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To cite this article: D J Knight and L Tronchin 2020 *J. Phys.: Conf. Ser.* **1655** 012130

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San Vitale's Aural Networks in the Context of Pandemic and Transformation

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Abstract. We wish to offer a survey of our published work on the Archaeoacoustics of the sixth century basilica of San Vitale, Ravenna, in the context of the contemporary pandemic known as the plague of Justinian. The ordered sequence of reverberant aural encounters at San Vitale is posited as a method of spiritual and physical cleansing. The original metrical verse in the atrium of San Vitale refers to the church as an *arcem* (stronghold) from the *cuntagia mundi* (contagions of the world), a sentiment contemporaneous with the continued effects of the plague. An allegorical route-way from Christ's nativity to resurrection signifies transformation. The resemblance of San Vitale's interior to Constantinople's *mese* processional urban route and the two-story colonnaded frontages enclosing the Forum of Constantine - an intriguing example of an indoor acoustic space designed as a compressed network of recognizable signifiers echoing a specific outdoor urban space elsewhere.

1. Introduction

We have published our measurements and explorations of the acoustic characteristics of the sixth century basilica San Vitale at Ravenna over the past decade [1, 2, 3, 4, 5]. We have also explored the full sensory impact of the architecture [5, 6, 7]. More recently, the broader physical and ideological context of the church has been investigated by specific measurements [7, 8, 9, 10, 11, 12, 13]. We offer a survey of these findings here. In addition, a new exploration of meanings is posited in relation to the context of the sixth century plague of Justinian outbreak, and how San Vitale may have been a response to affect transformation and provide spiritual and physical health. Resemblances of the interior of San Vitale to key sites at Constantinople are identified.

The thesis is developed that the interior reverberation and echo, in tandem with architectonic and representational schemes, were conceived as a strategy at Ravenna - the sixth century Western capital of the Roman Empire - as a way of packaging a complex network of ideas within the semblance of particular exterior spaces in the Eastern capital [13].

2. Survey of San Vitale's Acoustics

2.1. Methods

In 2006 we conducted the survey and measurement of the internal acoustic characteristics of San Vitale. Various methodologies were employed following this initial survey [8] to analyze the recorded measurements.

The initial acoustic measurement included a dodecahedron sine sweep sound source, with a range from 31.5Hz to 16000Hz. In 2013 a more powerful, elegant and simple measurement methodology



was applied to San Vitale [8]. This method was based on a spherical microphone array that would provide measurements of 3D multichannel Impulse Responses at a fine spatial resolution (figure 1).

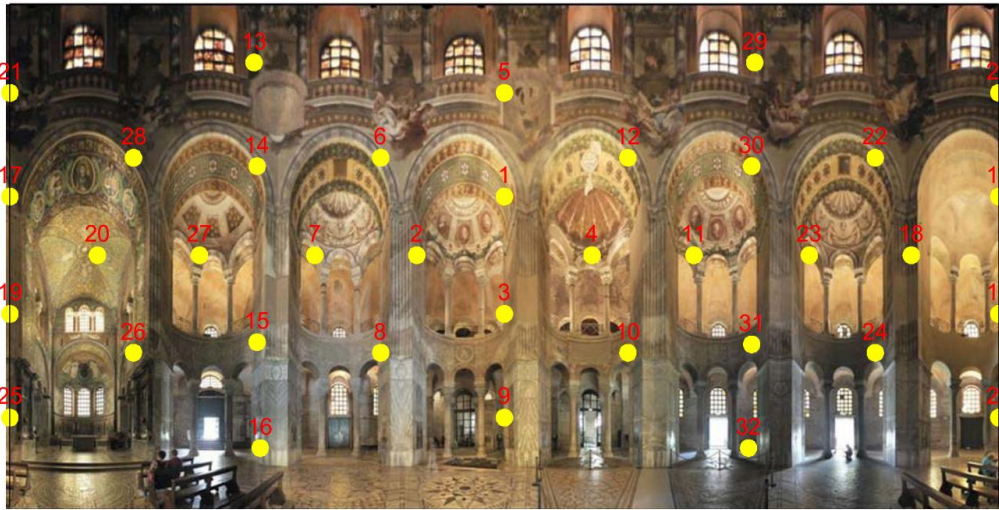


Figure 1. Map of the 32 microphones in a 360 degree view of San Vitale.

