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Lucas Giles

University of Cambridge, Doctoral Candidate

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Medieval Architecture and Technology: Using GPR to Reconstruct the Choir Screen at Santa Chiara in Naples*

LUCAS GILES

Cambridge University, Doctoral Candidate

Medieval churches were originally divided into distinct sections, designed to create a system of social hierarchy within their interior spaces. They were rich in elaborate decoration and filled with an assortment of liturgical objects which are largely now lost or decontextualized from their original setting. Among these objects included (*inter alia*) altars, paintings, tapestries, tombs, and internal divisions.¹ One of the most important of

*I am indebted to a number of colleagues for this project: Many thanks must first go to my research collaborators. Particular thanks must go to Andrea Basso and Elisa Castagna with whom I worked so closely and to Paolo Borin for his technical guidance. Thanks must also go to their professor Andrea Giordano who coordinated their arrival at Duke and who so diligently oversaw their involvement in the project. I am also grateful to him for putting us in touch with Leopoldo Repola and Emanuela de Feo. Their collaboration has been fundamental to this research. I must also thank the church of Santa Chiara and Padre Vincenzo Palumbo who has been so accommodating in allowing us to do research on the church complex. I am also indebted to friends, colleagues and professors who have been so supportive in offering their invaluable advice. In particular, Donal Cooper was hugely helpful at the start of this project. Thanks as well to David Zielinski and to Regis Kooper who were so influential in setting up the DiVE application and to the anonymous reviewers. I'm also particularly grateful to the editors of this journal, Sarah Blick and Brad Hostetler, who provided me with an opportunity to publish this research and who have been so encouraging throughout. Finally, I must also pay special homage to my advisor for this project, Caroline Bruzelius. None of this would have been possible without her.

these lost components was the choir screen or *tramezzo*, as it is commonly referred to in Italy.² These semi-architectural structures separated the areas occupied by the clergy and the laity, dividing church interiors into a series of liturgical zones.

Two visual and material sources, commonly used to introduce these masonry partitions, are well-known to historians of art and architecture. The first is a pictorial example from the Upper Church in Assisi depicting the *Crib at Greccio* (**Fig. 1**).³ Here we

¹ This gave medieval church interiors a particularly crowded aesthetic. See here the important contribution by S. De Blaauw, "Innovazioni nello spazio di culto fra basso Medioevo e Cinquecento: la perdita dell'orientamento liturgico e la liberazione della navata" in J. Stabenow (ed), *Lo spazio e il culto* (Venice, 2006), pp. 25-51. See also D. Cooper, "Franciscan choir enclosures and the function of double-side altarpieces in pre-tridentine Umbria," *Journal of the Warburg and Courtauld Institutes*, 64 (2001), p. 1. In this article, Cooper uses the term "cluttered" to describe this phenomenon when he discusses the impact of the Counter-Reformation on stripping away "the clutter of the medieval nave."

² *Tramezzo* is the most common name used within an Italian context. However, depending on the region in which they were referenced, they could be termed as *pontile*, *intermedium*, *podium*, *palco*, *portico*, *ostium*, *pulpitum*, *corrodoi* or *murus*. For all these different terms, see J. Cannon, *Religious Poverty, Visual Riches: Art in the Dominican Churches of Central Italy in the Thirteenth and Fourteenth Centuries* (London, 2013), p. 39. In England, choir screens were referred to as rood screens, whilst in France the most common term is a *jubé*. A greater number of choir screens survived in Northern Europe, so there is a broader literature on the topic. In relation to French and German examples, see particularly J. Jung, *The Gothic Screen. Space, Sculpture, and Community in the Cathedrals of France and Germany, ca. 1200-1400* (New York, 2012). For the most recent publication on European examples (with a particular focus on England), see S. Bucklow, R. Marks, and L. Wrapson, *The Art and Science of the Church Screen in Medieval Europe: Making, Meaning, Preserving* (Woodbridge, 2017). See particularly the article by Cooper for a comprehensive study into Italian screens. Within the article, he reviews existing research on Italian *tramezzi* whilst providing some more general comments on their form, function and decoration: D. Cooper, "Recovering the Lost Rood Screens of Medieval and Renaissance Italy," pp. 220-245. For more Italian examples, see also those that emerge in a collection of essays in *L'arte medievale nel contesto 300-1300. Funzioni, iconografia, tecniche* (Milan, 2006), especially as part of the essay by P. Piva: "Lo spazio liturgico: architettura, arredo, iconografia (secoli IV-XII)," pp. 141-180.

³ For a study on the entire fresco cycle, see D. Cooper and J. Robson, *The Making of Assisi: The Pope, the Franciscans, and the Painting of the Basilica* (New Haven, 2013). For research on the *Crib at Greccio* scene, see also J. Robson, "Assisi, Rome and the Miracle of the Crib at Greccio," in Z. Opacic and A. Timmermann (eds), *Image, Memory and Devotion: Liber Amicorum Paul Crossley* (Turnhout, 2011), pp. 145-155.

are witnessing the screen from the reverse with the viewer positioned in a privileged location amongst a group of friars and laymen. Of particular note are the female figures



Figure 1 Giotto and workshop, *Miracle of the Crib at Greccio*, fresco, c. 1290-97, Upper Church, Basilica of San Francesco, Assisi. Photo: after D. Cooper, "Recovering the Lost Rood Screens of Medieval and Renaissance Italy" in S. Bucklow, R. Marks and L. Wrapson, *The Art and Science of the Church Screen in Medieval Europe: Making, Meaning, Preserving* (Woodbridge, 2017), pl. LVII.



Figure 2 Pietro Lombardo's workshop, choir screen, 1475, Basilica of Santa Maria Gloriosa dei Frari, Venice, the screen frames an altarpiece painted by Titian, *Assunta*, 1516-18. Photo: after D. Cooper, "Recovering the Lost Rood Screens," pl. LXI.

located beyond the screen who cluster around the central portal of the *tramezzo*. The other, is one of the best-preserved surviving examples, at the Frari in Venice (**Fig. 2**).⁴ Here the screen acts as a visual frame directing the vision towards the high altar and towards Titian's monumental altarpiece (which was incorporated into the church about 40 years later).

⁴ For the most recent publication on this particular screen, see A. Sherman, "'To God alone the honor and glory': Further notes on the Patronage of Pietro Lombardo's choir Screen in the Frari, Venice," *The Burlington Magazine*, 156 (2014), pp. 723-728.

So why is that, upon entering a medieval church in Italy today, we are confronted by a vastly different experience? What happened to all the choir screens which would have once adorned these structures and why do church interiors more closely resemble an open, Renaissance-style space?⁵ Choir screens were a victim of the enormous liturgical shifts encountered after the Counter-Reformation during the 16th century. Following the Council of Trent, they were systematically removed from Italian churches in an effort to correct any remoteness felt by the lay public when viewing mass. With little trace being left behind *above ground* of their prior existence, they very quickly fell away from historic memory.⁶

This effect is still palpable today as choir screens have largely remained on the periphery of academic discussion. Only comparatively recently has the importance of these structures been recognized with the emergence of scholars like Donal Cooper and before him Marcia Hall.⁷ But despite partially filling this academic lacuna, and

⁵ Often stripped of their original furnishings, these gutted medieval interiors more closely resemble the Renaissance preference for spatial harmony and architectural unity. The Renaissance bias has very much colored our own aesthetic taste, an affect which is still palpable today. See De Blauww (2006).

⁶ On this topic, see M. Gianandrea & E. Scirocco, "Sistema liturgico, memoria del passato, sintesi retorica: l'arredo ecclesiastico medievale in Italia del Controriforma al post-Vaticano II," in I. Foletti, M. Gianandrea, S. Romano & Elisabetta Scirocco (eds.), *Re-thinking, re-making, re-living Christian origins* (Rome, 2018), pp. 407-452.

⁷ Marcia Hall's famous reconstruction of the screen at Santa Croce in Florence remains a bench mark for art and architectural historians. The reconstruction was based on the discovery of the screen's foundations which were revealed during the repaving of the church after the flood in Florence in November 1966: M. B. Hall, "'The 'Tramezzo' in Santa Croce, Florence, Reconstructed,'" *The Art Bulletin*, 56 (1974), pp. 325-341. She also published a reconstruction of the screen at Santa Maria Novella in Florence during the same year (1974): M. B. Hall, "The ponte in Santa Maria Novella: the problem of the rood screen in Italy," *Journal of the Warburg and Courtauld Institutes*, 37 (1974), pp. 157-173. The appearance of these two articles in 1974 could be said to initiate the beginning of the modern study of screens, with

establishing some important fundamentals with regard to their form and function, there is still much we don't know. This is, in part, due to a distinct lack of extant evidence (both visual and archival) in relation to Italian screens. As only a handful of *tramezzi* have remained intact, research on the field is both slow and gradual, with documentary discoveries only occasionally surfacing.

