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Three tales of two cities? A comparative analysis of topological, visual and metric properties of archaeological space in Malia and Pylos

Abstract
Topological and visual analyses in the space syntax tradition on the one hand and GIS-based spatial analyses on the other have started out on very different trajectories, not only in the scope of applications but also in their underlying premises; the Euclidian metric basis of the latter, for instance, stands in stark contrast to the idea of a configurational topology which forms the basis of traditional space syntax. More recently, there has been a notable convergence both in analytical scope and in the form of software implementations; this has not been paralleled, however, by comparable efforts in terms of explicitly comparative or even integrative studies, a gap we seek to (begin to) address in the present paper on the basis of parallel analyses of topological, visual and metric properties for two case studies. The purpose of this exercise is threefold: Firstly, comparisons of the respective analytical results will aid an appreciation of the strengths and potential weaknesses of specific approaches as well as an identification of both complementary and alternative techniques, but will ultimately also help to gain a reliable basis for future integrative work. Secondly, and more specifically, GIS-based metric integration analysis will be introduced and 'field-tested' in comparison with conventional space syntax analyses, from which it derives – in a first step towards a more integrated perspective – part of its inspiration. Thirdly and no less importantly, we seek to contribute to a better understanding of the archaeological contexts under discussion, i.e. the Middle Bronze Age Building A of Quartier Mu at Malia on Crete and the Late Bronze Age palace of Pylos at Ano Englianos in Messenia.

1 Introduction

Analysis of topological, visual and metric properties of spatial settings has seen numerous applications in archaeology in recent years, particularly in the form of space syntax analysis and GIS-based techniques since the 1980s and 1990s respectively. Despite their common interest in the spatiality of past human life and the search for a multi-faceted, empirical framework for studying this particular domain, space syntax and GIS techniques in archaeology long constituted distinct fields of research.

This could be seen to be due, in part, to the disciplinary history of both approaches outside archaeology. One of the most notable differences in this regard lies in the fact that GIS was conceived as a technology more than anything else, coming into existence without any particular theoretical basis and thus not depending on any specific epistemology – its positivist branding today is largely explicable through its eventual adoption by spatial-analytical geography in the 1970s and 1980s (Pickles 1995; Schuurman 2000; Kwan 2004; Harvey et al. 2005; Sheppard 2005; Leszczynski 2009; Hacıgüzeller 2012a; 2012b; cf. Wheatley, this volume) –, whereas the main advocates of space syntax have proposed and continue to advocate it as an encompassing theoretical framework (e.g. Hillier 1999,

p. 165; 2008). However, the latter position has found little support in archaeology and related disciplines such as social anthropology, where such theoretical aspirations have been mostly either ignored in favour of a 'toolbox' approach – which as with GIS allows for the methodology's use in different theoretical frameworks – or even severely criticized (cf. Leach 1978; Batty 2004, p. 3; Thaler 2005, p. 324; Dafinger 2010, p. 125–127, 134–140). In acknowledgment of this previous reception, but also in order to facilitate an integrative discussion together with other approaches (cf. Thaler 2006, p. 93–100; Dafinger 2010, esp. p. 137), space syntax will be consciously taken as a methodology 'only' in this paper.

It would appear, given this common methodological stance, that the reasons for the separateness of space syntax and GIS-based studies in archaeological practice may more plausibly be identified in both technical issues, i.e. in particular the software employed in analysis, and differences of resolution, i.e. the scale of contexts commonly studied through either set of techniques. It deserves particular attention, therefore, that it is precisely in these two respects that a remarkable convergence can be noted in recent years: archaeological GIS, for example, is to some degree experiencing a 'scaling down', which in terms of resolution brings it closer to the traditional remit of space syntax studies. While the landscape level is still most commonly focused upon (Wheatley 2004; cf. Wheatley and Gillings 2002; Conolly and Lake 2006), there have been a small number of promising applications on the architectural scale as well. Cost-distance (Hacıgüzeller 2008) and 3D visual analysis (Paliou 2008; Paliou et al. 2011) at the building level have demonstrated how current GIS technology permits a study of phenomenological and cognitive properties of buildings through a detailed study of their configurational properties.[1] In terms of software applications, space syntax techniques have been incorporated as add-ons within a GIS environment in several instances, and GIS has also served as a digital cartographic platform in which to import space syntax results (cf., e.g., Turner 2007a). Perhaps most important of all is that recent versions of Depthmap as the software mainstay of current space syntax work have come to include GIS-like features; it is now possible to enter non-spatial data in the database tables provided by the software and, much as in any GIS software, these database tables are linked to the spatial features represented (Turner 2007b).

1 We would like to thank the participants of the workshop "Spatial analysis of past built environments" for their valuable comments as well as their encouraging feedback and likewise express our gratitude to the organizers of the workshop for providing an intellectually stimulating environment for discussion. Piraye Hacıgüzeller would like to thank Bourses d'Excellence Wallonie-Bruxelles International (WBI) for their support, which has made this research possible. Ulrich Thaler gratefully acknowledges the support of the Graduiertenkolleg "Formen von Prestige in Kulturen des Altertums" at Ludwigs-Maximilians-Universität München.
There has been a noteworthy parallel trend in GIS studies of modern urban environments since the early 2000s, which strongly suggests that, in the future, traditional GIS analysis may be accompanied by a new set of techniques on an architectural and urban scale stemming from an interest in configurational properties of space (metric, visual and topological), which is in its turn informed by space syntax approaches (Ratti 2004, p. 12; cf. Jiang and Claramunt 2002; Ratti 2002).

All these trends mean that archaeologists studying ancient built environments have an increasing number of analytical approaches and – potentially complementary or possibly alternative – techniques at their disposal, often at the push of a button.[2] What is therefore needed at this point is a sound body of comparative research in which different techniques are applied to specific test cases. To contribute to such a body of research is the main aim of this paper, and for this purpose, the analyses for each of the case studies will be followed by separate discussions on interpretative archaeological aspects and the comparison of analytical results from different approaches.

A further and related aim is to view the performance and results of an innovative GIS-based technique of metric analysis, which is first introduced in this study (for a related approach cf. Hacıgüzeller 2008), against the results of 'tried-and-tested' topological and visual space syntax analysis, which follow a deliberately conservative line (cf. Thaler 2005, p. 326), in order to better appreciate the potential as well as potential problems of the new approach. The latter differs from metric analysis conducted within a space syntax framework, as will be explained in more detail in the methodology section, in being raster-based and, concomitantly, allowing the researcher to take into consideration differences of elevation in architectural systems, as represented by, for example, stairs or ramps. Thanks to the spatio-statistical, data management and cartographic tools provided by GIS software, this technique also allows the manipulation of metric configurational results in a statistically and visually informed manner (cf. Gil et al. 2007, p. 16).

As a final point, which brings us back to the distinction between archaeological interpretations and methodological comparisons, we also hope to offer a meaningful contribution to a better archaeological understanding of the buildings which form our case studies, Building A of Middle Bronze Age Malia on Crete (fig. 1) and the Late Bronze Age palace of Pylos at Ano Englianos in Messenia (fig. 2), as well as the social phenomena they bear silent witness to. If not for that hope ... why bother?

2 Methodology

2.1 Topological properties

The topological analysis here presented follows a mostly conservative space syntax methodology. Space syntax has been applied in numerous archaeological studies (cf. Cutting 2003, p. 5–7; Thaler 2005, p. 324–326) ever since its first systematic formulation in

2 It should be noted that the availability of a technique through its implementation in computer software is of little if any help without an appropriate familiarity with the technique itself; it is generally advisable to watch the spell-checker of your word-processing software closely, but this necessitates a basic grasp of orthography and grammar – spatial analysis software is no different.