A custom-built dodecahedron, incorporating a perfectly flat digital equalization system produced a sine sweep between the range 50Hz and 16000Hz, from this the enhanced acoustic 3D survey recorded fine-grained 3D Impulse Responses. From these recordings were calculated the acoustic characteristics of San Vitale's interior space, including Reverberation Time (T_{20} and T_{30}), as well as speech and music perception Clarity (C_{50} and C_{80}) [8], and other acoustic parameters (figure 2).

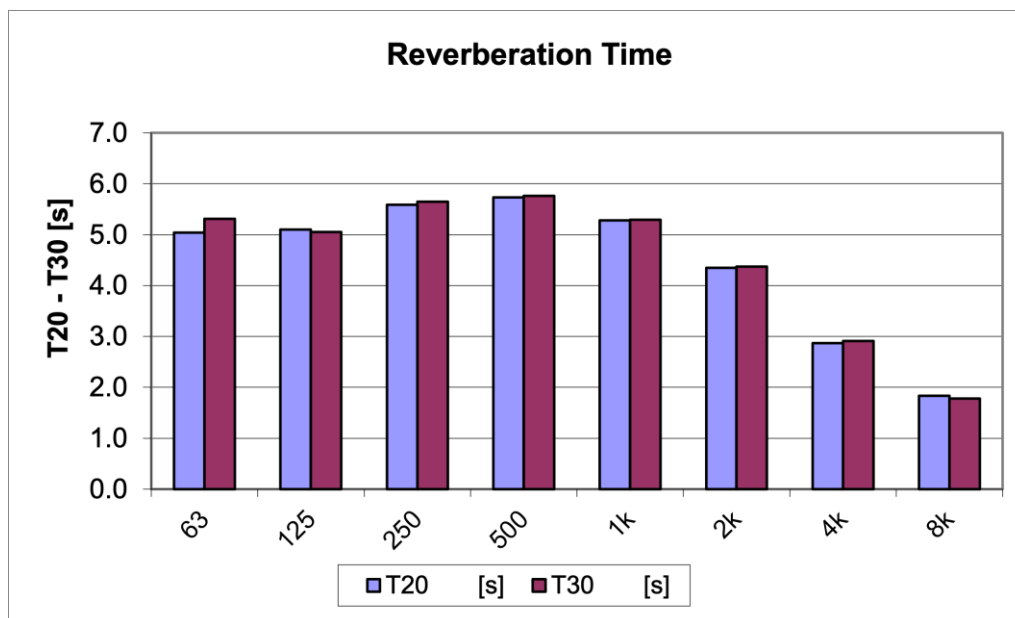


Figure 2. Reverberation times (RT_{20} and RT_{30}) measured in San Vitale.

2.2. The main characteristics

The acoustic characteristics measured within San Vitale included Clarity of musical perception (C_{80}) and of speech perception (C_{50}). When the sound source was located at the high altar, the musical perception inside San Vitale is low, averaging -7.4dB between the range 125Hz (-8.7dB) and 63Hz (-6.05dB). At this same location, speech perception is very good when the listener is within the inner

octagonal space of the ground floor, as well as within the ambulatory inside the north narthex entrance, directly opposite the high altar [5].

It was also revealed that the most effective and intelligible speech inside San Vitale is at the upper frequency range, between approximately 4000Hz and 8000Hz, a higher pitch of spoken voice. The acoustics are therefore more effective for mid-range normal speech, but also well suited for oratorical acclamation with compensations of speech rate, articulation, pitching, intonation, and projection. Further, the resonant frequency of San Vitale was identified as 4Hz, and that the entire volume of air within the church would resonate if the officiating cleric intoned on E [7].

The anagogic verticality of the architecture affords a complex aural network and sonic play in the vocalizations between those situated on the ground floor and those in the upper storey *matroneum* level. The sung *versus* chant, *Lux de luce*, revealed complex resonances that surrounded and immersed the listeners. The lower male voice on the ground floor emanated throughout the space while the higher female voice was clearly heard the *matroneum*, through both direct sound and also the echo that rained down from the central dome [5].