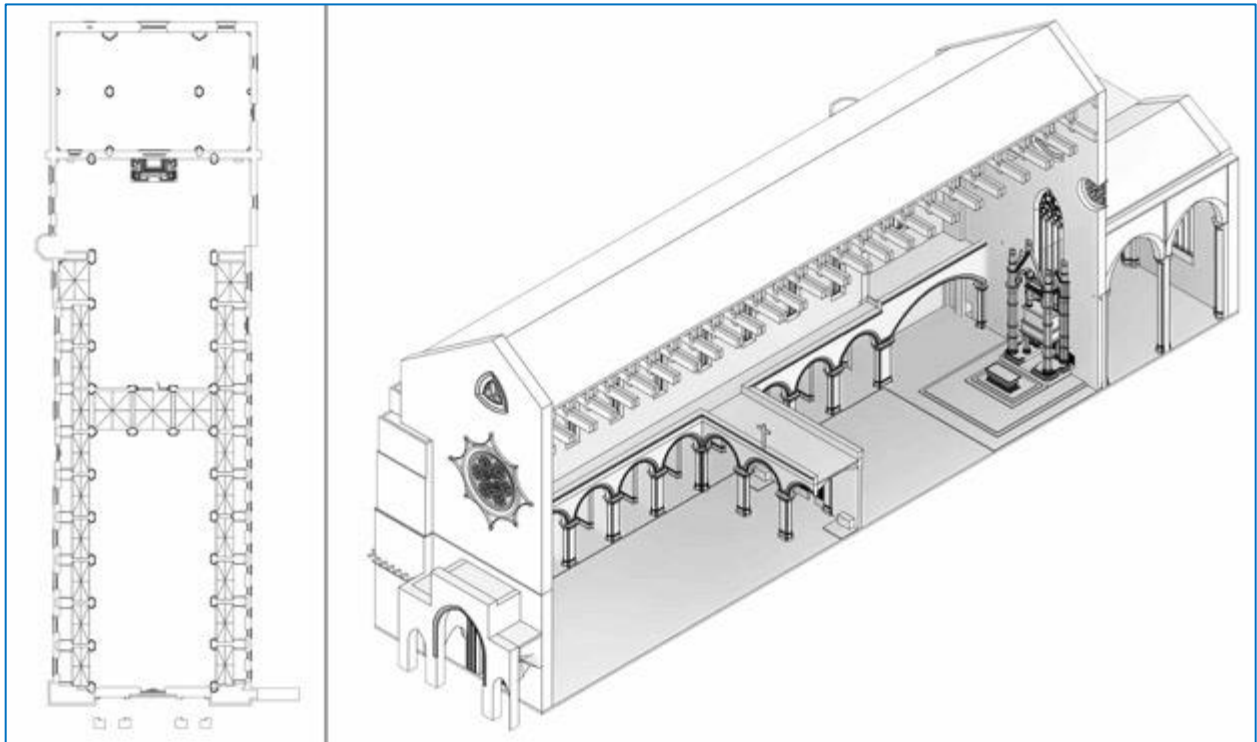


Figure 3 Santa Chiara, Naples, views of the hypothetical screen, church plan (left) and side view (right). Photo: author.

Hall displaying a remarkable sympathy towards archaeological techniques (particularly at Santa Croce) and documentary evidence (at both churches). For Marcia Hall's most recent work on screens, see M. B. Hall, "Another Look at the Rood Screen in the Italian Renaissance," *The Institute for Sacred Architecture*, 27 (2015), pp. 11-19. For an alternative reconstruction of the screen at Santa Croce, see A. De Marchi & G. Pirazzoli, *Santa Croce. Oltre le apparenze* (Pistoia, 2011).

This project is an attempt address some of these shortcomings through the implementation of a new research strategy which transcend the limitations of visual and archival evidence. It proposes an innovative cross-disciplinary approach, employing archaeological techniques to uncover the one element of *tramezzo* screens that generally does survive – the under-floor foundations. It focuses on a particular case study that culminates in a hypothetical reconstruction of the lost choir screen from the church of Santa Chiara in Naples (**Fig. 3**). The historical questions prompted by this research are significant (particularly in relation to liturgical and burial practices), and it is hoped that this article will induce new research questions, serving as a springboard for scholars to conduct more comprehensive research into the screen at Santa Chiara.

Despite gaps in our knowledge about Italian *tramezzi*, considerable advances have been made in the past decades, allowing us to establish some basic principles in relation to their form and function.⁸ We know that they were ubiquitously present in most

⁸ Although this is not an exhaustive list, some important recent publications include Cooper (2017) as well as C. Bruzelius, *Preaching, Building, and Burying: Friars in the Medieval City* (New Haven and London, 2014), particularly p. 11, 24, 31, 57, 97. For the Dominican order, see also Cannon (2013), particularly the opening chapter. In addition to these contributions (which are more focused on a general treatment of screens), a number of case studies have also emerged, particularly from Andrea de Marchi. These include: A. De Marchi, “Il ‘podiolus’ e il ‘pergulum’ di Santa Caterina a Treviso: cronologia e funzione delle pitture murali in rapporto allo sviluppo della fabbrica architettonica,” in A. C. Quintavalle (ed.), *Medioevo: arte e storia* (Milan, 2008), pp. 385–407. A. De Marchi, “‘Cum dictum opus sit magnum’: il documento pistoiese del 1274 e l’allestimento trionfale dei tramezzi, Umbria e Toscana fra Due e Trecento,” in A. C. Quintavalle (ed.), *Medioevo: immagine e memoria* (Milan, 2009), pp. 603–621. A. De Marchi, “Due fregi misconosciuti e il problema del tramezzo in San Fermo Maggiore a Verona,” in A. C. Quintavalle (ed.), *Arredi Liturgici e Architettura* (Milan, 2007), pp. 129–142. In this collection of essays, two other important studies on screens are included: G. Valenzano, “La suddivisione dello spazio nelle chiese mendicanti: sulle tracce dei tramezzi delle Venezie,” pp. 99–114 and T. Franco, “Appunti sulla decorazione dei tramezzi nelle chiese mendicanti: la chiesa dei Domenicani a Bolzano e di Sant’Anastasia a Verona,” pp. 115–128.

medieval Italian churches and were located between the nave and the choir stalls (normally in close proximity to entrances for the monastic communities). We also know that their primary function was to segregate different religious communities – namely the clergy from the laity, as well as men from women. This was in order to inhibit physical (and visual) access to the most sacred areas of the church. And finally, we know that they were highly decorative structures, with coordinated iconographic programs. These included altars, paintings, sculpture, textiles, and lay tombs, making their western façades one of the most visually impressive elements of the medieval church interior.⁹

However, many unresolved issues remain, particularly in relation to access and precisely which communities, which genders, and which social classes could advance beyond screens (and to what extent entry might have been temporarily granted). The goal of this project is, therefore, to provide a methodological blueprint for the study of lost screens, demonstrating how GPR (ground-penetrating radar) technology can serve as an innovative new data source. It will not only involve the digital reconstruction of the Santa Chiara screen (based on the GPR survey), but it will also involve recontextualizing the screen within a 3-D model of the church. In addition, these models will be incorporated into a series of virtual and augmented reality applications to be presented to the public. Digital technologies and the use of a collaborative research model will therefore play a

⁹ In the first chapter of Joanna Cannon's book on the Dominicans, she provides an excellent overview of the function of Dominican screens (which can be broadly applied to the other Mendicant orders). She bases this analysis on the 1249 Dominican general chapter in which specifications for the construction of screens were laid down. This is combined with evidence from three particular examples: San Eustorgio in Milan, Santa Sabina in Rome, and San Domenico in Bologna (whose screens were all installed before the 1249 general chapter). She argues that the requirements outlined in the general chapter, combined with evidence from these three examples, provides some basic protocols for the formal and functional properties of choir screens. She equally suggests that these principles were mostly adhered to in the subsequent examples that followed: See chapter one of Cannon (2013), particularly pp. 38-40.

central part of this study. These technologies serve both as a research tool during the reconstruction process and as a platform to visualize our hypothesis to the public.

The goal of this article is therefore two-fold: the first, to augment our understanding of Santa Chiara as a historic monument through the reconstruction of its screen. This will provide a significant contribution to the study of the building, allowing a more-comprehensive understanding of how the complex would have functioned and been experienced in its original context. It is hoped that this will prompt new research questions in relation to spatial zoning, the performance of liturgical ritual, and issues surrounding lay burial. The second goal is to demonstrate how technology can serve as an effective research tool in the field of art and architectural history. Using the Santa Chiara case study as an example, this article will show how the implementation of emerging technologies can help to shed new light on existing historical material as well as providing fresh insight into a particular research topic.