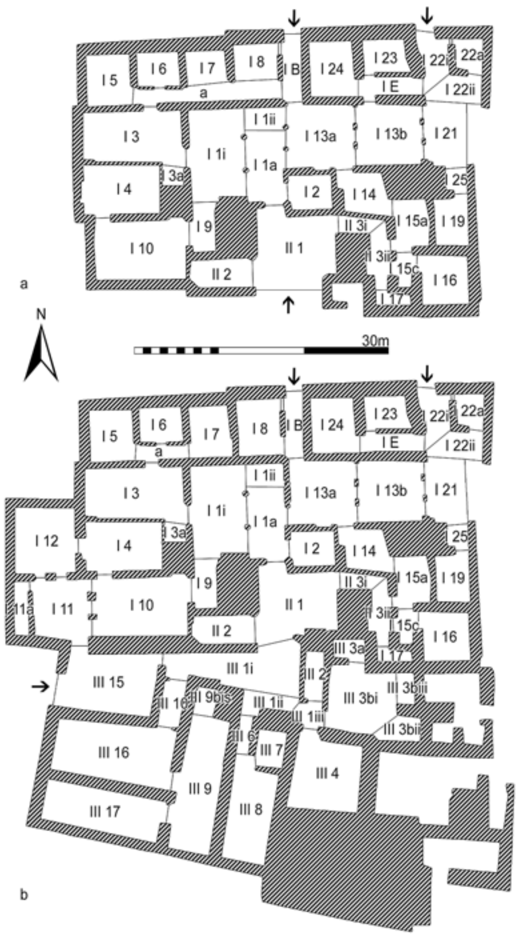

Figure 1 | Malia, Quartier Mu, Building A: a) plan of phase 1 with room numbers, points of access indicated by arrows; b) plan of phase 2 with room numbers, points of access indicated by arrows.

the mid-1980s (Hillier and Hanson 1984),[3] but still retains a certain 'exoticism' in the field. Bill Hillier's (this volume) introductory article sets out the basics of the methodology as well as a number of central concepts. Several of these will be employed in this paper, such as integration as a normalized measure and the most commonly used spatial indicator of topological properties, the notion of global and local qualities and effects, the distinction between the convex[4] and the axial break-up of a building as the basis for parallel

3 Hillier et al. (1976) deal with 'generative syntaxes' only, not the analytical methodology, under the heading of 'space syntax', whereas Hillier et al. (1983) offer a first brief overview of what is today commonly referred to as 'space syntax'.

4 A convex space is defined, in strict terms, as an area in which each point is visible from each other point. For practical purposes, these more or less equate with rooms within a building, while courts often need to be subdivided into several units. Ultimately, what constitutes a convex space is a matter of resolution – each impediment to sight, e.g. a column, pilaster or convexly curving wall, would demand a subdivision of a given space. A slightly

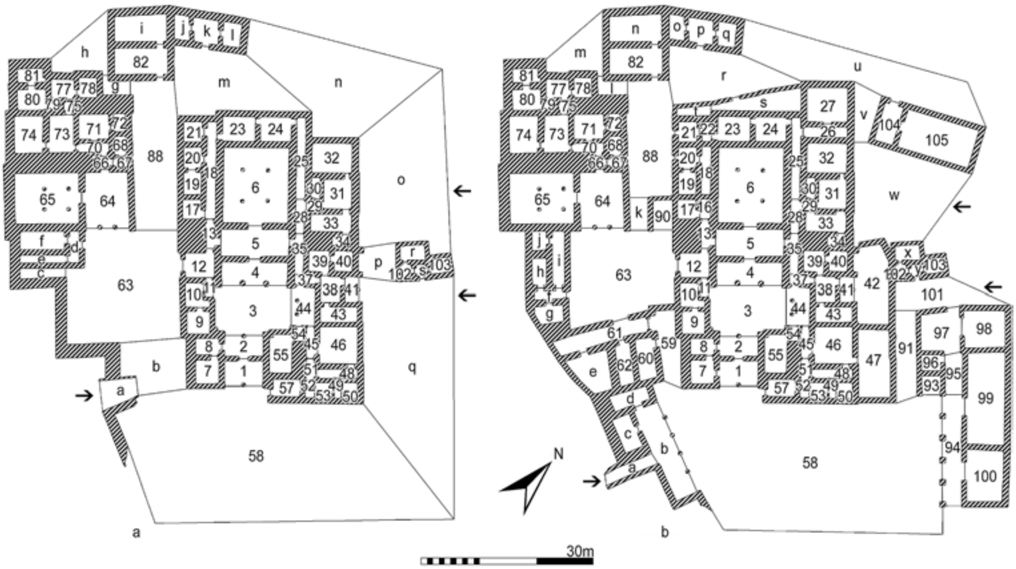

Figure 2 | Pylos, palace: a) plan of earlier building state with room numbers, points of access indicated by arrows; b) plan of later building state with room numbers, points of access indicated by arrows.

analyses,[5] the differentiation between a-, b-, c- and d-type spaces and the mapping of integration cores, with the reader being referred to Hillier's paper for an introduction. Some specifics as well as some additional concepts and a few points of departure, however, necessitate brief comment:

In purely practical terms, the term 'j-graph' will here be used more narrowly to refer to a justified graph which takes the carrier space, i.e. the outside of a building, as its root space. A 'global' analysis of integration will take into account each spatial unit's relationship with each other space in the entire building; in a 'local' analysis, relationships with immediate and mediate neighbours up to a step-depth, i.e. a radius of 3, are taken into account. Cores of integration, both convex and axial, are defined conventionally as the 10 % most integrated units, e.g. the 6 most integrated convex spaces out of a total of 56.

more intuitive form of break-up has been termed 'semi-convex' elsewhere by one of the authors (Thaler 2005, p. 327; 2009, p. 27); this term, however, is dropped here in acknowledgment of the fact that in many published analyses 'convex' is not entirely convex (cf., as arbitrarily chosen examples, Hillier and Hanson 1984, p. 168–169 fig. 103–104 [cf. Hanson (1998, p. 41 fig. 1.19) for a different break-up of the same complex]; Hanson 1998, p. 34 fig. 1.14, p. 93 fig. 3.6) – with good reason.

5 For the analyses in this study, both convex and axial break-ups were hand-drawn. Although Depthmap features a reduction from an all-line to fewest-line axial map (Turner et al. 2005; Turner 2007b, p. 46), drawing by hand was preferred, amongst other reasons, because it allowed the inclusion of columns as visually non-permeable structures without having to include a topological ring around each individual column; this was felt to be the most adequate representation, but is incompatible with the reduction algorithm used by Depthmap.

Two additional types of areas, i.e. sets of convex spaces, are mapped in the following analyses, areas of primary access and areas of primary control; neither are commonly used in space syntax work in precisely the present form,[6] but both follow a very basic topological principle: they allocate individual spaces – and, consequently, areas within a building complex – to one of a given set of root spaces according to closest proximity in terms of step-depth. The root spaces for mapping areas of primary access are, as the designation indicates, those convex spaces which permit access to the building complex, i.e. entrances. The root spaces for mapping areas of primary control are an ultimately arbitrary, but meaningfully chosen set of convex spaces. In the current study, spaces are chosen which are termed 'primary integrators' and characterized, in the first instance, by their local integration surpassing that of all immediate neighbours; as a second criterion applied to the resulting subset of spaces, only those spaces are considered 'primary integrators' which display absolute values of local integration falling within the top 5 % of all convex spaces. Other criteria could also be chosen, and it is not co-incidental that the above-stated criteria single out, in the present analysis, the main courts of the respective building.

A further but unavoidable element of arbitrariness is encountered wherever archaeological sources indicate the former presence of rooms, but do not inform us of their exact layout, specifically the position of doors. In this case, substitute spaces are included in the analysed plans in an approximation of the likely original layout; these placeholders restore or approximate, if used in moderation, the original 'balance' of the topological system as a whole and thus allow its meaningful analysis, e.g. the calculation of average values of integration.[7] In the present study, this is relevant in the case of the palace of Pylos,[8] where, for instance, the neighbours of room 82 are omitted from most published plans (e.g. Blegen and Rawson 1966, key plan), although their existence seems indubitable (cf. Blegen and Lang 1963, p. 157; Blegen and Rawson 1966, p. 289–291; Blegen et al. 1973, p. 44 fig. 311; Kilian 1987, fig. 2; Thaler 2009, p. 64–65). The more general difficulty of arriving at the unambiguous plans needed for the types of formal spatial analyses here discussed is illustrated yet more clearly, in the case of Building A at Malia, by the different representations of the building even within the present volume (cf. Letesson, this volume), with yet another set of plans found in McEnroe's (2010, p. 64 fig. 6.15–6.16) recent study of

6 Hanson (2000, p. 108–110) uses an approach closely comparable to mapping areas of primary access.

7 The values of specific spatial indicators calculated for the substitute spaces individually are, of course, largely meaningless. Nevertheless, any consideration of the balance of a built structure should leave us in no doubt that the suggestion to systematically exclude rooms which are not clearly definable in archaeological terms (van Dyke 1999, p. 467) is inevitably counterproductive (cf. Thaler 2005, p. 326). What, however, constitutes a 'moderate' use of substitute spaces remains a matter of personal judgement, both on the part of the researcher performing the analysis and those wishing to evaluate it.