The further vocal performance of *Lux de luce* was recorded in 2007 to isolate for purposes of Auralisation and use in a virtual model. This performance was recorded in the 90Hz anechoic chamber at the Institute of Sound and Vibration Research (ISVR) at the University of Southampton. This recording was then convolved with the surveyed Impulse Responses of the church [5, 10, 14].

2.3. Details of Reverberation and Echo

Impulse Responses were recorded in 2006 and from these were identified average T_{30} Reverberation Times, calculated from the decay range between -5dB and -35dB, and T_{20} , calculated from the decay range between -5dB and -25dB. The average duration of T_{30} , in San Vitale was identified as 4.70 seconds, and, of T_{20} , 4.46 seconds [5, 10]. A noticeable increase was observed in Reverberation Time from 125Hz to 31.5Hz [10].

The sound source was moved to different locations throughout San Vitale's interior. The RT mapping for the sound-source located before the high altar in the Sanctuary revealed that the least amount of reverberation was located at the forward centre of the inner octagon, at and below 4.64 seconds. This spreads to 4.7 seconds enveloping the entire Sanctuary, chancel and apse. A secondary area of low reverberation was noticed at the back of the church, inside the main northern narthex entrance [1, 5].

3. Combination of Sensory Analysis

In tandem with the acoustic measurement of San Vitale, a combination of several aural and visual experiments was employed, in order to acquire a more well-rounded understanding of San Vitale's sensory attributes [10]. To compliment the acoustic data, visual experiments were conducted by constructing and testing virtual models of San Vitale [2, 5, 6].

The construction of virtual models of San Vitale [2, 4] made it possible to accurately identify a number of architectural details otherwise obfuscated and difficult to observe. One such exploration was the play of light and shadow, through natural light entering through the original coloured windows. The results of artificial lighting by hanging oil lamps and candles awaits future experimentation and analysis.

However, luminescence was measured on remaining glass coloured discs that originally adorned San Vitale's windows [5, 10]. A hypothetical original window was virtually constructed and natural external lighting measurements were mapped across the interior [10]. Movement, isovist visibility sight-lines [5] and visuality view-sheds inside San Vitale have also been discussed [6].

4. The Route-way to San Vitale

Following our intensive study of the acoustic and visual atmospheres of San Vitale's interior, it became necessary to revisit the broader physical and historical context of the structure [7, 9, 10, 12, 13]. The reconstructed route-way to San Vitale has been shown to be an intentionally significant and meaningful series of encounters. Bishop Ecclesius's broad plan in c.526 has been demonstrated [9] to

create a model Holy Land pilgrimage at Ravenna. The destination is San Vitale, which symbolically resonates as the New Jerusalem, the Heavenly City and return to Paradise.

4.1. *San Vitale as an allegory of the Heavenly City*

San Vitale has been shown to signify the Heavenly City, styled after key elements of the contemporary sixth century city, namely important recognizable elements of Constantinople in particular [14].

The Old Golden Gate, the *mese* processional route, the Forum of Constantine and the Royal Palace of Constantinople may be the design features compacted into San Vitale. The atrium and narthex entrances may reflect the Old Golden Gate. The internal octagonal space of the ground floor and the colonnaded upper story *matroneum* balcony resemble a contemporary city forum, namely the Forum of Constantine in the Eastern capital. Beyond the Milion mile-stone there, at the termination of the *mese*, stood the sacred royal palace *sacrum palatium* (Greek: *Hieròn Palátion*).

This arrangement may have also existed at Ravenna, elements characteristic of the sixth century City (*Urbs*). What is important is that recognizable elements of the City were created in a compact design for San Vitale. This architectural representation of the Heavenly City as a gated processional path and an urban open space leading to the royal sacred palace ruled over by the triumphant Christ / *Agnus Dei*, reveals the elegance of San Vitale's original design.