Case Study: Santa Chiara

The methodological approach briefly outlined in the introduction to this paper has been tested on Santa Chiara primarily because of the importance of the building within the context of *trecento* Naples. The church, built between 1310-1340, was commissioned by the ruling Angevin family. Originally dedicated to *Corpus Domini*, it's one of the largest buildings in the city and it stands in the heart of Naples (**Fig. 4**).¹⁰ The significance of the church, both in terms of scale and its symbolic importance, allows us to suspect

¹⁰ The literature on Santa Chiara is extensive. For the most recent publication and bibliography, see F. Aceto, S. D'Ovidio & E. Scirocco (eds.), *La Chiesa e il Convento di Santa Chiara: committenza artistica vita religiosa e progettualità politica nella Napoli di Roberto d'Angiò e Sancia di Maiorca* (Battipaglia, 2014). Caroline

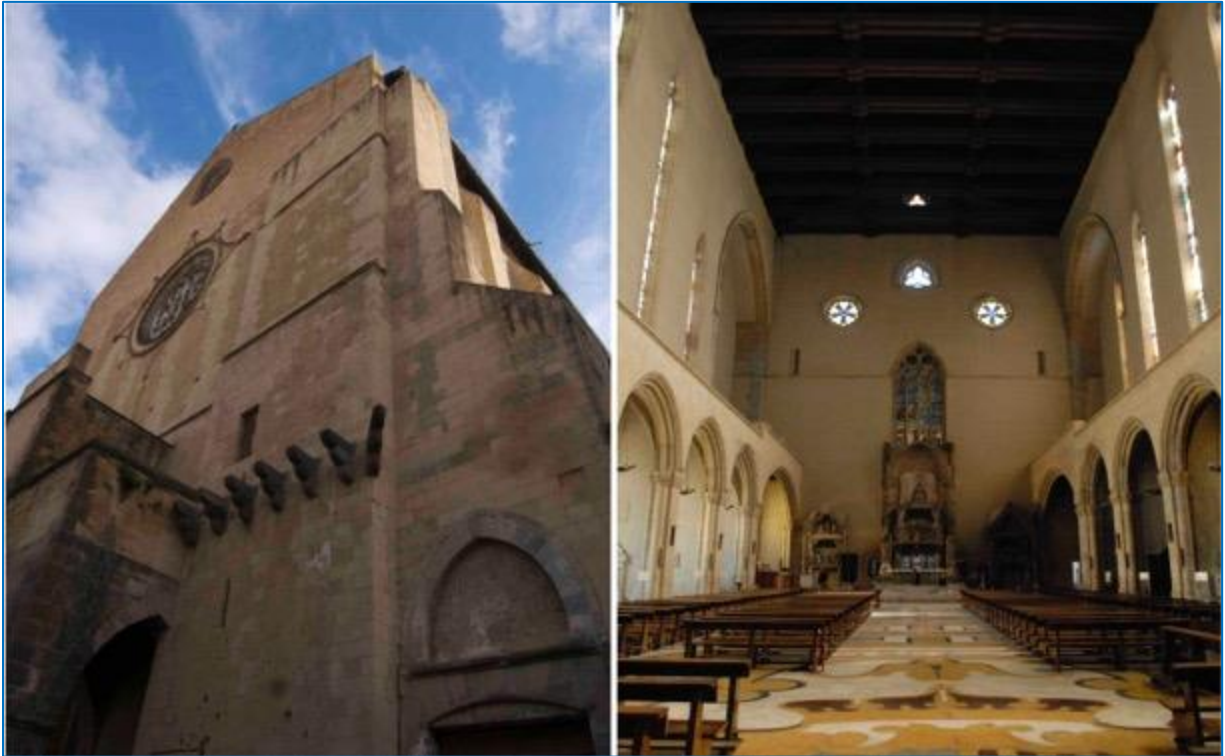


Figure 4 Santa Chiara, Naples, c. 1310-1340, façade (left) and interior (right). Photo: author.

that that choir screen played a crucial role within the interior of the church. The building performed a variety of functions, perhaps most significantly, acting as a major site for royal commemoration.¹¹ To this day, it still holds some of the most important royal tombs

Bruzelius has also conducted considerable research on the building. See C. Bruzelius, *The Stones of Naples: Church Building in Angevin Italy 1266-1343* (London, 2004), pp. 133-153 as well as C. Bruzelius, "Queen Sancia of Mallorca and the Convent Church of Santa Chiara in Naples," *Memoirs of the American Academy in Rome*, 40 (1995), pp. 69-100. Finally, Mario Gaglione has a large bibliography on the church and all of his articles can be found on academia.edu. See especially M. Gaglione, "La basilica e il monastero doppio di S. Chiara a Napoli in studi recenti", *Archivio per la storia delle donne*, 4 (2007), pp. 127-209.

¹¹ The multiple functions of the church have been discussed in detail in Aceto, D'Ovidio & Scirocco (2014). This important publication includes discussions (amongst others) about the religious and political implications of the church, the context which precipitated its construction and the reasons for its geographical location, the influence of Queen Sancia of Mallorca in its founding, and the original

in the city, including the patron of the church, Robert of Anjou (**Fig. 5**) and his wife – Queen Sancia of Mallorca.¹²

The complex was designed as a double convent, intended to house both Clarissan nuns and Franciscan friars, as well as a lay community and the royal family. The concept of separation between the different religious populations was a fundamental component of the church interior with the now-destroyed choir screen playing an integral part as it served to demark the boundary between the areas occupied by the clergy and the laity. Designed on a northwest-southeast axis, the rectilinear building plan was composed of a series of liturgical zones divided into rectangular shapes of varying sizes.¹³ These rectangles can be sub-divided into three main areas (**Fig. 6**):

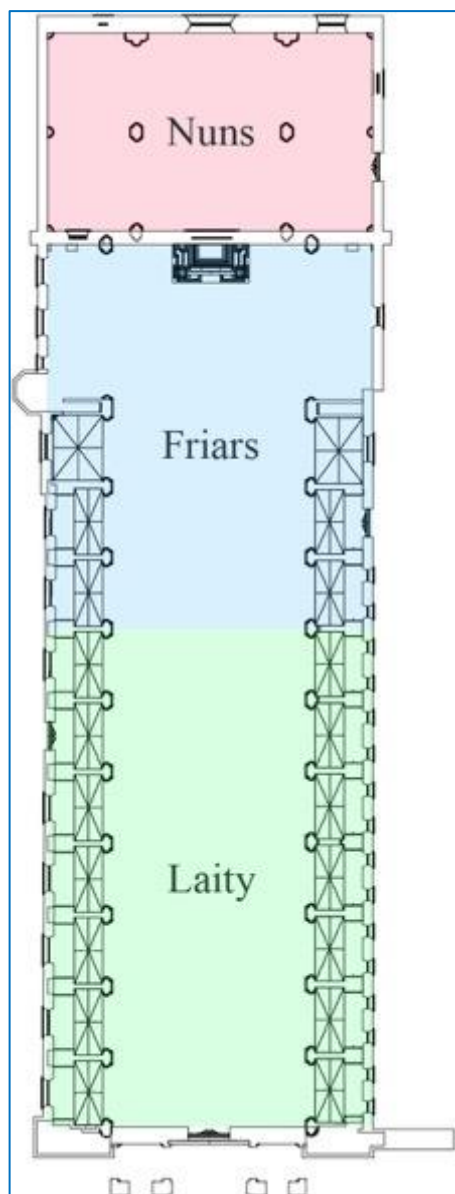
decorative program, some reconsiderations on the royal tombs, as well as an analysis of the impact of lay patronage on its foundation.

¹² For research on the tombs, see particularly V. Lucherini, “Le tombe angioine nel presbiterio di Santa Chiara a Napoli e la politica funeraria di Roberto d’Angiò,” in *Medioevo: i committenti* (Parma, 2010), pp. 477-504. In this study, Lucherini carefully analyzes the lexis and chronology used in contemporary documents which suggest that Santa Chiara was not originally intended as a royal burial site. See also T. Michalsky, *Memoria und Repräsentation. Die Grabmäler des Könighaus Anjou in Italien* (Göttingen, 2000). For the most recent work focusing on the tomb of Robert of Anjou, see S. D’Ovidio, “Osservazioni sulla struttura e l’iconografia della tomba di re Roberto d’Angiò in Santa Chiara a Napoli,” *Hortus Artius Medievalum*, 21 (2015), pp. 92-112. Robert’s tomb, which stands behind the high altar, marks Santa Chiara as an exceptional monument in the city of Naples. Indeed, documents attest to his desire to be buried in the church – namely a will completed in 1343 (just before his death): “Item voluit et ordinavit corpus suum sepeliri in ecclesia sui reginalis Sancti Corporis Christi de Neapoli, ibi provideatur de certa speciali elemosyna, sicut serenissimæ dominæ reginæ Sanciae, consorti sue et aliis exequutoribus infrascripti sui testamenti hujusmodi visum fuerit”; cited in Lucherini (2010), p. 484.

¹³ The high altar (which is the original medieval version) sits at the southeast end of the church. It’s one of the few objects which survives from the 14th-century interior. For a study into the altar, see E. Scirocco, “L’altare maggiore Angioino della Basilica Napoletana di Santa Chiara,” in *La Chiesa e il Convento di Santa Chiara: committenza artistica vita religiosa e progettualità politica nella Napoli di Roberto d’Angiò e Sancia di Maiorca* (Battipaglia, 2014), pp. 313-358.



Figure 5 Santa Chiara, Naples, Tomb of Robert of Anjou (prior to the bombing of the church in 1943). Photo: after G. Dell’Aja, *Il restauro della Basilica di Santa Chiara in Napoli* (Naples, 1980), p. 200.



--A retrochoir where the nuns were located (highlighted in red).¹⁴

--A presbytery where the friars were located (highlighted in blue).

--The nave area where the lay community were located (highlighted in green).¹⁵

The church was clearly designed with a definitive hierarchy in mind, resulting in the various religious populations experiencing an entirely different view of mass - both visually and aurally. The nuns, located in the retrochoir, were separated from the main body of the church by a solid wall. Their visual access to the elevation of the Holy Eucharist was granted by three grilled masonry apertures, which would have also

Figure 6 Santa Chiara, Naples, floor plan showing the location of each religious community. Photo: author.

¹⁴ This retrochoir was particularly large and housed a sizable number of sisters. These numbers grow rapidly over a relatively short time period (between 1311 and 1318): In 1311, Pope Clement V granted an initial quota of 100 sisters. In July 1317, this was expanded to 120 sisters by Pope John XXII, and in January 1318, 30 more sisters were added to the convent -- a total of 150. For a chronological overview of these expansions, see Bruzelius (1995) p. 74.

