spaces (STAVROULAKI and PEPONIS, 2005; CLARK, 2007). An isovist is the set of all the points that are visible from a given location in space. It was introduced in the analysis of architectural configurations in 1979 by BENEDIKT (1979: 52), who originally defined it as a 3D entity, which comprises all visible surfaces that surround a human observer. Despite this, and for the sake of simplicity, an isovist in urban analysis is considered as a horizontal 2D plane at the eye level of the viewer (Figure 1). Similarly, a visibility graph consists of a set of edge connections between mutually visible points in 2D space. It can indicate locations in the study area that are visually integrated (seen from relatively numerous observation points) or segregated (seen from relatively few viewpoints) (Figure 2). Both analyses can be computationally performed with Depthmap, a software developed in the Virtual Reality Centre for built environment at the University College of London. The works of STAVROULAKI and PEPONIS (2005), and CLARK (2007) form characteristic examples of how these approaches can be applied for the interpretation of past ecclesiastic spaces. Clark's research on Byzantine churches in Jordan considers the measures of spaciousness (area), openness (isovist perimeter^2/area) and complexity (area/isovist perimeter^2) of isovists calculated from the altar, ambo and from the seat of the presiding cleric for six distinct church types (CLARK, 2007). He then performs a Visibility Graph analysis for the same spaces and makes comparisons regarding the various levels of visual integration that possibly signify changes in liturgical rites and in the relationships between congregation and clergy (CLARK, 2007: 102).

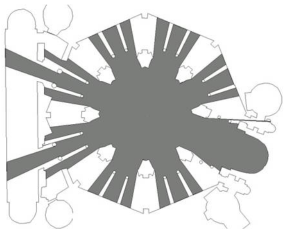

Figure 1: *An isovist*

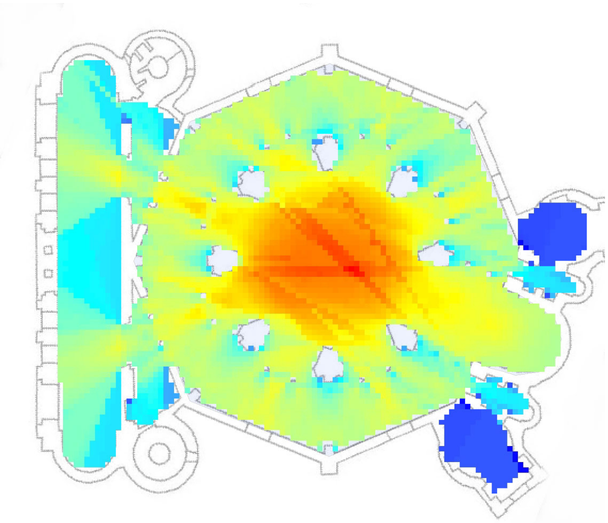

Figure 2: *Visual Integration (HH) (red values-high/blue-low) for the ground floor of San Vitale.*

Isovist and visibility graph analyses are useful for describing aspects of human visual experience in ritual spaces that lack second storey galleries or exedras, but are limited when it comes to buildings that have such features. As mentioned above, San Vitale has a second storey gallery presumably used in the sixth century by female members of the congregation. If that was the case, the visual experience of the female participants looking down on the scenes unfolding at the ground floor cannot be effectively examined with 2D methods of analysis, which can only take into account a single horizontal or vertical slice of space (depending on whether they are performed on a building plan or elevation) at the eye level of the viewer.

Visibility analysis in 3D spaces, a methodology originally developed by the Archaeological Computing Research Group at the University of Southampton (EARL, 2005; PALIOU and WHEATLEY, 2007; PALIOU, 2009; PALIOU *et al.*, 2011; PALIOU, 2011), aims to overcome such limitations. It is based on the premise that when a virtual environment is illuminated with a single light-source that casts rays in all directions, illuminated and non-illuminated areas of the model will correspond to visible and non-visible surfaces respectively. The application of the analysis first of all requires the creation of a 3D model of the space under study (Figure 3) and consequently the identification of visible and non-visible areas for each viewpoint in the study area.