4.2. *The interior acoustics expanding exterior acoustics*

The significance of identifying the internal octagonal space of San Vitale with an open urban two-storey colonnaded forum is intriguing. The busy noisy semi-enclosed urban forum was a complex network of aural atmospheres filled with the social communications of an urban civic population. This is mimicked inside San Vitale, almost as a theatre in the round of urban life.

The expansion of the sensed dimensions of the interior, through a seamless network of visibility and acoustics is worth exploring. Reverberation and echo have the effect of expanding the perceived dimensions of space and time. Local (dry) sound becomes bathed and enriched in longer delay and decay times, increasing the psychological sense of physical distance. These acoustic phenomena at work inside San Vitale transform the familiar and ordinary into the extraordinary, the normal into the paranormal.

The mosaic scheme that survives in San Vitale communicates visual abundance, plenty, and concord. Fruits of the sea and land are manifested throughout the chancel and apse as indications of a return to Paradise and good health. The multiplication and expansion in the visual decoration is echoed in the qualitative acoustic characteristics of the interior. The everyday is transformed at all levels of space and time inside San Vitale, perhaps a signal of transformation.

4.3. *Pandemic and Transformation at San Vitale*

In the ninth century, Agnellus documented the original sixth century dedication mosaic in San Vitale's atrium, in which appears the expression *cuntagia mundi* (contagions of the world). The church is likewise referred to in this verse as an *arcem*, which can mean a refuge and sanctuary. This phrase and term may indicate that San Vitale was understood to be a safe place away from disease, or at least a safe place in which one might be transformed and cleansed from the contagions of the world. The historical context for this is that the outbreak of the pandemic known as the Plague of Justinian began in 541/2, within the final phase of decoration at San Vitale.

In the mid-sixth century, medical knowledge of virus and endemic / pandemic disease was based on the writings of Galen, Celsus, and various eastern schools of thought. The other significant method of protection was spiritual cleanliness / absolution from sin and evil. Disease was equated with Evil and the Church was an institution intended to cure such problems. At Ravenna, in the northwestern quarter, the route-way previously described [8, 9, 10, 13] from Santa Maria Maggiore, representing Bethlehem, to Santa Croce, representing Jerusalem and Golgotha, and ending at San Vitale, the destination of the New Jerusalem / the Heavenly City, is a path that is meant to transform and spiritually cleanse. To apply the term 'hospital,' or 'spiritual hospital' to San Vitale, would be to anachronistically misuse a later social and architectural development. However, the concept meaningfully resonates in sixth century Ravenna.

The acoustic and other sensorial aspects of San Vitale can be additionally understood through the lens of this historical context of needing to clean and be protected from pandemic. If we suppose the sequences of internal and external spatial encounters was an intrinsic part of the design that Bishop Ecclesius planned in c. 526 [8], the accompanying acoustic and visual attributes along this sequence can be considered integral to the plan. The experience of being immersed in meaningful interior and exterior spaces, en-route from allegories of birth (Bethlehem) to death (Jerusalem) and resurrection (the New Jerusalem), create a model of pilgrimage through the Holy Land and a way of increasing Christian spiritual enlightenment. In this sense, the internal acoustic characteristics of San Vitale, in tandem with the visual aspects, signify perfect time and space; a return to Paradise. The *Agnus Dei* (Lamb of God) is depicted at the centre of the four rivers of Paradise, in the vaulted sanctuary ceiling over the high altar.

4.4. A Stronghold against the Contagions of the World

Agnellus (61) reported the now lost, original metrical verses rendered in silver *tesserae* in the atrium courtyard to San Vitale:

Ardua consurgunt venerando culmine templa
 Nomine Vitalis sanctificata Deo.
 Gervasiusque tenet simul hanc Prothasius arcem,
 Quos genus atque fides templaque cunsotiant.
 His genitor natis fugiens cuntagia mundi
 Exemplum fidei martiriique fuit.
 Tradidit hanc primus Iuliano Ecclesius arcem,
 Qui sibi commissum mire perfecit opus.
 Hoc quoque perpetua mandavit lege tenendum,
 His nulli liceat condere menbra locis.
 Sed quae pontificum constant monumenta priorum,
 Fas ibi sit tantum ponere, seu similes.