8 Substitute spaces and, more generally, additions to the preserved built structures are not specifically marked in the plans reproduced here in order not to overcomplicate the latter. For an overview of additions cf. Thaler (2005, p. 325 fig. 141) and for a detailed discussion of the earlier and later state of the building cf. Thaler (2009, p. 56–70).

Minoan architecture. In the specific case, such inconsistencies can hardly be avoided until a final and detailed publication of the architecture of Building A is available (cf. Poursat 2012, p. 177), but they highlight the necessity to carefully examine all available information in the preparation of plans for analysis. For Pylos, a general discussion of the plans is set out elsewhere (Thaler 2009, p. 56–70) in greater detail than would be possible in the present context.

As stated at the outset of this methodological introduction – and as the reader will hopefully agree on the basis of the above remarks – space syntax is applied in this paper in a largely conservative fashion, which necessitates a further comment on the reason for this choice and on a difficulty not arising from but related to it: studies of contemporary architecture in the space syntax tradition regularly rely on comparing analytical results with real-life observations, e.g. of human movement in the architectural contexts under analysis, a luxury which archaeological contexts do not afford the researcher. Therefore, it seems highly advisable for the latter to concentrate on those space syntax methods and indicators which have most consistently produced meaningful results in studies of present-day contexts (cf. Thaler 2005, p. 326), integration in particular. This, however, means that 'unresolved issues' of the space syntax mainstream could potentially prove particularly problematic for archaeological applications. Since integration is a normalized measure, i.e. one not directly obtained from the topological graph, but one transformed to allow comparison between systems of different sizes, normalization is probably the most important issue in this respect. Although alternatives to integration as commonly defined, i.e. as the reciprocal of real relative asymmetry (Hillier and Hanson 1984, p. 109–113; Peponis et al. 1997, p. 771), have been suggested (Teklenburg et al. 1993; Livesey and Donegan 2003), these are most often tacitly ignored and rarely is a comparative discussion even attempted,[9] let alone brought to a satisfactory conclusion. In the topological analyses presented here, the standard definition of integration is employed – in the hope, however, that in future its use will either be based on more than a tacit consensus or abandoned if comparative studies suggest a more reliable alternative.

2.2 Visual properties

Visual graph analysis (VGA) as implemented in Turner's Depthmap software (Turner 2001; 2004; 2007b) goes one step beyond 'classic' topological space syntax analysis in that it develops a sensitivity for metric properties; the size of a room within a given building will

9 Sailer (2010, p. 129–132) is a noteworthy exception; the alternative normalization of axial maps she arrives at (Sailer 2010, p. 130–131, p. 132 fig. 5–12) is, however, too specifically geared to analysing office buildings to be used in the present study.

influence its visual integration.[10] In many other respects, as Hillier (this volume) clearly illustrates, it represents a direct continuation of traditional space syntax, in which a new type of node and a new type of link are introduced,[11] while the methodological apparatus is retained. Amongst other things, this means VGA continues to use[12] formulae of normalization previously established for topological analysis and, again and perhaps even more so than in topological analysis, the issue of normalization may prove problematic, as indicated by Turner in the handbook for an early version of the software: “Not enough work has been done at the time of writing to see […] if any normalisation of depth is a sensible idea for such [i.e. visibility] graphs” (Turner 2004, p. 15). While a previous study had noted “preliminary evidence” that traditional normalization, particularly using the P-value (Hillier and Hanson 1984, p. 113–114 incl. table 4), “may be a valid method to overcome the problem of size” (de Arruda Campos and Fong 2003, p. 35.9) and while it could be claimed that meaningful results of numerous analyses conducted since provide empirical confirmation of the ‘sensibility’ of normalization, we are not aware of a theoretical solution to the issue; indeed, it has been suggested recently that normalized indicators for VGA should not be used in the analysis of complex buildings and that mean path lengths could be referred to in their stead (Sailer 2010, p. 132–133). In the present study, integration as a normalized indicator is employed, but the main focus is on the interpretation of the resulting maps rather than on specific numerical values – a visual approach to visual integration, as it were.[13] Still, the choice of relying on integration in VGA follows mainly from the idea of following the common practice of studies of modern contexts as explained in the section on topological methodology, and the reader should be aware of potential problems. Brief mention is also made of visual connectivity, a more basic characteristic, which only takes into account immediate intervisibility and is defined as the number of other grid points visible from any given grid point (Turner 2004, p. 10).

10 Cf. Turner (2001, p. 31.8), who suggests entropy as a topological measure to counter this area dependence, also noting, however, that both entropy and relativized entropy lead to interpretative problems of their own (Turner 2004, p. 15). In the present study, which combines VGA with both topological and metric analysis, no need was felt to render VGA more ‘topological’, and area dependence is considered a strength as much as a weakness of visual integration; entropy or relativized entropy are therefore not employed.

11 The nodes or spatial units can be understood either as locations, in which case “a graph edge connects vertices representing mutually visible locations” (Turner 2001, p. 31.1) or as ‘isovists’, in which case “a spatial network is […] calculated from overlap” (Turner 2007b, p. 43). The latter definition illustrates even more clearly the close connection with axial and, if adjacency is substituted for overlap, convex space syntax analysis; the former definition is more closely comparable to the way space is represented through square raster cells in GIS analysis.

12 More precisely: Depthmap continues to offer and researchers commonly make use of this offer.

13 Based on the output of Depthmap 8.15.00c, maps resulting from normalization by D- and P-value were visually identical; both were also found closely similar to those resulting from normalization by the formula suggested by Teklenburg et al. (1993) and comparable in general terms if not in all specifics to maps of mean depth (i.e. mean path length). Where numerical values for visual integration are given below, these represent Depthmap’s output for P-value normalization.

Agent-based analysis, in which agents navigate through a layout by reference to their direct visual field, from which they pick a random direction after a given set of steps, was conducted as an adjunct to visual analysis. Since the main focus of this study is on comparison of 'traditional' space syntax with GIS approaches, only this most basic form of agents provided by Depthmap was employed, which has been found in present-day studies to produce good correlations with observed movement in some contexts (Penn and Turner 2002a; 2002b; cf. Turner 2007c, 166–167). Default settings of the software were used unless otherwise noted, with the exception of the length of analysis and the time individual agents remained in the system, both of which were stepped up by a factor of 10 to better capture long-term patterns.

As to the underlying plans, which again include the substitute spaces introduced for topological analysis, VGA was initially conducted both on the basis of an eye-level plan excluding and a floor-level plan including built features such as benches (cf. Hillier, this volume). Their inclusion, however, was found to have little impact on the results, which is perhaps less than surprising since the few indisputable built features are almost all 'wall-hugging'; therefore, the results presented here for VGA are based on one version of the plans only, viz. those plans not including built features. Agent-based analysis, on the other hand, relies on the plans including built features, since, as in the metric analysis discussed below, these have to be subtracted from the surface available to human movement even where they do not impede sight.

Two distinct problems in relation to the plans arose from the sensitivity of both VGA and agent-based analysis to the size of individual spaces. The first of these resulted from gaps or uncertainties in the data available on the outer limits of one of the complexes under analysis, the palace of Pylos. In this case, the comparative analysis of alternative reconstructions provides a satisfactory solution for VGA, as will be explained in section 4.1.2. below. The other problem was encountered in trying to apply agent-based analysis in Pylos and closely corresponded to problems also encountered in studies of present-day contexts which include large open spaces (Turner 2007c, p. 165–166, p. 169–170). Efforts to counter this through tweaking the representation of the spatial layout, e.g. by reducing courts to either passages linking the doors of buildings or even to a more arbitrary set of corridors either following main axes or hugging the walls between doors, did not lead to satisfactory results. Occlusion-driven agents, which form a more recent development not taken into consideration here, may well produce more meaningful results (Turner 2007c, p. 175–178).