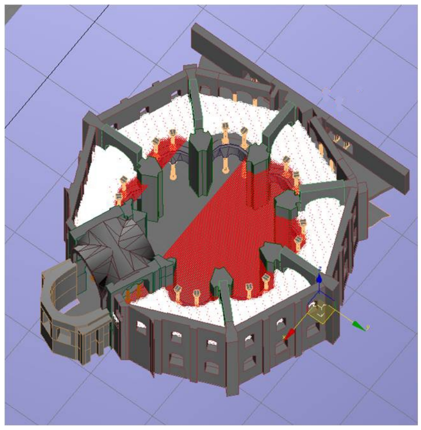

Figure 3: *A 3D model of San Vitale (created by Giannakopoulou (2007), modified by E. Paliou, based on Deichmann 1989). The slice of space demarcated in white defines the sampled area (10270 viewpoints) and corresponds to an average viewer's eye level of 1.70m.*

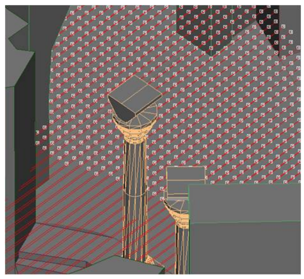

Figure 4: *The study area (second storey gallery) is sampled using a grid defined by 20cm intervals.*

This is accomplished by sampling the space where observers could have been located using a grid (Figure 4) that defines equally spaced intervals and animating the light source over each grid centroid (viewpoint) placed at an average viewer eye level. The texture (Figure 5) of the target object that incorporates information on illumination (e.g. visibility) is then extracted for each light location using *texture baking* tools, which are now standard features of most 3D modelling programs.

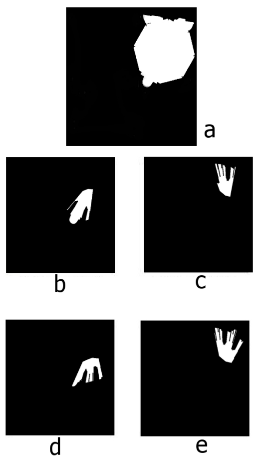

Figure 5: *Textures of the ground floor area (white = visible, black = non-visible). a: Ground floor in full view, b-e: the visibility/non-visibility of the ground floor from viewpoints in the second storey gallery.*

At a second stage a series of map algebra operations and scripted batch processes are performed using GIS software, in order to analyse and summarise information contained in the extracted textures. In this way new types of mapping are created, such as "times seen" (Figure 6, 9), namely maps that indicate how many times the target object can be seen from the study area, and scalar fields (Figure 8) showing the changes in the visible area of a target object through space.

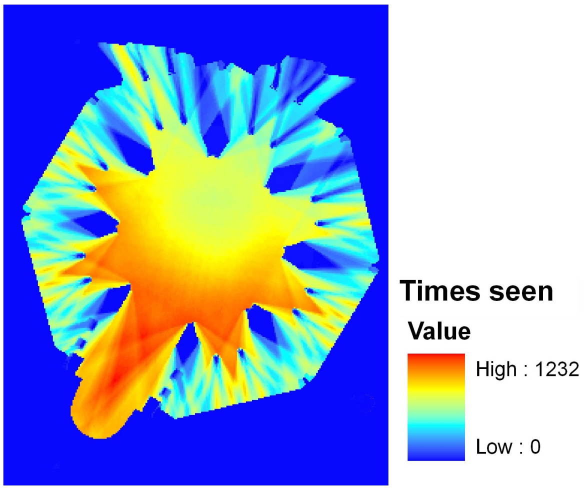

Figure 6: *Times seen of the ground floor from the gallery (sampling every 20cm).*

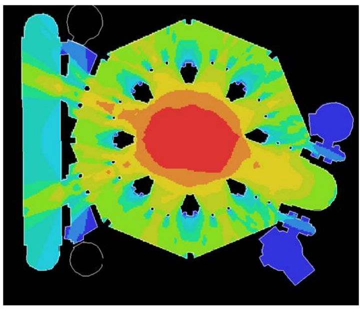

Figure 7: *Visual connectivity for the ground floor (grid spacing 20cm, (red values-high, maximum: 18479/blue- low, minimum: 127;created with DepthMap).*