The lofty temples rise to the venerable rooftops,
 Sanctified by God in the name of Vitalis.
 And Gervase and Protase also hold this stronghold,
 whom family and Faith and church join together.
 The father fleeing the contagions of the world
 was to the sons an example of faith and martyrdom.
 Ecclesius first gave this stronghold to Julian,
 who wonderfully completed the work commissioned to him.
 He also ordered it to be maintained by perpetual law
 that in these places no one's body is permitted to be placed.
 But because tombs of earlier bishops are established here,
 It is allowed to place this one, or one like it [15]

When we reconsider the wording, a possible connection to the contemporary Plague of Justinian becomes suggestive. The verse expresses Saint Vitalis fleeing from the contagions of the world as an example of faith and martyrdom to his sons. The contagions of the world can simply mean mortality, which the saint, through martyrdom, transcends. However, the exact use of the words *cuntagia mundi* is intriguing.

When we search for the phrase "*cuntagia mundi*", as found in the original dedicatory verses of San Vitale (reported later by Agnellus), we find that the usage found in an early poem by Claudius Claudianus (Claudian: 370-404 A.D.). The particular phrase is found in his *Phoenix* (10):

"...saeva nec humani patitur contagia mundi."

While it is evident that Claudian substantially based his poem on the earlier, longer treatment by Lactantius, *De Ave Phoenix* [16], the phrase we are interested in is Claudian's. By the ninth century, the mythology of the phoenix had become an allegory for the resurrection of Christ [17], as in the alliterative poem in the Old English *Exeter Book*.

A further relevance to San Vitale and the phrase in Claudian's *Phoenix* is that he reiterates the mythical bird, symbolizing resurrection, lives in Paradise, where, earlier, in the days of Ovid, the Phoenix was thought of as living in Elysium, the ancient counterpart of Paradise (*Amores* 2. 6. 54) [18]. San Vitale has been interpreted as representing the New Jerusalem and a return to Paradise [9]. This pre-supposes that the dedicatory verse would have been understood as containing a reference to Claudian's *Phoenix* and the associations of that mythical creature to Christological resurrection and Paradise, it supposes a certain level of education in order to be fully understood. Perhaps one contemporary student did learn and understand the significance, Venantius Fortunatus. It is, for instance, very suggestive that we find the phrase "*contagia mundi*" in two separate poems by Venantius Fortunatus.

Venantius Fortunatus (c. 530, born at Duplavis (or Duplavilis), now Valdobbiadene, near Treviso in Venetia/Veneto - c. 600/609 AD). Some-time in the 550s or 560s, he travelled to Ravenna to study, and there he was given a classical education in the Roman style. For instance, it has been noted that his later works show familiarity with not only classical Latin poets, but also Christian poets, including Claudian [19]. He left Ravenna and arrived at the Merovingian court at Metz in the spring of 566.

In Book VI of his collected poems, number IV is addressed to Berthichilde and includes the lines:

"...immaculata micans nescis contagia mundi, Sordibus humanis libera membra geris."

Also, in Book IX (*cap.* IV), an epitaph to Chlodobercthi (Clodobert I):

"...Sed cui nulla nocent queruli contagia mundi, non fleat ullus amor, quem modo cingit honor."

From these examples, two conclusions might be drawn. First, that the versifier of San Vitale's dedicatory verse was aware of Claudian's poem *Phoenix*, and not long afterwards Fortunatus encountered the verse at the church and/or in his classical studies at Ravenna. Or, Fortunatus had a hand in the verse composition of San Vitale, using his knowledge of Claudian's poem as a source. The latter theory places Fortunatus in Ravenna in the late 540s, somewhat prior to his accepted presence there. The first theory appears to be the more likely, that the verse at San Vitale was composed by someone who had the classical education to know Claudian's work, and that this was then observed by Fortunatus a few years after San Vitale's completion, certainly before 566.

The first collection of poems made by Fortunatus were written over the first ten years of his life in Gaul, dedicated to Gregory of Tours and published in 576 or thereabouts [20]. The fourth poem of Book Four, in which Fortunatus uses the phrase "*contagia mundi*" is dedicated to Berthichilde, a consecrated virgin who had changed her garments to those of a religious, but still stayed at home [21]. The second collection, Books 8 and 9, was published shortly after Radegund's death in 587 [20].