2.3 Metric properties

GIS-based metric integration analysis is an innovative technique, methodological details of which are presented in Appendix 1; in this section the focus is on the way in which the correlation between average metric distance (AMD) and standard deviation of metric distance

(STMD) values can be interpreted in terms of configuration, the main analytical approach in this study. Before moving on to a more detailed discussion of this particular approach, however, two issues which are significant for the rest of the paper need further clarification. The first of these is the 'metric cost-of-passage surface' created to model architectural space through the steps explained in Appendix 1. Subsequent to acquiring the surface, the standard GIS-based cost-of-passage analyses, which are mainly applied at a landscape level, become applicable on an architectural scale. Note that cost-of-passage analyses typically include least-cost paths and cost-distance allocations (cf. Burrough and McDonnell 1998; Wheatley and Gillings 2002; Conolly and Lake 2006), both of which have been conducted for the case studies of Malia and Pylos. Secondly, 'metric integration core' is a term that essentially refers to an area comprising raster cells with AMD values that fall within a value class which starts from the minimum AMD value and has a width of one standard deviation of the AMD value distribution. The term is used frequently in the metric analyses presented later in this article. The core has been used as a means of comparing integration of different spatial systems in the analysis below.

Returning to the correlation of AMD and STMD values, a summary of the interpretative scheme used for the correlation of these values is presented in table 1. These configurational interpretations are based on whether or not observed AMD and STMD values are higher or lower than their expected values, calculated on the premise that in permeable systems, AMD and STMD values will be in direct correlation with one another.[14] Permeable systems will in essence comprise a globally central core (with low AMD and STMD values), a periphery (with high AMD and STMD values) and intermediate areas with varying degrees of centrality and peripherality (with medium AMD and STMD values). Accordingly, for each spatial system examined here, the minimum and maximum observed AMD and STMD values are taken as the start and end points of a line which represents the expected linear correlation between the two variables. And it is on the basis of this line that expected values are estimated and compared to the observed values (i.e. values extracted from the GIS map) in order to assess whether or not the figures observed are either lower or higher than what is expected.

As indicated in table 1, one of the possibilities for the correlation of AMD and STMD values is that they both stay low. In this case, the metric distance values for a given cell location do not vary much, remaining low overall and thus pointing to the centrality of the raster cell location within the entire spatial system. A second possibility is that for a given raster cell the AMD values may stay low while the standard deviation values are relatively high. This particular combination can be taken as an indication for raster cells which are central to a significantly large part of the system whilst being far away from relatively large

14 Further research on metric integration analysis should preferably be aimed at clarifying such issues by applying the technique on purely geometric (e.g. square, rectangular, circular etc.) and thus perfectly permeable spatial systems, to examine the 'behaviour' of different geometric shapes in terms of AMD-STMD correlation.

Table 1 | Configurational interpretation of correlations between AMD and STMD values.

		Standard Deviation of Metric Distance	
		Low	**High**
Average Metric Distance	**Low**	Central for the entire spatial system (i.e. globally central)	Centre of a possible sub-system (i.e. locally central)
	High	Peripheral; connected to the rest of the spatial system through metrically long sequence of spaces that are mostly narrow and/or constitute tree-like topological structure	Peripheral; but if found close to local centers (i.e. low AMD, high STMD), possibly part of a sub-system

areas too; this would be the reason why metric integration values vary considerably, while AMD values remain low. The combination is likely to point to a relatively peripheral locale serving as the centre of a *large* subsystem (term henceforth used interchangeably with 'spatial cluster' and 'compartment'), of which the relative size (i.e. largeness or smallness) is assessed in relation to the entire building size. Another possible combination is high AMD values accompanied by relatively low STMD values. This combination can indicate a metrically isolated raster cell in the entire spatial system; at a more local level, the combination indicates that very few cells are close to the cell under observation. Raster cells with this particular combination of AMD and STMD values exhibit low variations of metric distance values because a substantial amount of the other raster cells in the spatial system is relatively far away. In fact, the combination indicates that the raster cell connects to the rest of the system through a metrically long sequence of spaces. The difference between the 'ordinary' peripheral cells and this particular type – reflected by low STMD values – is the relative (metric) narrowness and/or tree-like topological configuration of the spaces that need to be traversed to reach the latter. Both qualities will have an impact on STMD values, rendering them lower than expected. Regarding the tree-like configuration, note that high AMD and low STMD raster cells are often located towards the end of topologically long branches with many b-type spaces. From a cognitive perspective, areas exhibiting this particular AMD and STMD correlation may indeed be those perceived as distant or inaccessible, a property suggested as being also indicated by low axial integration (Sailer 2010, p. 98). Lastly, there are those cells with both high AMD and STMD values which are simply peripheral within the spatial system as listed in table 1. In certain cases these areas may be part of a subsystem if they are found close to raster cells with low AMD and high STMD values, which in fact would be the centre of such subsystems as discussed above.

Finally, two additional points have to be made concerning metric analysis. Firstly, the interpretations presented in table 1 are preliminary and may possibly entail equifinality issues which may have been overlooked here because of the limited number of case studies. In other words, other configurational properties may also provide explanations for the particular correlations of AMD and STMD values set out in table 1. Future applications in other architectural systems will certainly enrich our knowledge on the issue. Secondly, identification of spatial clusters using the framework presented here is very much affected by a subsystem's size in relation to the entire spatial system as well as the degree to which it is peripheral (i.e. its distance to the centre of the system). In terms of size, a small spatial cluster within a large spatial system may easily be missed, a phenomenon observed for Building A and the Palace of Pylos. Besides, spatial clusters closer to the centre of a spatial system are more difficult to identify with this approach than those at the periphery. This is because a subsystem at the centre would typically have low AMD and STMD values, which render it globally central. As a result, any spatial cluster at the centre would unavoidably be missed, and the area will be interpreted as the centre of the entire system rather than being a globally central subsystem. Further research on GIS-based metric integration analysis would be most rewarding in further clarifying such issues.

3 First case study: Malia

3.1 Analysis

3.1.1 Topological properties

Previous work on Maliote architecture in the vein of space syntax analysis comprises a study by Romanou (2007), whose thoughts on the use of genotypes are of great methodological interest, as well as Letesson's (2009, this volume) studies on the configurational variation within Cretan Bronze Age architecture and an article of much more limited scope by Thaler (2002). The Middle Minoan II complex of Quartier Mu, with its exceptional preservation, offers a subject for consideration for both Romanou (2007) and Letesson (this volume), who deal with the 'house-workshops' and Buildings A and B respectively. Our focus here is more specifically on Building A only, the central and largest building of Quartier Mu.

Building A is surrounded by nine other buildings, five of which are identified as house-workshops. As there is no consensus about space use in Quartier Mu, varying interpretations have attributed different functions to Building A, mostly emphasizing a combination of ceremonial, storage, residential and administrative practices (Poursat 1983; 1987; 1995; 1996; Poursat and Knappett 2005; cf. Schoep 2002). For topological as well as for other forms of spatial analysis, it represents one of those particularly promising cases where archaeology can distinguish the plan of a building in two different phases, and we can thus trace the effects of its transformation through time.