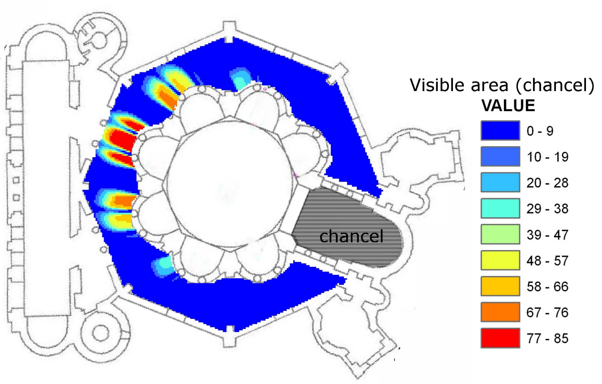

Figure 8: *Visible area (%) of the chancel from the gallery.*

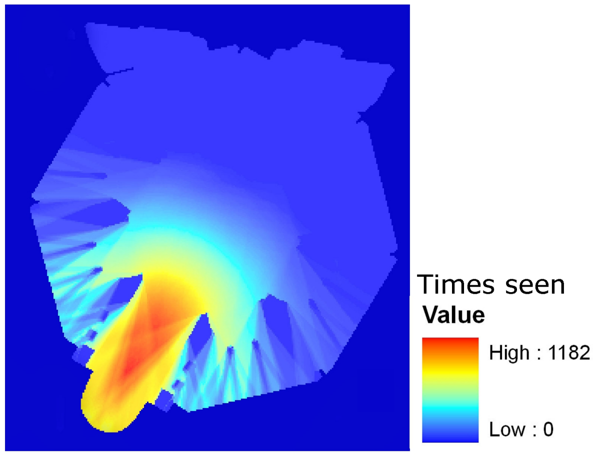

Figure 9: *Times seen from those locations in the gallery from which more than 20% of the area of the chancel can be seen (1640 viewpoints).*

The results from the application of the analysis in San Vitale allowed the examination of visual access to the liturgical drama in the chancel from the *matroneum*, and identified patterns of inter-visibility between female congregation members in the gallery and males on the ground floor.

The "times seen" describing how many times the ground floor is sighted from the *matroneum* gallery (Figure 6) summarises the results of 10270 viewpoints (one every 20cm). This suggests that the most visible ground floor area from the *matroneum* is the chancel, which would have been the main focus of attention during the liturgy, as the high altar is situated there. However, the difference in visual access to the chancel area from the *matroneum* and ground floor is striking: from the former the chancel is visible 1,026 times on average (Figure 6) while from the latter 12,623 times (Figure 7)[1]. It derives then, that female members of the congregation had very limited visual access to the ritual in relation to those situated at the ground floor. If women, besides the galleries, occupied the aisles flanking the nave (left or/right) at the ground floor, as applies to the sixth century liturgy at Constantinople (TAFT, 1998: 36-39), then they would still have been situated in the least visually integrated areas (as suggested by Visibility Graph analysis in Figure 2). On the other hand, the sight lines of men observing the liturgy from the main nave area would not have been obstructed by architectural elements (Figure 1).

Furthermore, the "times seen" of Figure 9 that considers only those locations of the galleries that could offer a

[1] Numbers refer to the average of values recorded for the chancel area only. N.B. In the case of figure 6 1,026 stands for the average amount of times each pixel in the chancel area is seen from the *matroneum*. In Figure 7 12,623 refers to the average amount of times each cell of the analysis grid (20cmx20cm) in the chancel area can be seen from the ground floor.

view to a significant part of the chancel area (e.g. they could see over 20% of the area of the chancel, Figure 8, non dark blue) suggests that women able to view the ritual performances, had at most times limited visibility of the nave area occupied by men.