5. Discussion

The present Covid-19 pandemic has been the context in which we have revisited our study of San Vitale, in its contemporary context of the first historically recorded pandemic known as the Plague of Justinian. The outbreak of this cataclysmic virus was in AD 541/2, within the years of San Vitale's construction (c. 526-548). The mention on the church's original atrium mosaic dedication of *cuntagia mundi* / the contagions of the world has an added resonance for us now.

When we consider the evocative effects of the acoustics and visual design in the context of this church's representation of a transformed city and place of refuge from the pandemic contagions of the contemporary world, the acoustical atmosphere and rich aural network operating within this important sixth century basilica become ever more intriguing and relevant to our own times.

The acoustic characteristics of San Vitale, the architectural design, mosaic schemes, and route-way to the church can be reviewed against the backdrop of the sixth century pandemic. By the time the

atrium dedication was installed in mosaic, in the final phase of preparing the church for service, the pandemic had already ravaged Constantinople. This is a significant identification that bespeaks Ravenna's aspirations at a complex historical moment to have political / ecclesiastical ascendancy in the Western Empire, to rival the power of the Eastern Empire. The goal of becoming another *axis mundi* (centre of the world, *i.e.* Western Empire) has been discussed [5]. Within the light of the Plague of Justinian and that deadly pandemic within the Mediterranean basin, it is also perhaps right to consider Ravenna's strategy, by the time San Vitale was being completed, to offer a healthy alternative to Constantinople.

The relation between San Vitale and the contemporary Plague of Justinian has been previously mentioned [5]. We have shown here how the original dedicatory verse above San Vitale's entrance included a specific phrase from Claudian's *Phoenix*, a phrase that is also found in Venantius Fortunatus, who lived and studied at Ravenna in the years immediately following San Vitale's opening. The phrase *cuntagia mundi* / the contagions of the world can be read in context to the contemporary Plague of Justinian, which was quickly becoming a Mediterranean pandemic when the verse was installed in mosaic above San Vitale's entrance. Research has identified the cause of the Plague of Justinian (541-542, recurring until 750) was *Yersinia pestis*, the same bacterium responsible for the Black Death (1347-1351) [22]. The first wave of the Plague of Justinian began in 541, reaching Constantinople in 542, and Ravenna probably by the winter of 543 [23].

This is an intriguing association between pandemic and San Vitale as a sacred place that was intended as a destination of transformation and rebirth. With this added meaning, San Vitale can be understood further as a sanctuary and possible "cure" to the diseased world. In this way, San Vitale can be viewed as an early votive church. The lineage of votive churches extends beyond sixth century Ravenna, to name but two in Italy, both in Venice; the *Chiesa del Santissimo Redentore* ("Il Redentore") designed by Andrea Palladio, begun in 1577 and completed in 1592. The other is the Baroque church *Santa Maria della Salute*, designed by Baldassare Longhena, started in 1631 and completed in 1687.

The inclusion of the phrase *cuntagia mundi* in the dedicatory verse above the entrance to San Vitale is highly suggestive; the symbolic/allegorical/physical narrative of Holy Land pilgrimage and Christological transformation is made relevant to the contemporary situation of the Plague of Justinian, the [technical virus name], at the very onset of this Mediterranean pandemic. The use of this phrase effectively re-casts the design intentions to include a message of religious sanctuary from worldly disease. Perfected time and space is perhaps understood as a cure to mortality and imperfect Nature. At the very least, there are deep theological reverberations here.

San Vitale is additionally recast when Maximianus replaced Victor's name in the chancel mosaic. And, further, inadvertently, the supposed image of Theodora in the chancel mosaic becomes, early on, a commemorative image. These various early alterations to the biography of the structure complicate attempts to unravel the complexities of Ecclesius's original design.