¹⁵ See Piva (2006) for a more general study on the spatial organization of medieval churches.

created a funneling effect for the amplification of sound.¹⁶ The male community were located beyond the choir screen, within a precinct of stalls which would have been open towards the altar. By being in the vicinity of the high altar and without any architectural obstructions to contend with, their visual and aural experience would have been unimpeded, providing them with the most-privileged location in the church. Finally, the lay congregation, who were located beyond the screen, would have encountered a restricted view of mass due to their physical distance from the high altar and the visual obstruction of the screen's architecture.

Despite the importance of Santa Chiara in the context of Naples, and a large body of work on the church, the medieval choir screen has only been intermittently referenced in existing literature on the building.¹⁷ Thus far, no attempts have been made to locate the screen, to reconstruct its appearance, or to understand how it might have impacted the interior space. As a crucial liturgical structure, a hypothetical reconstruction (establishing its location and physical properties) could have a transformative effect on our understanding of this monumental church, allowing us to better comprehend how Santa Chiara would have functioned as a liturgical space.

¹⁶ On the issue of how nuns of the Mendicant orders experienced mass in the Middle Ages, see C. Bruzelius, "Hearing is Believing: Clarissan Architecture, ca. 1213-1340," *Gesta*, 31 (1992), pp. 83-91. Bruzelius argues that, prior to Santa Chiara, Clarissan nuns were prevented from having any visual access to the high altar during liturgical rituals. As a result, their participation in mass was primarily aural with any connection to the divine mostly being experienced through the ear.

¹⁷ In particular, see P. Vitolo, "Ecce rex vester'. Christiformitas e spazio liturgico," in *La Chiesa e il Convento di Santa Chiara: committenza artistica vita religiosa e progettualità politica nella Napoli di Roberto d'Angiò e Sancia di Maiorca* (Battipaglia, 2014), pp. 227-274. In this study, she focuses on the liturgical arrangement of the church, but also refers to the medieval screen. See also S. D'Ovidio, "La trasformazione dello spazio liturgico nelle chiese medievali di Napoli durante il XVI secolo: alcuni casi di studio," in I. Foletti, M. Gianandrea, S. Romano & Elisabetta Scirocco (eds.), *Re-thinking, re-making, re-living Christian origins* (Rome, 2018), pp 93-119.



Figure 7 Santa Chiara, Naples, church interior (after the bombing of the church in 1943). Photo: after G. Dell’Aja, *Il restauro della Basilica di Santa Chiara in Napoli* (Naples, 1980), p. 40.

The lack of research on this important structure perhaps stems from the paucity of documentary and material evidence relating to the screen. It means that the challenges to this topic are significant. Santa Chiara was subjected to heavy bombing during the Second World War, destroying much of the original church (**Fig. 7**). The drastic restoration it

underwent in the 1950's also makes any close reading of the building problematic.¹⁸ The bombings, too, had a devastating impact on Santa Chiara's archives, destroying a large proportion of historical documents related to the church. No historical source has yet been found which references the screen. Material evidence is equally thin: the only surviving fragment is a series of eleven relief panels depicting scenes from the life of Saint Catherine (**Fig. 8**).¹⁹ Currently residing in the *museo dell'opera di Santa Chiara*, these were badly damaged during the Allied bombing of Naples in 1943.



Figure 8 Museo dell'opera di Santa Chiara, Naples, Saint Catherine Reliefs (Death of King Constus panel). Photo: after G. Chelazzi Dini, *Pacio e Giovanni Bertini da Firenze e la Bottega Napoletana di Tino da Camaino* (Prato, 1996), p. 48.

¹⁸ For the restoration of the church, see G. Dell'Aja, *Il restauro della Basilica di Santa Chiara in Napoli* (Naples, 1980).

¹⁹ These scenes are composed of eleven marble panels, which include the following episodes: The death of King Constus, Saint Catherine with a hermit, the mystical marriage of Saint Catherine, Saint Catherine with Emperor Maxentius, the incarceration of St Catherine, the dispute with the Emperor's wise men, the martyrdom of the converted wise men, the death of the converted Empress, the torture of Saint Catherine, Saint Catherine and the broken wheel and the beheading of Saint Catherine. G. Chelazzi Dini, *Pacio e Giovanni Bertini da Firenze e la Bottega Napoletana di Tino da Camaino* (Prato, 1996), esp. pp. 49-59. The book mainly focuses on the sculptures' attribution, so there is little discussion regarding the original location of the reliefs or an analysis of its iconographic program. For the earliest publication on this topic, see S. Fraschetti, "Dei Bassorilievi rappresentanti la leggenda di Santa Caterina in Santa Chiara di Napoli," *L'Arte*, 1 (1898), pp. 245-255 and E. Bertaux, *Santa Maria di Donna Regina e l'arte Senese a Napoli Nel Secolo XIV* (Naples, 1899).

Collaboration: Forming a Team of Experts

Initially, this study began as a one-person research project where I was attempting to produce both the digital content and the historical research. While I did manage to build a preliminary model of the church in AutoCAD and 3D Studio Max, this reconstruction was based on old floor plans and elevations which later proved to be inaccurate. As the project developed, it became clear that expert knowledge was required to fulfil the technical component of my research. In particular, it was imperative that an accurate model of the church was identified. With the help of Caroline Bruzelius and Andrea Giordano, I was able to bring together a team of experts, including specialists from Naples and the surrounding regions. The team was composed of an international group of scholars and students from a number of disciplines including archaeology, architecture, engineering, and art history. Their help and participation were integral to this project and without their collaboration, none of this research would have been possible.

Emanuela de Feo (from the Università di Salerno) provided an accurate record of the current building, having produced a laser scan of the entire complex as part of her doctoral research. Using this as our primary point of reference for the second iteration of the model, we were able to build a much more accurate 3-D representation of the church. Elisa Castagna and Andrea Basso (two architectural students from the Università di Padova in Italy) created the model using an architectural software called Revit. They spent a semester at Duke University (in the Fall of 2016) working closely on the project. Then Leopoldo Repola (from the Università di Suor Orsola Benincasa in Naples) oversaw the ground penetrating radar survey, and subsequently processed all of the following GPR data.

The Reconstruction: GPR and 3D Modelling

The first step in hypothetically reconstructing the Santa Chiara choir screen, was to look for the foundations of the structure using the geo-radar scanner (**Fig. 9**). This technology works by sending electromagnetic pulses through a surface (here the pavement of the church). Then, using an antenna located at floor level, one is able to receive any reflections of those pulses produced when the energy passes through a material with different electromagnetic permittivity.²⁰ This allows archeologists to detect and map subsurface regions with different material properties by measuring the portion (and strength) of energy which rebounds back to the antenna. Through the production of a series of longitudinal and latitudinal underground slices, it is then possible to produce a rough three-dimensional view of a buried site, with a depth ranging from a few centimeters to several meters.



Figure 9 Santa Chiara, Naples, ground-penetrating radar process. Photo: author.

²⁰ For a more in-depth explanation of the technology, see C. Gaffney & J. Gater, *Revealing the Past: Geophysics for Archaeologists* (Stroud, 2003), p. 47.

The scans at Santa Chiara were carried out in June 2016 using an IDI HI-MOD instrument in conjunction with K2FastWave software. A 200 MHz and 600 MHz frequency antenna were also employed, allowing depth investigations at both 17.4m and 8.5m. The subsequent data was then processed using IDS Launch GRED HD. The initial survey comprised a 16m x 6m rectangular area in the nave between the mid-point of the 6th and 8th bays of the church (and later included an expanded area down the nave towards the high altar). This initial choice of location was based on the hypothesis that the screen was likely to have been located between the public entrance to the church (at the 6th bay on the east/left flank of the nave) and the entrance to the friars' cloister (in the penultimate chapel on the west/right flank). The radar data was compiled by forming a rectangular grid on the surface of the pavement, composed of a series of orthogonal lines arranged longitudinally and transversally at a distance of 0.5m apart. This grid was used as a scanning path for the geo-radar instrument, providing a series of 24 transversal slices and 36 longitudinal slices across the width of the nave. According to their positioning on the grid, the geo-radar data was then processed and plotted on a plan of the basilica (**Fig. 10**).

The red lines represent areas of concentrated material, most likely stone, which are located roughly 0.5m underground. The grey lines represent the surveyed area where little-to-no signal was deciphered by the radar scanner. The most significant forms are discernable between the 7th and 8th bays of the church (**Fig. 11 - highlighted in yellow**). These disruptions more or less match the width of the chapel walls, roughly correlating to a 1m diameter. They also traverse the entire width of the nave, extending to the foot of the chapel pilasters. Although the foundations are not entirely straight (creating a slight zig-zag effect), they do provide a consistent link between the equivalent piers on each



Figure 10 Santa Chiara, Naples, church plan showing the GPR data acquisition paths (above) and the subsurface materials recorded by the GPR instrument (below), courtesy of Leopoldo Repola. Photo: author.

flank.²¹ And given the regularity of these subsurface forms, there was sufficient evidence to support the presence of our foundations, perhaps indicating that the screen might have been comprised of a traversing wall which spanned the width of the nave.