It is however also important to note that some locations at the *matroneum* would have offered special and literally transcendental views from above (Figure 10). Women located in these areas, would have perhaps the most advantageous visual access during the service as they were able to observe clearly both the unfolding events at the ground floor and a great number of congregation members in the nave area at the same time.

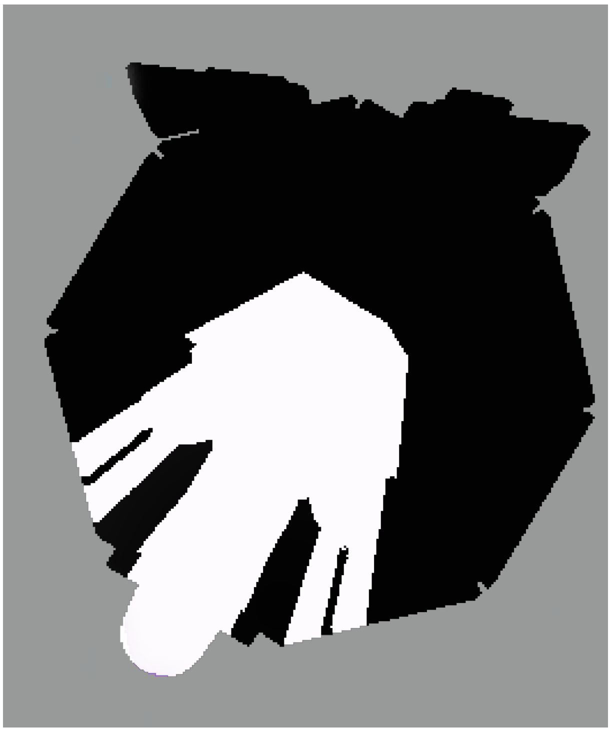

Figure 10: *Visible area of the ground floor from the matroneum from a position opposite the chancel (white = visible, black = non-visible).*

4. Multi-sensory mapping: Integrating visual and acoustic data.

"*Rather than discrete modalities [senses] the sensorium needs to be considered as a complex whole, where what we might think of as recognisable modalities intertwine, blend and blur with one another"* (FRIEMAN and GILLINGS, 2007: 8)

Vision is only one sensory register within the sensorium, which also includes hearing, touch, smell and taste, and should not be equated as all perception nor lightly prioritized over the other senses. Works in archaeology that seek to investigate human experience and perception in past environments by solely discussing vision, have been criticised by some trends in archaeological theory (HAMILAKIS, 2002) as not only limited but also fundamentally flawed. Given the difficulties involved in identifying all aspects of the sensorium in partially preserved archaeological material remains, the fact that most studies focus on only one sense, usually vision and occasionally hearing, is not surprising. As LLOBERA (2007: 52) has noted, such attempts should not be discouraged simply because they don't capture the entire picture. Nonetheless, it is true that archaeological interpretations would have much to gain if more enriched approaches to human perception were adopted, wherever possible.

During the liturgy in San Vitale a number of sensory information, visual, aural (speech and chant), olfactory (burning incense), gustatory (communion bread and wine) would have been shared among the assembly, significantly contributing to shaping the experience of the ritual. The visibility patterns produced by 2D and 3D visibility analysis can describe only a few aspects of human sensory engagement within an ecclesiastic space. Fortunately, the acoustic survey and mapping of San Vitale (TRONCHIN *et al.*, 2007; 2008) is an important step towards a more complete investigation into how the liturgy was perceived by members of the congregation. Spatial distribution maps of acoustic values can describe, for example, perceptible speech (Figure 11) and singing clarity at the ground floor that would have affected the communication and reception of theological meaning to those present.