We have noted elsewhere (Knight 2010:71) that the verses reported on the exterior facade, at the narthex entrance, of Santa Croce, to the immediate south of San Vitale, begins:

Christe, Patris verbum, cuncti Concordia mundi,... (Agnellus 41)

O Christ, Word of the Father, concord of all the world [14]

In the dedicatory verse at San Vitale's entrance, the church is described twice as *arcem*, translated as a "stronghold" [15] (Deliyannis 2004:177), equally relevant as both sanctuary and refuge. This can be further explored. The *Arx* is a specific stronghold or citadel on the northern spur of the Capitoline Hill in Rome. Citadels in other Roman cities are sometimes referred to as *arces*, as at Cosa, Tuscany, and the northwest corner of *Londinium* (London). However, significant to our study, the original *Arx* of Rome was the site of several temples, one in particular was dedicated in 217 BC to Concordia.

Turning from Santa Croce towards the destination in Ecclesius's plan, San Vitale further echoes Concordia. The ancient goddess was often visually depicted wearing a long cloak and holding a *patera* (sacrificial bowl). The visual echo of this to the mosaic depiction of the lead royal female in San

Vitale's northern chancel "Imperial panel" (popularly identified as Theodora), is striking. Here, the regal female wears a long cloak, but she offers a bejewelled *calix* (chalice) as the container of the Blood of Christ, the lead male figure (popularly identified as Justinian) in the southern panel offers the *patera* holding the eucharist.

The echo of Concordia in the male figure of Christian Emperor is combined with his female counterpart decorated with allusions to Mary, as the Magi appear on the hem of her long dress. These additive symbols communicate a powerful harmonious message of social concord and patronage/"matronage". It is also, therefore subjectively significant that the Greek equivalent of Concordia is Harmonia. The metaphor of musical harmony as an ideal of social concord is important to our understanding of the acoustic characteristics within San Vitale. The structured exterior pathways between Santa Maria Maggiore and Santa Croce on to San Vitale are real outside acoustic spaces that contain the complexities of "discordant" natural sounds. These are markedly different to the internal space of San Vitale.

San Vitale's internal representation of an exterior public urban place such as the Forum of Constantine and is as much a depiction as are the visual mosaic schemes. Former illustrations of space syntax within San Vitale identify the central octagonal space as having a high level of visual integration [6, 24]. Likewise, and also predictably, this central area is also one of the best locations from which to perceive music and speech [10], as found also in XVII Century [11].

For a contemporary sixth century congregation visiting these buildings, the subtle allusions in these usages of Concordia and *arcem* probably operated as significant memories of the classical past, and how Christianity had transformed tradition.

The identification of San Vitale's dedicatory verse and relationship to the contemporary pandemic can now be placed within a wider context. A relevant network of buildings and concepts include the fact that Sabinus, Bishop of Canosa, Apulia, accompanied Ecclesius of Ravenna in the entourage of Pope John I to Constantinople in 525. Upon their return to Italy in 526, Ecclesius began his building scheme at Ravenna, of which San Vitale is the core. Sabinus, upon returning home began his own building programme at Canosa. His new church was a double-shelled *tetraconch*, the second of Italy's centrally planned congregational churches of this period, San Vitale at Ravenna and the earlier S Lorenzo at Milan. Sabinus dedicated his new church to SS Cosmas & Damian, later re-named S Leucio [5].

When Ecclesius was initiating the construction of San Vitale, and in the short period between July 12th 526, when King Theoderic's chosen candidate became Pope Felix IV, and a few days later at the end of August when Theoderic died, he and his daughter Amalasuetha donated to Felix the *Bibliotheca Pacis* and nearby Temple of Romulus in Rome. Felix converted the ancient buildings into a Christian basilica and dedicated it to SS Cosmas & Damian. These Syrian Christian brothers were 5th Century physicians who were martyred. By the sixth century they were venerated as the patron saints of physicians and called upon as protection against plague.

These are therefore compelling associations between San Vitale and relevant contemporary dedications and strategies against pandemic. The entire site at San Vitale is a resonant narrative, from the nativity located at Santa Maria Maggiore, to the Crucifixion at Santa Croce, preparing the congregational "pilgrim" for the transformation of resurrection inside the ultimate destination of the Heavenly City, the New Jerusalem and return to Paradise - San Vitale, a stronghold against the contagions of the world.

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