²¹ These discrepancies in the recorded data might be a consequence of the inevitable imprecisions recorded by the geo radar scanner. But equally, given the damage the building suffered during the Second World War, it's possible that subsurface materials might have been disrupted during the bombing or the subsequent restoration of the church.

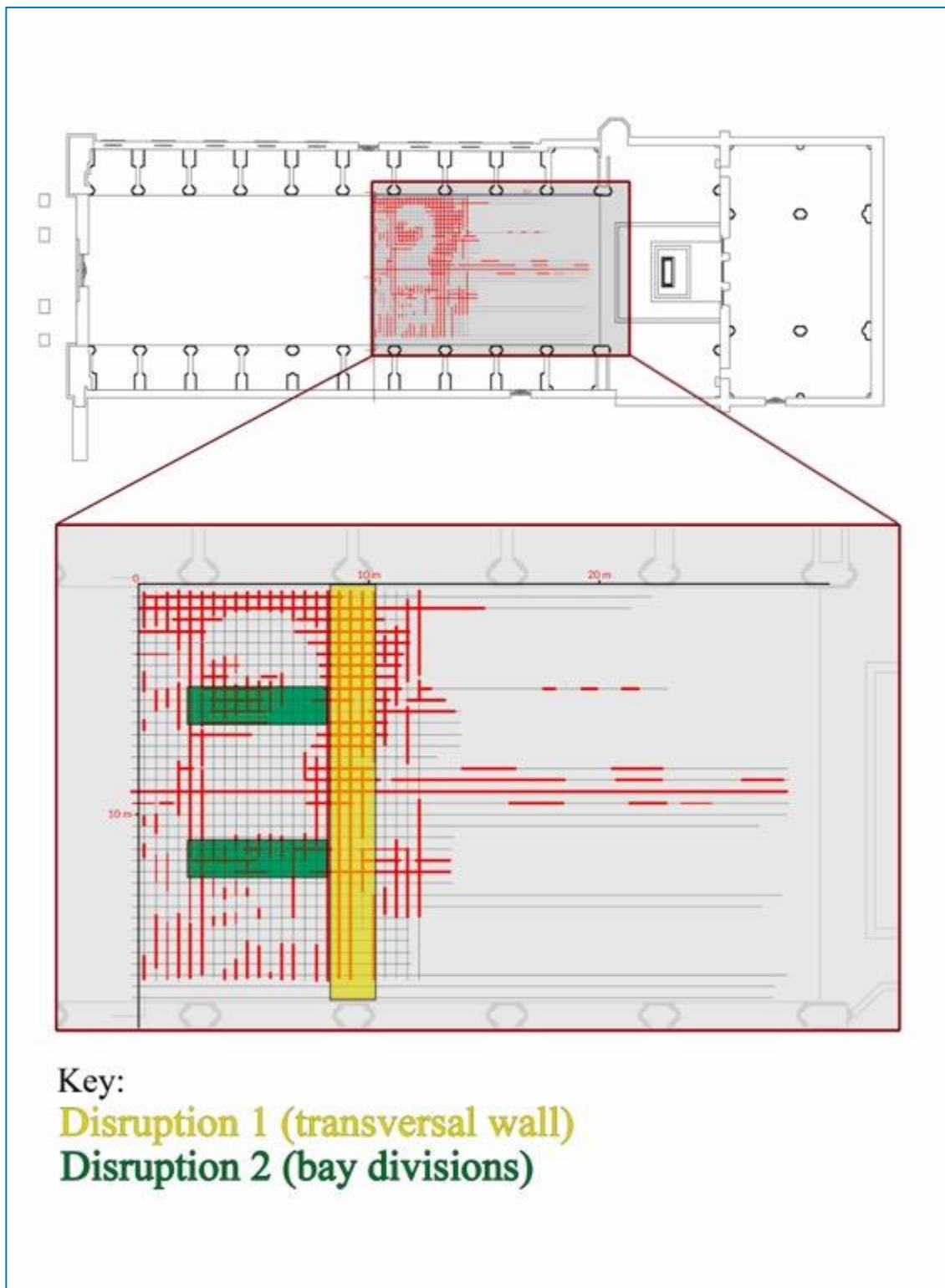


Figure 11 Santa Chiara, Naples, GPR data plotted on a church plan with interpretations of the author (highlighted in yellow and green) for the foundations of the screen. Photo: author.

The second notable feature is the presence of two longitudinal disruptions (**Fig. 11 - highlighted in green**) which extend towards the counter-façade from the previously described transversal foundations. These primarily stop between the 6th and 7th bays of the church (in line with the nave piers) and are roughly equidistant from one another and the nave walls. This suggested a number of things:

1. That the screen was divided into three bays – perhaps of similar dimensions.
2. That the screen was a deep structure - probably similar to the side chapels in depth.
3. That the screen was likely to have incorporated a vaulting system to support its depth.

Based on this evidence, we devised our hypothetical model for the screen (**Fig. 3**). As a hypothesis, this three-bayed, deep architectural arrangement bore a striking resemblance to a structure used to house the St Catherine relief panels - the long horizontal strip of reliefs previously mentioned. Photographs taken prior to the bombing of the church documented these reliefs on the counter façade of Santa Chiara, positioned on top of a similar architectural structure to the hypothetical screen (**Fig. 12**). It served as an elevated choir precinct after the regulatory changes brought forward by the Counter-Reformation, and it was used to house the Franciscan Friars in the 16th century.²² The semblance of this structure to our hypothetical screen was striking. Not only do they both incorporate a set of comparably-sized bays (which span the width of their adjoining side chapels), they also include a vaulting system supported by a set of free-standing pilasters

²² The friars were stationed at the top of this architectural arrangement, in an elevated position at gallery level. This was a significant departure from the more-common displacement of choir precincts to a location behind the high altar – otherwise known as a retrochoir; this was most likely a consequence of the pre-existing location of the Clarissan nuns.



Figure 12 Santa Chiara, Naples, counter-façade prior to 1943 church bombing (Saint Catherine reliefs highlighted in red). Photo: after G. Dell’Aja, *Il restauro della Basilica di Santa Chiara in Napoli* (Naples, 1980), p. 35, altered by the author.

in front of each bay. In addition, the elevated position of the St Catherine relief panels might have mirrored their anterior location on top of the screen. It suggests that there might have been an overlap in their design lineage – or even that elements of the old *tramezzo* might have been used to construct the new choir precinct. In any case, further research is required to prove or disprove any temporal links between these two structures and whether any formal similarities were indeed intentional.

There were a number of additional factors which supported our hypothesis for the reconstructed screen: first, it matched examples of *tramezzi* found in churches with comparable floor plans. Screens in single-aisled nave churches like Santa Chiara tended to be divided into three units with an open central portal. More often than not, these also included vaults to support a gallery space above (for the performance of liturgical functions) and to create additional chapel space within the screen. Three Mendicant examples - some of which have been hypothetically reconstructed – are San Francesco in Prato a Perugia (a 13th-century Franciscan complex), Santa Caterina a Treviso (a 14th-century Servite building), and Santa Maria delle Grazie a Varallo (a 15th-century Friars Minor church) (**Fig. 13**).²³ In all three instances, the choir screens are likely to have been divided into three chapels, incorporating cross vaults which spanned the length of a bay.

The second piece of evidence is visible within the church itself. By comparing measurements of the different architectural elements in the interior space, we noticed a distinct correlation between the side chapels and the nave: the side chapels measured close to 6m and the nave measured over 18m. This provided additional evidence

²³ The screen from San Francesco in Prato was hypothetically reconstructed by Donal Cooper in an article pertaining to an altarpiece by Raphael located in the church. See D. Cooper, “Raphael’s altarpieces in S. Francesco al Prato, Perugia: Patronage, setting and function,” *The Burlington Magazine*, 143 (2001), pp 554-561. For Santa Caterina, the screen was reconstructed in De Marchi (2008). Santa Maria delle Grazie’s screen still survives and was probably spared because of the intricate fresco cycle depicting scenes from the passion which extend to the ceiling.

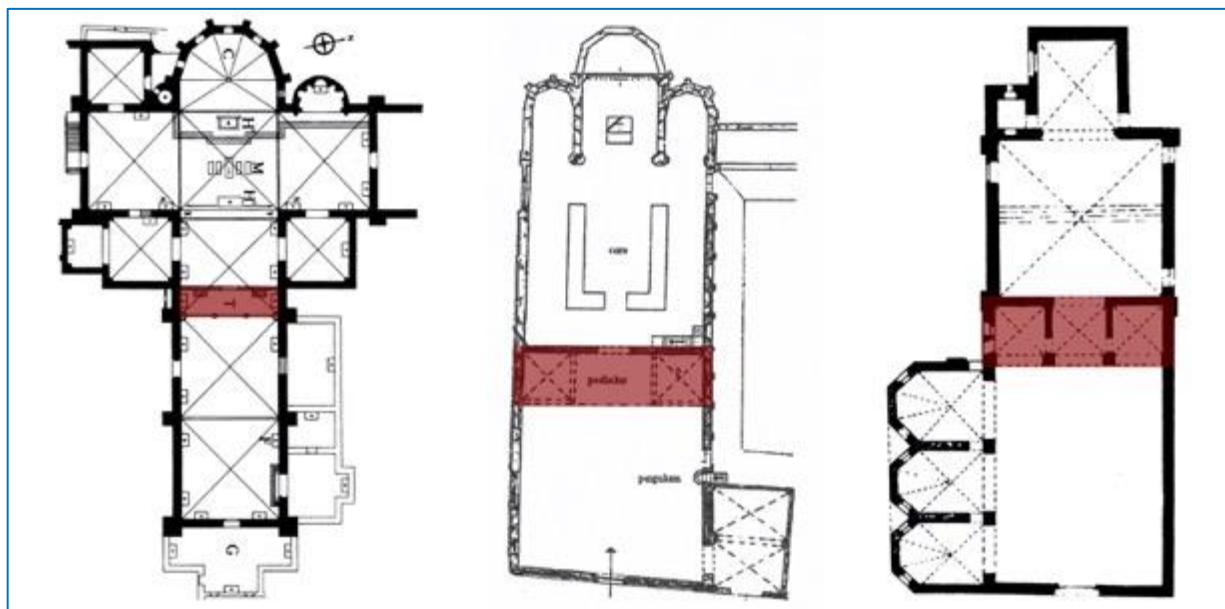


Figure 13 San Francesco in Prato a Perugia (left), Santa Caterina a Treviso (center) and Santa Maria Delle Grazie a Varallo (right) and their *tramezzo* screens (highlighted in red). Photo: author.