In the case of Building A this transformation is quite drastic in terms of size, converting a former 35-room into a 56-room structure, but, at least at first sight, changes in spatial characteristics seem less dramatic. The convex integration core (fig. 3) in the earlier phase is formed by an east-west axis of spaces consisting, in decreasing order of integration, of

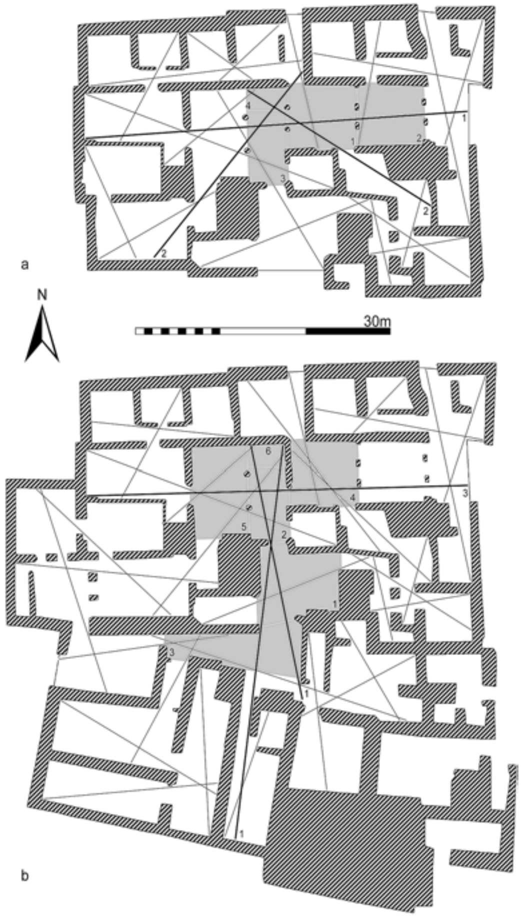

Figure 3 | Malia, Quartier Mu, Building A:
a) plan of phase 1 with convex integration core indicated in light grey, axial break-up in grey and axial integration core in black, numbers denote rank order; b) plan of phase 2 with convex integration core indicated in light grey, axial break-up in grey and axial integration core in black, numbers denote rank order.

I 13a, *I 13b*, *I 1a* and *I 1ii*, which remains part of the core when a second, north-south axis develops due to the extension of the building, with the core now including spaces *II 1*, *I 1a*, *III 1i*, *I 13a*, *I 1i* and *I 1ii*. A look at axial integration confirms this: the longest and most integrated line of the earlier phase, which passes from *I 3* through to *I 21* on the west-east axis, is relegated to third place in the later phase by two lines falling on the north-south axis, although it still shows a considerably higher integration than any line outside this core of three (fig. 3). The two north-south lines both cover spaces *I 1Iii*, *I 1a*, *II a*, *III 1i* and *III 1ii* along with, in one case, *III 6* and *III 8* and, in the other, *III 1iii*.[15]

15 It would be tempting to replace the two lines on the north-south axis with a single line, but if both the north-eastern segment of the ring of spaces *I 1i*, *I 1ii* and *I 1a* and spaces *III 6* and *III 8* are to be covered by the longest feasible lines, both lines are needed. If the shorter one is omitted, which still leaves a fully connected system, the remaining line continues to show a higher integration than the line on the west-east axis.

Figure 4 | Malia, Quartier Mu, Building A:
a) plan of phase 1 with areas of primary access highlighted; b) plan of phase 2 with areas of primary access highlighted.

The boundary between areas of primary access (fig. 4) for the northern and north-eastern entrance is hardly shifted at all as a result of the re-modelling. Moreover, the north entrance remains, as in the first phase, a clear second to the south – or later west – entrance in terms of the number of rooms to which it provides topologically shortest access paths. Still, the northern access point does, hardly surprisingly, gain some ground towards the south, as the southern access point is shifted to the south-west. However, as in the changes described before, this one, too, appears to be a mere function of the enlargement of the building, more specifically in this case of the exclusive addition of rooms to its southern and not its northern part, rather than a reflection of any change in its underlying organizational logic.

At first glance, one might assume the same about changes in general integration values. Average convex integration drops moderately from 0.87 to 0.72 globally and 1.15 to 1.06 locally, and the integration of the carrier space, i.e. the integration of the building with its surroundings, from 1.34 to 1.10; if, in a comparative exercise, average integration is calculated for the northern part only of the building in its later state as a subsystem, i.e. with rooms I 11, I 11a and I 12 as the only additions, the resulting values of 0.70 for global and 1.05 for local integration match those of the entire system very closely; integration of the carrier cannot be meaningfully calculated for this subsystem. Changes in axial integration between the earlier and later phase are even less pronounced than those in the convex analysis, with the average falling from 1.33 to 1.25[16] globally and the axial integration of the carrier from 1.51 to 1.46, while average local axial integration remains almost stable with an earlier value of 1.53 and a later one of 1.52. For the northern part of Building A, axial integration shows an average of 1.28 globally and 1.48 locally. Overall, the values remain high; since in larger systems the movement-related axial system tends to assume greater importance,[17] the stability in axial integration deserves particular emphasis, considering the substantial enlargement of Building A. Furthermore, the high integration values for the carrier, which takes fourth and fifth rank respectively in the convex break-up of the first and second phase, are particularly noteworthy: this building is perfectly suited to communicating with its surroundings.

Yet if we take a closer look at possible reasons for the moderate loss of convex integration that we do observe, in particular by tracing the ringy and tree-like elements of the earlier and later j-graph (fig. 5) through a count of space-types a, b, c and d, we come upon one element of change that does appear significant and that does seem to relate to a meaningful change in the organizational properties of Building A. In the first phase, c-type spaces, i.e. spaces on a ring, are most common with a remarkable 49 % of the total, followed by the dead-end a-type at 37 %, cut-link b-type spaces at a rather low 9 % and the rare d-type connectors between rings at 6 %. In stark contrast, 71 % of all spaces are of 'branchy' types in the second phase, with a-type spaces at now 39 % the most common; indeed, even the formerly relatively sparsely represented b-type spaces at 32 % very clearly outnumber both ringy types, with c-type now at only 21 % and d-type spaces at 7 %. That this is no coincidence becomes obvious if we take another look at the plans: not only are all the additions to the south, e.g. the suite of rooms *III 10* to *III 17*, tree-like in structure, but also seemingly minor local changes in the older part of the building, most notably the blocking of doors between *I 13b* and *I E*, and probably between *I 8* and *a*, serve to break up former rings and create tree-like elements. It therefore appears that, in the later phase, we are witnessing a compartmentalization of the building, which appears to be deliberate, since it is partly effected through the walling-up of doors; while still very well integrated with its surroundings and providing good internal communication, Building A is now divided into more clearly delineated sections which can be more easily sealed off from one another.

16 This, however, is, at least partly, a function of the representation of the main north-south axis by two lines. If the shorter of these is omitted, axial integration shows a slightly more pronounced decline to an average of 1.16.
17 Cf. Hillier (1996, p. 132) on the correspondence between axiality and movement as well as the convex articulation of space and "'static' behaviours" and Turner's (2007c, p. 163–164, p. 177) emphatic statements on the role of axiality in larger systems, particularly settlements.

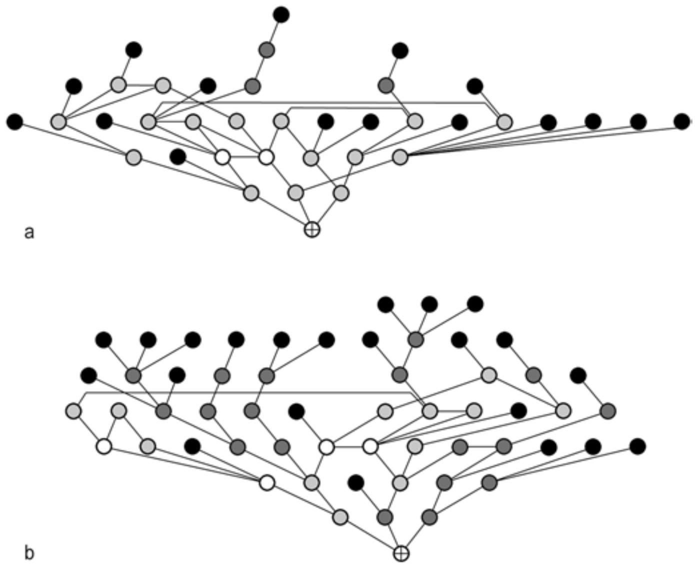

Figure 5 | Malia, Quartier Mu, Building A: a) j-graph of phase 1 with a-type spaces indicated in solid black, b-type by dark grey fill, c-type by light grey, d-type by white and the carrier space by a cross; b) j-graph of phase 2 with a-type spaces indicated in solid black, b-type by dark grey fill, c-type by light grey, d-type by white and the carrier space by a cross.