Although distinct mappings showing aspects of visibility and audibility in space are without doubt useful, it is argued here that spatial distribution maps that integrate acoustic and visual datasets would better represent the blending of the senses as described by anthropological theorists such as INGOLD (2000) and form a more theoretically informed basis for architectural analysis. FRIEMAN and GILLINGS' (2007) attempt to define the *sensory envelope* in landscape studies reflects similar considerations. A *sensory envelope* is a circular catchment around a location of interest identifying an

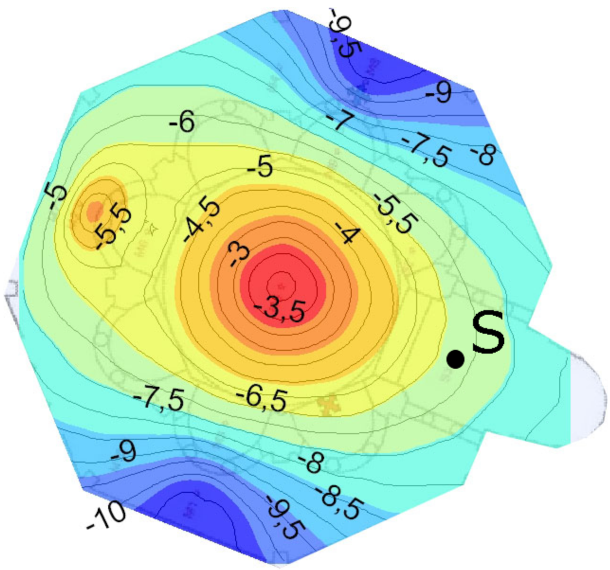

Figure 11: *Perceptible speech clarity (C50) of a sound source (S) placed immediately before the main altar in the chancel (based on TRONCHIN et al., 2007, fig. 6).*

area "where all of the senses are engaged" (FRIEMAN and GILLINGS, 2007: 10). The radius of the sensory envelope in the landscape is determined by one or more formal rules (e.g. 60 times the height of dominant tree species). A circular sensory catchment area surrounding a location of interest may have some interpretive value at large spatial scales (FRIEMAN and GILLINGS, 2007), nonetheless, it forms a rather crude indication for human perception in built environments at small spatial scales.

Consequently, this work proposes the creation of a more precise perceptual catchment in built spaces that can reveal fluctuations in the sensorium through space. This can be achieved by integrating different mappings that describe the spatial distribution of single modalities with data fusion methods. Data integration could be performed in various ways (graphical integrating method, Boolean operations, continuous integrating methods to name a few) using GIS software (KVAMME, 2006). For example, Figure 12 shows such a mapping that was created by multiplying standardised visibility and audibility datasets. The standardisation of the datasets was a necessary preparatory step in the analysis so as to ensure that maps with larger values would not appear dominant in the final outcome. Standardisation was achieved by calculating the mean (μ) and standard deviation (σ) of each dataset, then subtracting the mean from the value (xi) and dividing the result by the standard deviation (which must be non-zero):

$$z = (x_i - \mu) / \sigma$$

This generates values that have a mean of zero and a standard deviation of 1.

A constant value of 10 was added to each standardised dataset to avoid multiplying negative values. The resulting sensory catchment identifies areas on the ground floor of San Vitale distinguished by both high visual integration and acoustic clarity values (red-yellow). Although such mapping does not capture all aspects of the sensorium, it reflects better the synergistic relationship between vision and hearing that would have determined human experience in San Vitale. The creation of similar maps for the *matroneum* was not possible as acoustic datasets for that area were not available.

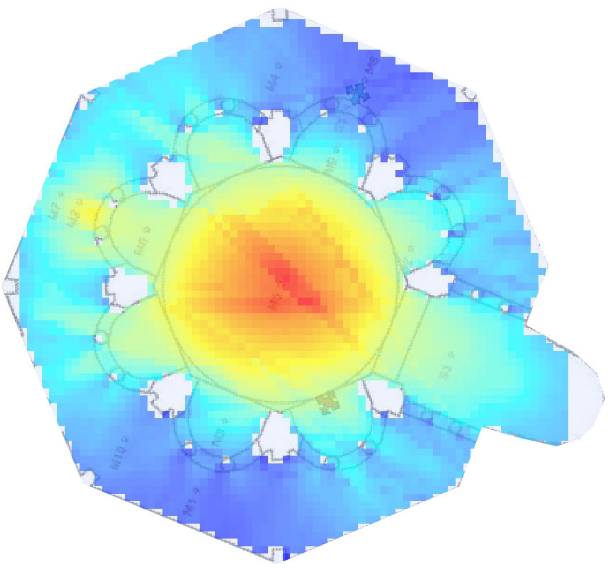

Figure 12: *Sensory catchment produced by integrating the visual and acoustic datasets of Figures 2 and 11 respectively, red=high, dark blue=low.*