suggesting a three-bayed structure, as we had interpreted from the radar data. In addition, it also made us question whether the side chapels might have served as an architectural model for the design of the screen, or even whether the two structures might have been built as a coherent whole. In either case, a unified visual effect would have been created within the interior space, precipitated by the continual throng of arches and the harmonious interchange between the screen and its adjoining side chapels.

Given this evidence, we were able to start building a three-dimensional hypothesis for the screen. If the screen did indeed match the dimensions of the side chapels, it would also have matched them in elevation; this would have made the choir screen a colossal 10m-high, aligning with the gallery spaces located above the nave chapels. As a result, a series of deep chapel spaces would have been created at ground level – most likely incorporating an open central portal flanked by two chapels with accompanying altars. The proposed height also provided a solution to the location of the St. Catherine reliefs (as previously alluded to at the precipice of the screen). By reaching the level of the

tribune, the screen could have incorporated a horizontal strip measuring 1.2m between the apex of its arches and the parapet of the screen. This would have been a perfect fit for the Saint Catherine reliefs which are 1m in height (**Fig. 14**).

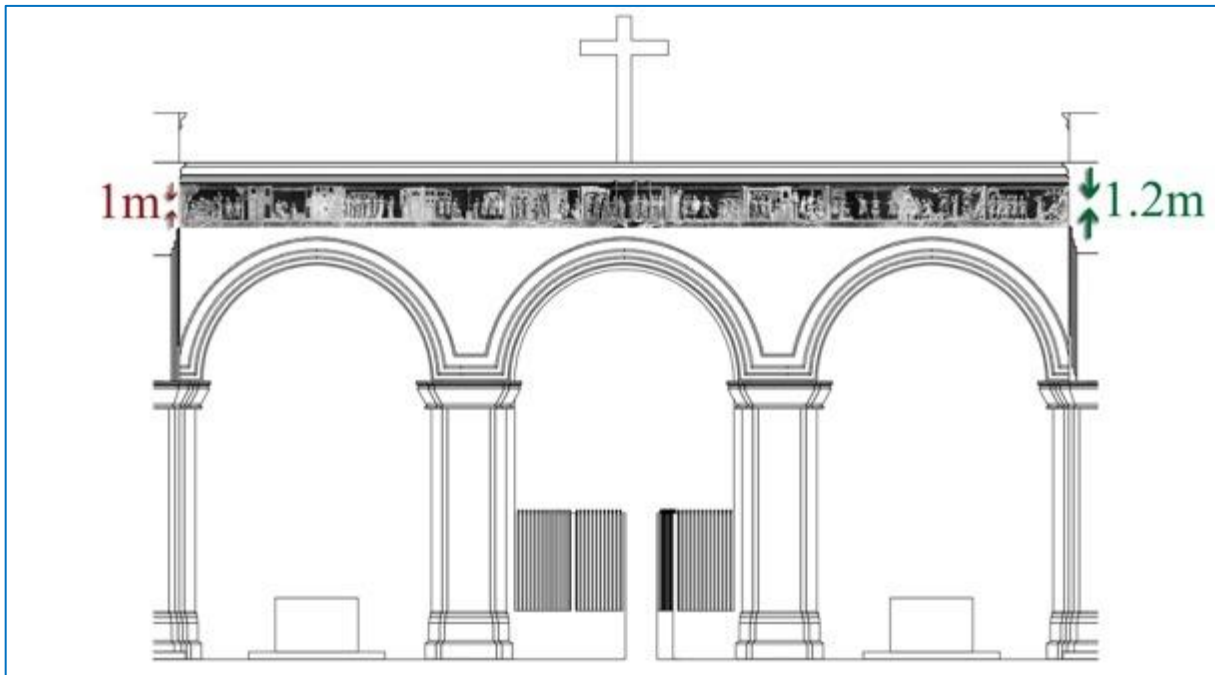


Figure 14 Santa Chiara, Naples, hypothetical screen, measurements of the St Catherine reliefs (red) and apex of the screen (green). Photo: author.

The enormous height of this hypothetical structure would have integrated well into its architectural setting and prevented the screen from being dwarfed within the immense, barn-like nave. In addition, this proposed height would also have allowed the choir screen to act as a bridge between the two gallery spaces above the side chapels, providing an access point across the nave at gallery level (**Fig. 15**). As it stands, there is no connection point between these two areas of the church. Reached using separate stairwells located at opposite ends of the nave, their autonomy had been a puzzling – and hitherto unexplained - aspect of the interior. By functioning as a connective bridge, the upper region of the screen (as was common practice) could have served a practical



Figure 15 Santa Chiara, Naples, hypothetical screen as a connective bridge between the two gallery spaces. Photo: author.

function for delivering sermons, for preaching, and for sacred theater. This would have demarcated the upper region of the screen as an important liturgical location, particularly in relation to the laity who would have witnessed such scenes (and, most probably, a crucifix) from below.

Finally, our hypothesis also provided an explanation for the curious location of two chapels occupying the church today. Located at the 7th bay of each wing (in line with the screen) and dedicated to Saint Claire and Saint Francis (the namesake of the church and the head of the Franciscan order), the positioning of these influential saints had previously perplexed art historians. Why would chapels with such important dedications be placed in such seemingly insignificant locations? Is there any explanation for their location in the middle of the church, at such a profound distance from the high altar? By relocating the hypothetical screen (which matches the location of these two chapels), it's possible to envision a scenario in which they were once part of the composition of the screen. Positioned within the large flanking chapel spaces, they could have been rotated 90 degrees, following the screen's destruction in the 16th century, thus relocating them to their current site at the 7th bay of each wing.

Having outlined the rationale behind this hypothesis, what is the effect of the screen once it is recontextualized within a model of the church (**Fig. 16**)? By standing on a different axis to the side chapels, it significantly transforms the spatial dynamic of the interior, providing a visible break to the architectural rhythm of the nave. The resulting effect is a creation of two autonomous spaces encased within a shared architectural shell. At the same time, however, because of its high arches, the screen does not inhibit the visual thrust towards the high altar, nor does it block the monumental tomb of Robert in the presbytery. Indeed, by closing off the flanking zones, the walled chapels either side

of the central portal actually focus the eye-line of the viewer.²⁴ They lead the eyes towards the monumental tomb of Robert of Anjou, visible through the open central axis (**Fig. 16**). The hypothetical screen therefore acts as both a facilitator and an inhibitor of visual access. By regulating the lay population's visual contact with the sacred, it may have created a desire for what was placed beyond.



Figure 16 Santa Chiara, Naples, view of the hypothetical screen (left), hypothetical screen as a visual frame for Robert of Anjou's tomb (right). Photo: author.

But the choir screen was also more than just a frame which governed physical and visual access to the presbytery, it was also a feature of liturgical importance in its own

²⁴ Jacqueline Jung has convincingly argued that medieval screens were often used as a framing device in "Seeing Through Screens: The Gothic Choir Enclosure as Frame," in *Thresholds of the Sacred: Architectural, Art Historical, Liturgical, and Theological Perspectives on Religious Screens, East and West*, ed. Sharon E.J. Gerstel (Washington D.C., 2006), pp. 185- 213.

right and a hub for lay veneration. It probably incorporated altars dedicated to important saints (such as Saint Francis and Saint Claire) and it was a principal location for preaching and prayer, and so a significant site used to promote lay identity. The location of a series of lay chapels surrounding the screen indicates that it likely functioned as a notable burial site too (a known function of medieval screens). This is further evidenced by the GPR survey which seems to show a series of significant disruptions circumnavigating the screen, which are particularly visible down the central axis of the nave (**Fig. 10**).