3.1.2 Visual properties

The results of VGA accord well with what was suggested above on the basis of the topological study. The visually most integrated area (fig. 6a, 6c) in the first building phase is part of the central group or row of spaces, i.e. the axis running west-east from *I 1i* to *I21*; more specifically, visual integration is at its highest in the western part of this axis including *I 1i*, *I 1ii*, *I 1a* and *I 13a*. These spaces, as previously stated, also form the convex integration core, i.e. topological and visual integration correlate well, although *I 13a* as the topologically most integrated convex space is somewhat less integrated visually than the other three spaces. This may reflect, to some degree, the influence of a short north-south 'axis' of relatively high visual integration reaching south into *II 1*. This axis, as also seen in the convex and axial analysis, becomes more pronounced in the second phase, when a second core zone of visual integration forms at its southern end in *III 1i* and *III 1ii*. In this southern core zone integration values even slightly surpass those of the northern one, which is now more narrowly confined to spaces *I 1a* and *I 1ii*. Interestingly, in terms of the more basic characteristic of visual connectivity (fig. 6b, 6d), the northern core zone remains more prominent, which reflects the fact that it is there that the main west-east and north-south axis intersect in light-well *I 1a*. More generally, both axes and also the shift from one west-east axis to two intersecting axes emerge yet more clearly in the mapping of visual connectivity than they do in the visual integration map. The drop in average visual integration from 0.65 to 0.41, on the other hand, can be seen to further reflect the afore-

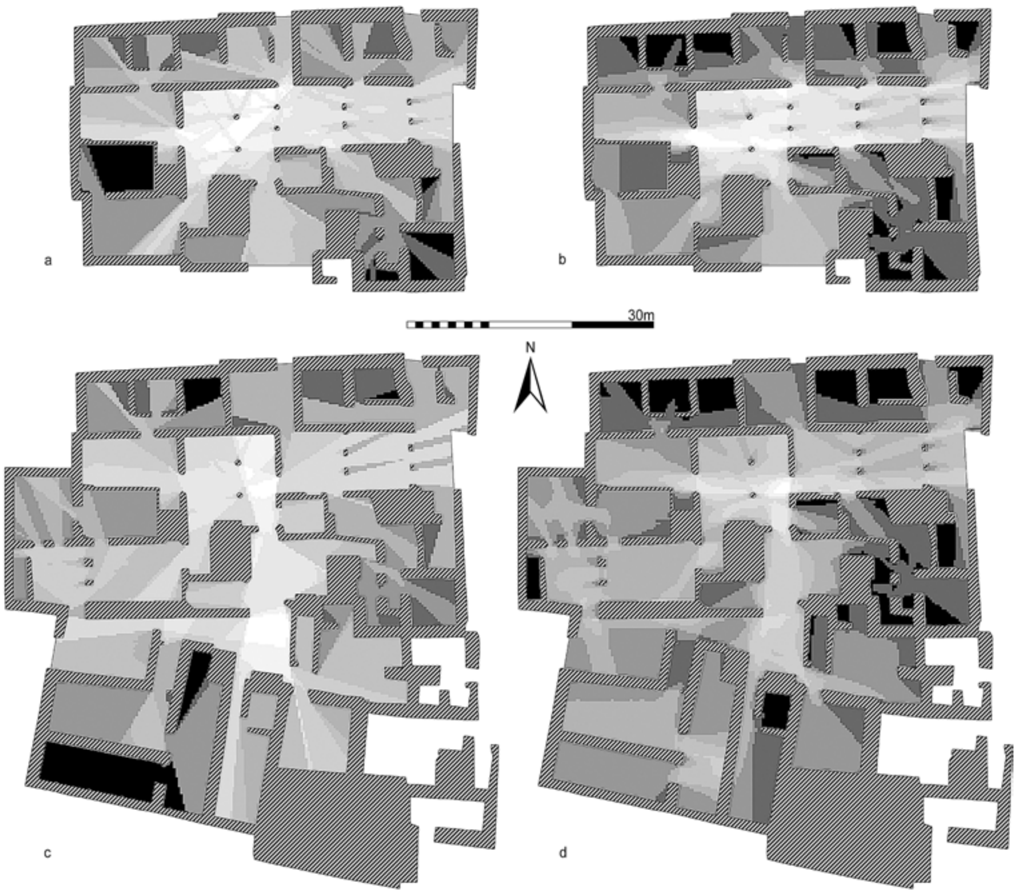

Figure 6 | Malia, Quartier Mu, Building A: a) plan of phase 1 with visual integration indicated by shading (lighter shading denotes higher integration); b) plan of phase 1 with visual connectivity indicated by shading (lighter shading denotes higher connectivity); c) plan of phase 2 with visual integration indicated by shading (lighter shading denotes higher integration); d) plan of phase 2 with visual connectivity indicated by shading (lighter shading denotes higher connectivity).

mentioned tendency to compartmentalize the building while maintaining high overall topological integration.

A further and vivid confirmation of the importance of the main integrative axes of Building A is provided by an agent-based analysis of its plan, which was performed using a deliberately fine grid of points spaced only approximately 16 cm apart, since it was felt that the detail of Building A's plan could not be adequately represented at a scale that approximates raster width to the length of a human step. To counter the resulting divergence from the human scale (cf. Turner 2007c, p. 171), the field of view and the number of steps before a turn decision were raised significantly after an initial analysis performed at Depthmap's

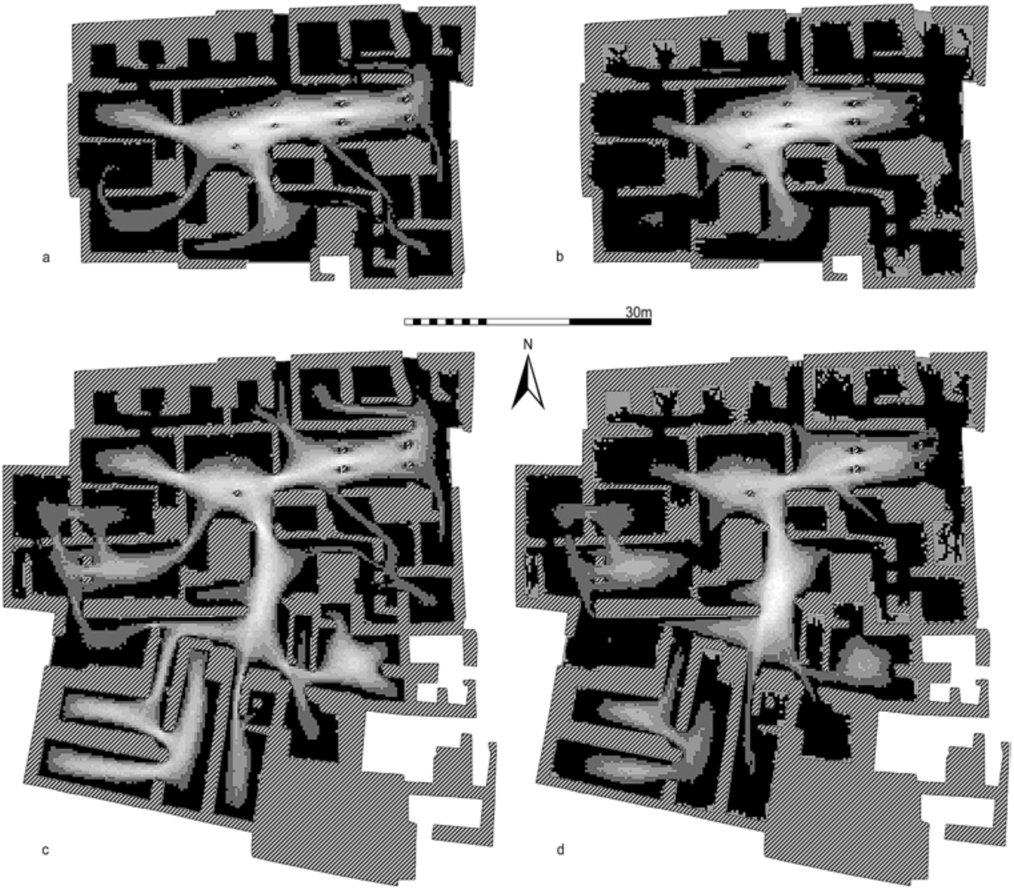

Figure 7 | Malia, Quartier Mu, Building A: a) plan of phase 1 with gate counts of agents with default field of view and number of steps before decision (lighter shading denotes higher density of movement); b) plan of phase 1 with gate counts of agents with increased field of view and number of steps before decision (lighter shading denotes higher density of movement); c) plan of phase 2 with gate counts of agents with default field of view and number of steps before decision (lighter shading denotes higher density of movement); d) plan of phase 2 with gate counts of agents with increased field of view and number of steps before decision (lighter shading denotes higher density of movement).