Discussion and conclusion

This paper has aimed to raise some theoretical and methodological issues associated with quantifying aspects of human perception in architectural spaces. 3D methods of visibility analysis were used here to investigate patterns of co-presence in the built environment within a theoretical framework similar to that used in earlier Space Syntax studies of ecclesiastic space. The 'times seen' of Figures 6 and 9 describe in quantitative terms the possibilities for visual access to the ground floor from the *matroneum* in San Vitale, and complement visual connectivity maps, created using 2D methods, of visibility analysis (Figure 7). Furthermore, ways of integrating visual and acoustic datasets so as to create sensory catchments that show fluctuations in the sensorium were suggested. Given that the creation of such spatial mapping was attempted here for the first time, it is noteworthy that it does appear to reflect social and religious behaviours of the sixth century documented in surviving written sources (TAFT, 1998).

The results of both 2D and 3D visibility analyses presented above suggest that men had privileged visual access to the performed ritual, while women would have been situated, mostly, at locations offering limited visibility to the chancel area, that would have been the main focus of attention during the liturgy. Sensory catchments for the ground floor created by combining visibility and acoustic datasets also suggest that sensory reception would have been better at the main nave occupied by men rather than the ambulatory aisles, where women might have been located. This seems to support the idea that the separation of men and women in church space was partly due to, or simply reflected, gender perceptions that ranked women after men (cf. TAFT, 1998: 87). Nonetheless, the *matroneum* also offered opportunities for special and transcendental views (Figure 10) to some of the female members of the congregation indicating that women's areas in ecclesiastic space were in some aspects advantageous, a fact that should not be discounted. It is also interesting to note that in San Vitale women in the *matroneum* would have had an eye-level and close view of important architectural and mosaic features (KNIGHT, 2010: 253-260) that would have been impossible from the ground floor.

In addition, the results of visibility analysis showed that sight lines towards the spaces at the ground floor that could have been allocated to women (the aisles, Figure

7) would often have been obstructed, making the viewing of most female members from the nave area difficult. The same would have applied for those situated at the *matroneum*. The placement of women at the less visually integrated spaces probably discouraged communication between male and female participants, serving perhaps, among other purposes, paternalistic attitudes aimed at protecting women from "inappropriate or dangerous male behaviour" (TAFT, 1998: 82-86).

Furthermore, the restricted visual access from the chancel towards areas allocated to women may also express religious perceptions of the clergy. A tenth century quote from the Life of St. John Chrysostom 27, (Symeon Metafrastes; TAFT, 1998: 49) refers to fifth century liturgy and may be indicative of such behaviours in Late Antiquity, although the degree to which similar perceptions were also adopted by the clergy in Ravenna in the sixth century is open to debate:

1. It is said… that, when he [Chrysostom] *elevated the Divine Bread while celebrating the liturgy, he became completely enraptured and through certain symbols saw the Holy Spirit descend upon the offered gifts. 2. But when one of the ministers serving with him cast an eye at a certain woman of those looking down from above, and stared at her with curiosity, the vision of the Spirit was thereby driven away. 3. He* [Chrysostom] *did not ignore this, but removed the minister for his position forthwith… 4. Then, providing for future eventualities he ordered that the galleries be curtained off with veils.*

While the scope has been necessarily limited, the application of sensory analysis to San Vitale indicates the proposed methods are capable of quantifying aspects of human perception and communication that could be indicative of social order and behaviour. The results are therefore encouraging for the use of these approaches in other cultural contexts, both prehistoric and historic. It is anticipated that such methods could best fulfil their potential in architectural analysis when used for making synchronic and diachronic comparisons of different architectural configurations, shedding light onto how built environments transform through space and time.

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