Some of these chapels have been identified in a recent publication by Alessandra Rullo, with a number of families being closely tied to the Angevin's (**Fig. 17**).²⁵ For instance, the 7th chapel on the right side of the church was shared by the Gianvilla and Sanseverino family. The Sanseverini were particularly close to the Angevin's, with Ruggero Sanseverino fighting with Charles of Anjou at the battle of Tagliacozza in 1268, a campaign for which he was handsomely rewarded with land throughout the Campania region.²⁶ In addition, an important coat of arms also survives (documented in pre-war photographs) on the first two panels of the St Catherine reliefs, located within a circular motif in the bottom right and left-hand corner of each panel (**Fig. 8**). The heraldry belongs to the Mansella family who served as mercenaries under the Angevins and who occupied a chapel at Santa Chiara (in the first bay beyond the proposed location of the hypothetical

²⁵ For the original diagram, see A. Rullo, "Patronato laico e chiese mendicanti a Napoli: I casi di S. Chiara e S. Lorenzo Maggiore," in *La Chiesa e il Convento di Santa Chiara: committenza artistica vita religiosa e progettualità politica nella Napoli di Roberto d'Angiò e Sancia di Maiorca* (Battipaglia, 2014), p. 377. This topic was previously pursued by M. Gaglione, *Sculture minori del Trecento conservate in Santa Chiara a Napoli ed altri studi* (Napoli, 1995) and E. Scirocco, "Die Kirchen Santa Chiara und Santa Maria di Monteoliveto als Bestattungsorte der Adligen in Neapel," *Working Papers des Sonderforschungsbereiches 640* (Berlin, 2011), pp. 3–42.

²⁶ Bruzelius (2004), pp. 177-180.

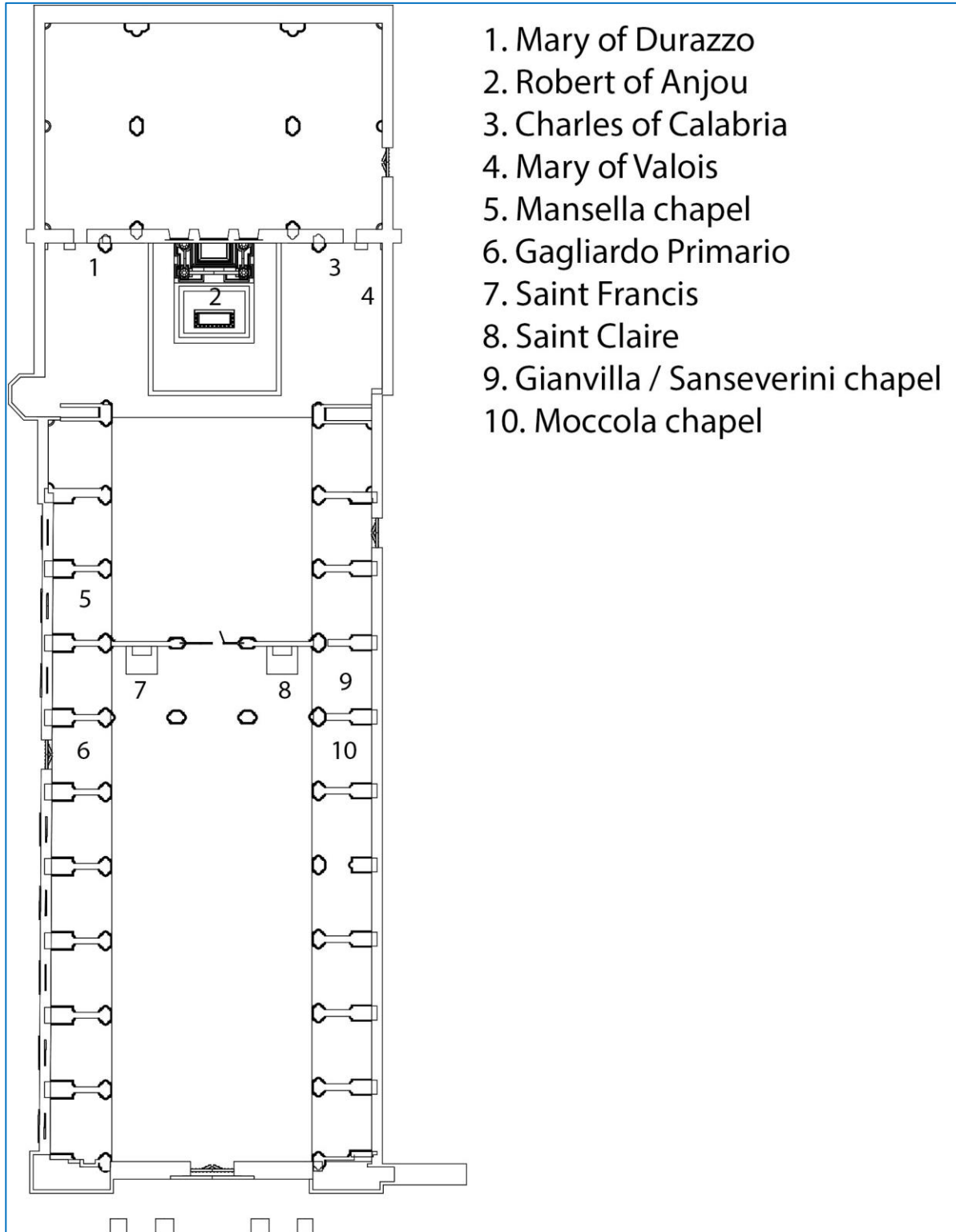


Figure 17 Santa Chiara, Naples, church plan showing the location of chapels, tombs and altars (adapted from Alessandra Rullo). Photo: author.

screen).²⁷ These indications demonstrate the importance of the choir screen in the formation of lay identity within the church.

Presenting the Research: AR and VR Applications

Substantial evidence points towards the screen at Santa Chiara as a fulcrum in the spatial delineation of the church and as a vital feature of the interior space. And yet, when entering the church today, it is easy to be misled into thinking that this structure had never existed – that the building was always intended to resemble an open space. So how then does one tackle these misconceptions? One of the final goals of this project has been to explore ways to combat this problem using technology to decipher new avenues to present our research to a public audience both offsite and onsite at the church.

First, we created an application within a fully immersive virtual environment, known as the DiVE facility at Duke University (**Fig. 18**). This system works using CAVE technology whereby the 3-D model is projected on to all six-sides of a cube sized room, including the ceiling and floor. It creates the illusion of three-dimensional space by allowing the user to inhabit the church, to wander through the building (which is visualized as a life-size model) and to dynamically interact with the surrounding environment. By wearing interactive goggles, the system is also able to pinpoint the location of the viewer through a motion capture system, allowing the model to react to the positioning of the user in real time. The effect is a type of quasi-interactive 3-D cinema

²⁷ The family was rewarded for their mercenary work, most notably Giovanni Mansella, who acquired much land from Carlo I of Anjou and who was nominated viceroy of Capitanata in 1280 (a region in modern-day Puglia). See note number 68 of Vitolo (2014), p. 243. For a 17th-century history of the Mansella family, see F. Della Marra, *Discorsi delle famiglie estinte, forastiere o non comprese nei seggi di Napoli imparentate colla casa della Marra* (Napoli, 1641), pp. 211-217. The tomb of Tomasso Mansella was also mentioned in Santa Chiara in the 17th century. His location is unidentified, but it's likely that it was located in the family chapel in the first bay beyond the choir screen. For the description of the tomb, see C. D'Engenio Caracciolo, *Napoli Sacra* (Napoli, 1623), p. 250.



Figure 18 Duke University, Durham, DiVE facility, view of the Santa Chiara model in the augmented reality application. Photo: author.