standard settings.[18] The first analysis (fig. 7a, 7c) picked up both the mono-axial core of the first and the bi-axial core of the second phase, but also a few less frequented, but still discernible subsidiary routes including the loops through rooms *II 1*, *I 1a*, *I 13a*, *I 14*, *I 15 a*, *II 3ii* and *II 3i* in both and through rooms *I 11*, *I 12*, *I 4* and *I 10* in the later phase only. The second analysis (fig. 7b, 7d), with larger fields of vision and less frequent turns, showed an even stronger concentration of movement on the main axes. This effect is most pronounced in

18 From 15 to 45 for field of view and from 3 to 10 for steps before turn decision.

the map for the first phase, where apart from the dominant west-east axis only the emergent north-south axis is discernible at all against a background of low movement density. In the map for the later phase, it is particularly noteworthy that movement of agents is most intensive in *II 1*, i.e. in the space that connects the visually most integrated areas. In either version of the analysis and either phase, it is furthermore conspicuous how little movement is attracted by the storerooms in the north of the building, particularly the group of rooms *I 5*, *I 6* and *I 7*, despite their topological proximity to the most integrated parts of the building. The significance of this observation is not quite clear, although the contrast to previously discussed aspects, where observations on visual properties were more easily correlated with topological results, is of some interest.

3.1.3 Metric properties

In the first phase, large areas of Building A have directly correlating AMD and STMD values (fig. 8a, 8b). As explained previously, low AMD and STMD values indicate centrality to the entire system, and this is the case for *I 13a* and the light-well *I 1a* in particular, but also for *I 1i*, *I 1ii*, *I 2*, *I 14* and *II 1*. In the first phase system, AMD and STMD values range from 8.4 m to 19.2 m and 3.6 m to 6.9 m respectively, while the globally central areas listed above have values of 8.4 m to 10.7 m and 3.6 to 5.0 m respectively. Note that these areas constitute the metric integration core together with *I 13b*. With 10.6 m as AMD and 5.5 m as STMD, *I 13b* is more of a locally central area than the rest of the core; moving further eastward this local centrality phenomenon becomes even more emphasized in *I 21*, where relatively low AMD values (13.3 m–13.6 m) coincide with high STMD values (6.4 m–6.6 m). As such, *I 21* may have been a local centre connecting rooms to its north (*I 22*–*I 24*) with those to its south (*I 19* and *I 25*) and west (*I 13b*), perhaps facilitating their use as a subsystem. In general the first phase building is fairly permeable, with directly correlating AMD and STMD values in many parts including the western part of *I 3*, *I 4*–*I 10*, *I 15*, *I 17*, *I 23*, *I 24*, and *II 2*, where *I 4* is the most isolated area; for these rooms AMD and STMD values range from 15.8 m to 19.2 m, and from 6.1 m to 6.9 m respectively.

The metric integration core covers 83.1 m² of the 248.9 m² system in the first phase, comprising 33 % of it. The metric allocation of areas to the entrances shows that the two north entrances are the closest for 52 % of the building (the north entrance 28 %, the northeast entrance 24 %), while the south entrance is the closest entrance for 48 % of it (fig. 9a). Importantly, the areas allocated to the northeast entrance match exactly with the subsystem indicated above, with *I 21* as the local centre.

In the second phase the metric integration core enlarges and shifts to the south (i.e. from the area in between *I 1a* and *I 13a* to the area in between *I 1a* and *II 1*); both is to be expected given the extension of the system towards the same direction. The AMD and

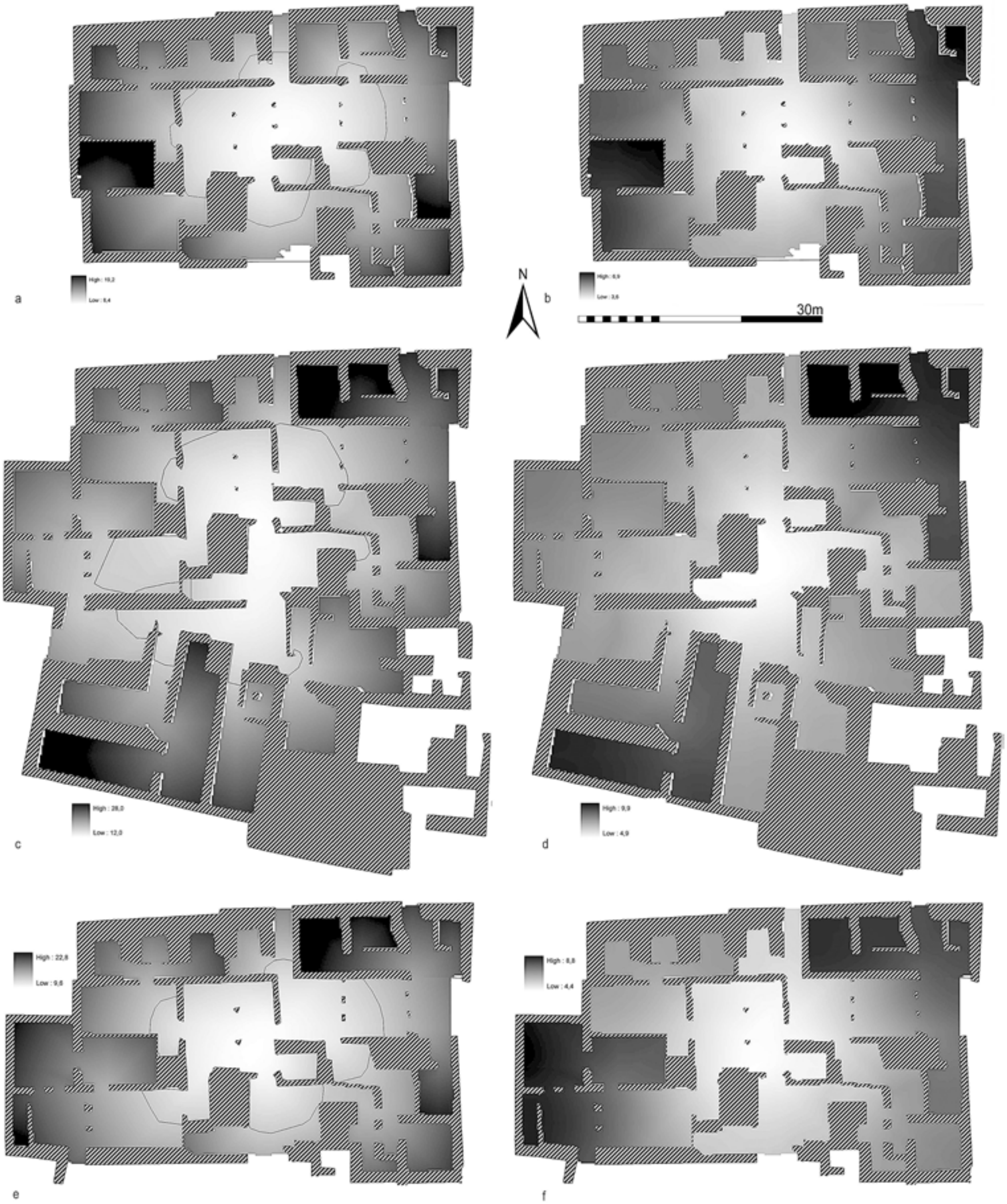

Figure 8 | Malia, Quartier Mu, Building A: a) AMD map of phase 1; b) STMD map of phase 1; c) AMD map of phase 2; d) STMD map of phase 2; e) AMD map of phase 2 (northern subsystem); f) STMD map of phase 2 (northern subsystem). The border of the metric integration core for each case is shown by a solid black line.