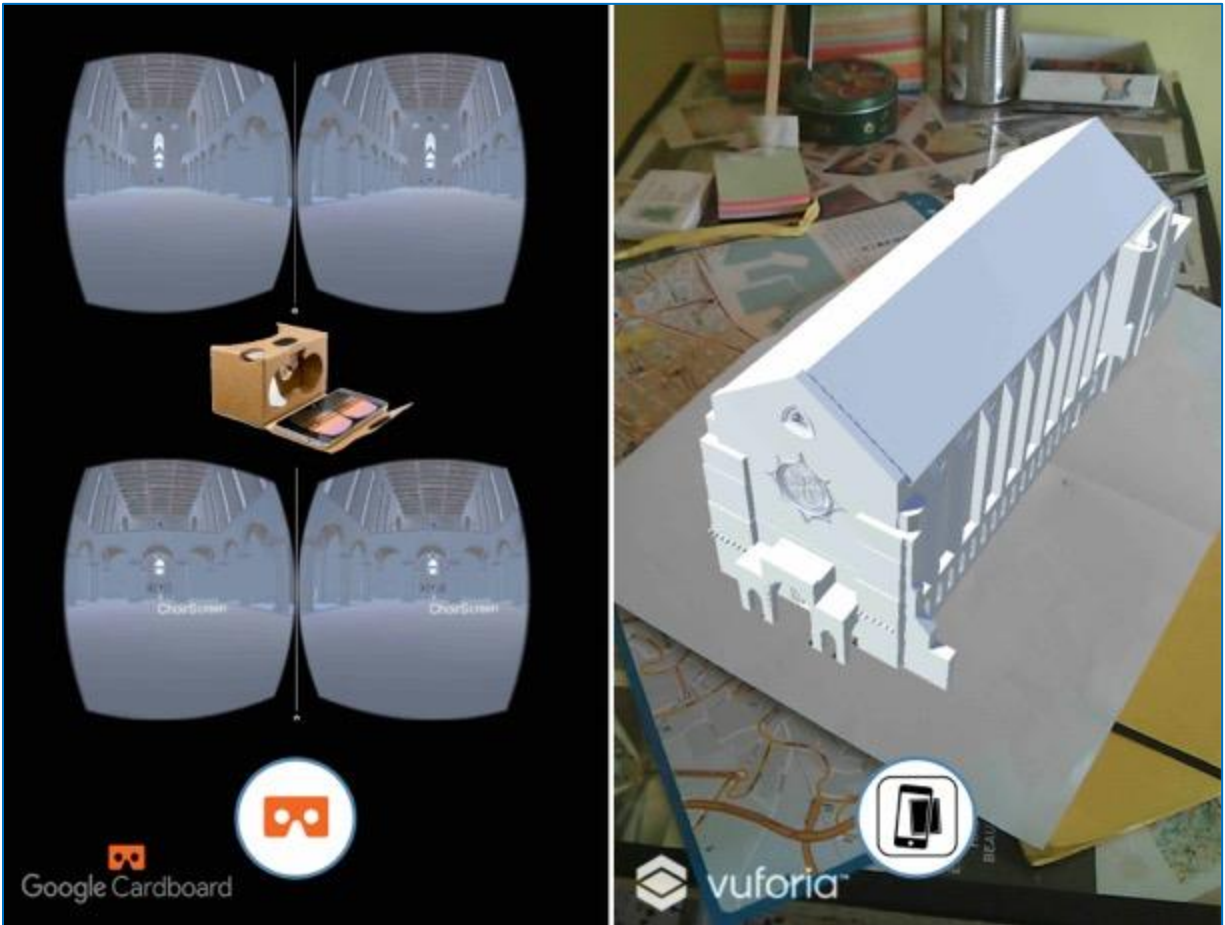


Figure 19 Santa Chiara virtual reality application (left), Santa Chiara augmented reality application (right), courtesy of Andrea Basso and Elisa Castagna. Photo: author.

(with 360-degree panoramic vision), allowing the user to immerse themselves in the virtual environment within the setting of a real, physical space. In the case of Santa Chiara, it provides an unparalleled understanding of the screen's spatial and optical effects, helping to demonstrate its profound impact on the interior of the church. The downside of this technology is that it's expensive to assemble and maintain, requiring a large, specially-designed area to house a 3m x 3m x 3m projection room (including six independent projectors).

As a consequence, we also decided to produce a series of cost-effective alternatives to the DiVE application, all of which can be enjoyed on a smartphone and therefore accessible to as many users as possible (**Fig. 19**). The first was a simple virtual reality

application built for Google Cardboard. The application works by inserting your smartphone into a low-cost headset containing two focal lenses. Worn like a pair of goggles, it allows the user to enter a virtual representation of the screen and the church. Through the recognition of head movements, it visualizes what one would see from any 360-degree angle, providing the user with a fully immersive representation of the interior of the church. Unlike the DiVE facility however, the user is positioned in a fixed location and unable to move freely through the model (beyond moving their head to change the angle and direction of their vision). This limits the capabilities of the virtual reality experience, preventing a more-complete understanding of the screen's visual impact on the interior of the church.

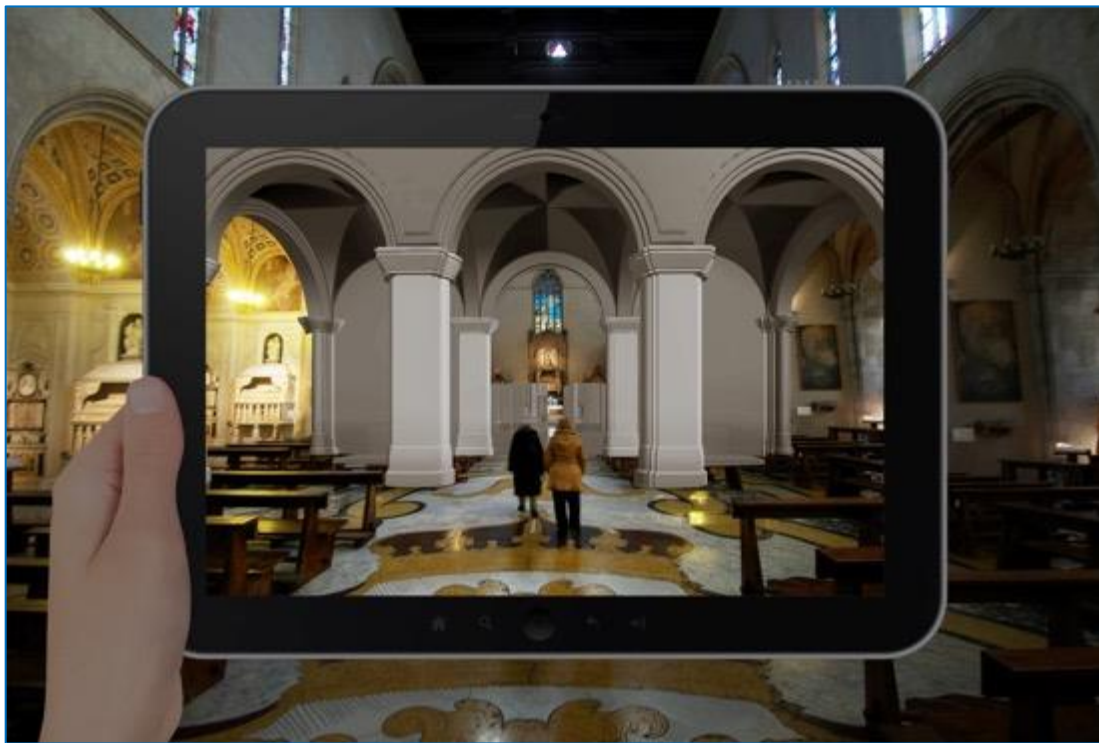


Figure 20 Future Santa Chiara augmented-reality application (courtesy of Julia Liu).
Photo: author.

The second application was an augmented reality app which visualizes the church on a smartphone-based on image recognition technology. Using a software called Vuforia, the smartphone camera can recognize a plan of the basilica and overlay a model of the

church on top of the image. By rotating and moving the phone around this image, one can explore the architecture of the church. Our future goal is to upscale this application to allow users to visualize and experience the screen within the confines of the church itself (**Fig. 20**). Adopting a similar type of technology, one would be able to use a phone or tablet to visualize the screen in real time. Through a series of image recognition targets located within the church, the user would have the ability to be able to interact with the existing architecture whilst also experiencing how the space changes as a result of the recontextualization of the screen.

Conclusion

The very nature of medieval buildings and their propensity to change over the course of time, means medieval architecture is a discipline ideally suited to the application of new technologies. Medieval churches, in particular, are especially susceptible to change whether that be through natural causes (like earthquakes) or as a response to societal changes (like liturgical alterations, changes in aesthetic taste or even war). However, we now have a substantially enhanced ability to map these changes. For instance, we can show how buildings (and cities) develop, we can reimagine monuments that have been destroyed and we can recontextualize the works of art that were once contained within these buildings. As a result, we are not only able to transform our own understanding of medieval architecture, but we also have the ability to transform how we present these findings to the public. Through using technology, we can tell more accurate and compelling stories about our lived environment and the buildings which once formed such an integral part of our medieval past. In so doing, we can close the gap between academic research and the wider public interest.

The benefits of technology are evident throughout this project, where digital tools played such a significant role in each of the three research stages: from the initial data

collection stage, to the interpretation and visualization of this data, right through to the public facing application of our findings. At the core of this project, ground-penetrating radar technology helped to uncover the foundations of the screen, a key step in determining its location and formal characteristics. A laser scan of the church also provided us with a precise record of the building, allowing us to build an accurate model of the church. With this preparatory data, we were then able to create a hypothetical reconstruction of the screen and to visualize this within a 3-D model of the building. Being able to visualize how the proposed structure would have been integrated into its architectural surroundings was a key interpretive research tool. Finally, through designing a series of virtual/augmented reality applications, we were able to visualize our hypothesis to the public. These new modes of representation, which are both three-dimensional and can be manipulated, provided a more interactive method for displaying our research.

It's clear, therefore, that the use of digital tools can serve as an effective research tool both in terms of shedding light on existing material as well as providing fresh questions about a particular research topic. In the case of Santa Chiara, using technology to examine the objects of our study (both the screen and the church itself), revealed new points of access to revisit pre-existing, or hitherto-unexamined aspects of this important religious complex. And in so doing, we have uncovered a crucial element of the medieval church which ultimately changes our perception of how this building would have been viewed in its original context. Looking forward, this discovery now offers the opportunity to explore (and study) a myriad of affiliated aspects at Santa Chiara: We can now re-examine the church's decorative program in relation to the choir screen as well as re-evaluate the impact of the royal tombs. Equally, we can reassess the configuration of religious space and explore how this affected liturgical practices. This set of issues (which is only a

preliminary list) is a product of the use of technology and our ability to propose a reconstruction of the choir screen based on a GPR survey.

It leaves me to conclude by saying that technology can have an enormous impact on the field of medieval art and architecture, offering new modes of study which can be integrated into conventional research. As this essay demonstrates, the appropriation of methodologies native to the field of archeology, provides fresh points of access for art and architectural historians to study medieval buildings. In particular, innovative scanning techniques afford considerable opportunities for research in the field, tackling both pre-existing points of contention as well as stimulating new research questions. Most notably, georadar tools can be especially useful for addressing the significant problem of *tramezzo* screens – one of the most important elements of the medieval church fabric. As a structure now almost entirely lost, evidence for their presence in medieval churches has only occasionally surfaced through mining visual and documentary sources. However, the application of ground penetrating radar technology provides scholars with the opportunity to unlock a wealth of new information about screens, ultimately enriching our understanding of how medieval churches would have been experienced in their original context. 🐼