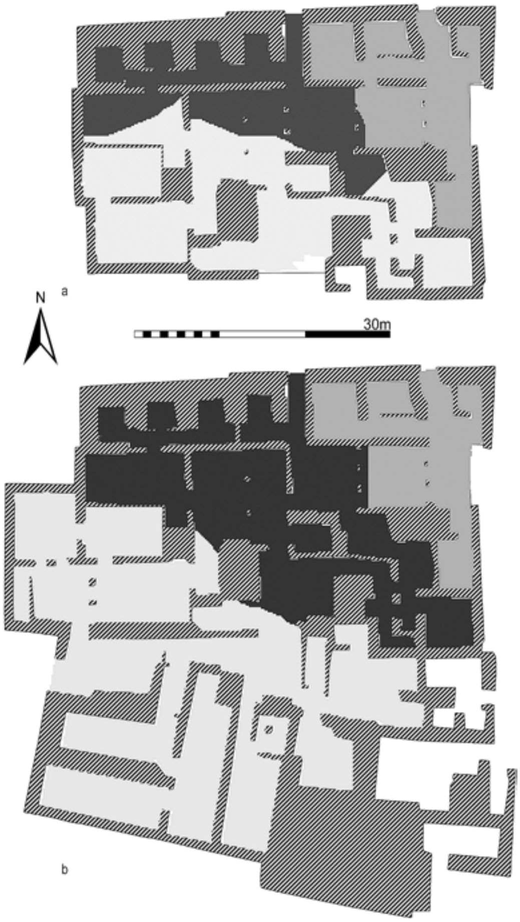

Figure 9 | Malia, Quartier Mu, Building A:
a) metric allocation map of phase 1 showing areas allocated to three different entrances; b) metric allocation map of phase 2 showing areas allocated to three different entrances.

STMD values range from 12.0 m to 28.0 m and 4.9 m to 9.9 m respectively in this phase (fig. 8c, 8d). The globally central area mainly comprises *II 1* and *I 1a*, but also *I 2, II 2* and *III 1,* where AMD values range between 12.0 m and 13.3 m and STMD values between 4.9 m and 5.8 m. Besides these globally central areas, the metric integration core also includes *I 1i, I 1ii, I 9, I 10, I 13b* and the eastern part of *III 15* with low AMD (14.1 m–15.8 m) but relatively high STMD (6.5 m–7.2 m) values, and as such they have local centrality properties. Beyond the metric integration core a similar trend continues: at the south of *I 4, I 11,* the southeast of *I 12, I 13b, I 14,* and the west of *III 15* and *III 16, I 21, I 22, I E* and *I 25,* a combination of low AMD (15.8 m–21.3 m) and relatively high STMD (7.2 m–9.4 m) values can be observed, pointing to varying degrees of local centrality.

There are three spatial clusters at the periphery of the building during the second phase: First, in the western part, the loop through *I 4, I 10–I 12* is a spatial cluster with the opening between *I 4* and *I 10* at its centre (if we take the northern part of the second phase building as a subsystem, the spatial cluster comprising *I 4*, *I 10–I 12* stands out more distinctly [fig. 8e, 8f]). Second, to the northeast, as in the first phase, *I 21*, *I 13b*, *I 19*, *I 22*, *I 22a*, *I 23*, *I 24*, and *I 25* constitute a spatial cluster with *I 21* as the centre. And third, to the southwest *III 9*, *III 16* and *III 17* form a cluster with the opening between *III 9* and *III 16* as its centre. In large parts of the building (comprising *I 5*, *I 7*, *I 16*, *I 17*, the western part of *II 2*, *III 3*, *III 4*, *III 7* and *III 8*) there is either a combination of relatively high AMD (15.7 m–19.6 m) and low STMD (5.2 m–7.0 m) values, or high AMD (19.0 m–22.3 m) and relatively low STMD (6.9 m–7.9 m) values. These spaces are likely to have this particular combination of AMD and STMD values not only because of their peripherality. As discussed previously in the methodology section, the correlation also has to do with being located at the end of long branches of the tree-like elements (*I 5* and *I 7*), forming narrow spaces themselves (*II 2* and *III 8*), being accessed through narrow spaces (*I 16*, *I 17* and *III 7*) or a combination of one or more of these configurational properties. Note, however, that for none of these spaces the trend is strong and, as such, they can be considered simply peripheral in a largely permeable system in terms of metric distance.

In the second phase, the metric integration core increases in absolute size to 124.5 m^2, but with the entire system expanding to 438.4 m^2 the core comes to comprise only 28 % of it, pointing to a slightly less integrated system than the first one. The allocation of areas to entrances shows a possible increase in the importance of the south entrance that shifts to the west in the second phase. This southwest entrance is the closest entrance for 54 % of the building now (fig. 9b), while the north entrance is now the closest entrance for 33 % of the entire system, which is also an increase compared with the first phase. The northeast entrance, on the other hand, is the closest entrance for the same area as for the first system, which constitutes 13 % of the second phase building; the area allocated to the northeast entrance in the second phase is in fact the spatial cluster with *I 21* at its centre, a compartment which can be identified clearly in both phases of Building A.

3.2 Interpretation

3.2.1 Archaeological interpretation

The major architectural change in Building A in the second phase is the addition of two rooms (*I 11* and *I 12*) to the west, and a series of spaces (section *III*) to the south. Additionally, the accesses between *I 7* and *I 8*, and *I E* and *I 13b* were sealed in the second phase, as were two out of three openings between column bases separating *I 1a* and *I 1ii* from *I 13a* (Daux 1967, p. 882; Poursat 1992). All three analyses – topological, visual and metric – point to the well-integrated nature of the building in both phases; while integration values decline in the second phase – a phenomenon which can *largely* (cf. section 3.2.2) be explained through compartmentalization – a high degree of overall integration is maintained. In fact, the sustained high integration, increasing compartmentalization and architectural modifications along with the largely unaltered plan of the northern part comprise a dialectical existence of change and continuity embodied in Building A at Middle Bronze Age Malia.

Specifically, *I 13b* is no longer as central in the second phase as it was in the first in terms of convex integration. The same observation can be made for *I 1i*, *I 3*, *I 13a*, *I 13b* and *I 21*; *I 13a*, *I 13b*, and *I 14*; and *I 1i* and *I 13a* in terms of axial, metric and visual integration values respectively. Spaces *I 1a*, *I 1ii*, *I 13a* and *I 13b* may deserve particular attention here as they comprise a 'Minoan hall'[19] in the first phase, which may have had ceremonial and/or communal significance (Poursat 1992, p. 41; cf. Marinatos and Hägg 1986) as part of or beyond the daily routine. Hall *I 13* (*I 13a* and *b*) is less integrated in the second phase, as indicated by the topological, visual and metric analyses. Moreover, the same hall is not readily accessible from the southwest entrance, whereas in the first phase the south entrance would have been an easy way to access it through a large paved vestibule and portico,[20] which in its context may have been considered prestigious. In fact, a later hall (comprising *I 10–I 12*) with pier-and-door partitions in the western part of Building A may have created a second phase alternative for some of the practices that originally took place in the first phase Minoan Hall. Note that, in the second phase, it is this new hall which becomes easily accessible through the southwest entrance preceded by a sandstone pavement ('*Trottoir Ouest*', cf. Poursat and Darcque 1990, p. 910) running along the western façade of the building, comparable to the paved entrance of the first phase building. While spaces *I 10–I 12* do not qualify as a Minoan Hall from a strictly typological point of view (lacking column bases and a light-well), it is noteworthy that spaces *I 10* and *I 11* have visual and metric properties comparable to those of *I 13a* and *I 13b* in the first phase.

A result shared by all three analyses is that they pick up *I 1a*, *II 1* and *III 1* (*i* and *ii*) and *I 1i*'s east as the centre of the building for the second phase and *I 1i*, *I 1a* and *13a*[21] for the first. For the second phase it is worth noting that all the stairs leading to the first floor of the building (i.e. *I A, II A, II B, III A* and *III B*) open onto this central zone. As such, it would be there that the daily buzz in Building A would be, provided enough people were present. It

19 Although the 'Minoan hall' as typologically defined (cf. Driessen 1982, p. 29) is not necessarily a category that immediately reflects the 'realities' of the Cretan Bronze Age, it is perhaps of significance to underline that spaces *I 1a*, *I 1ii*, *I 13a* and *I 13b* no longer constitute a Minoan Hall in the second phase, as two of the three openings between the column bases that separate *I 1a* and *I 1ii*, and *I 13a* were blocked.
20 This first phase vestibule becomes space *II 1* of the second phase system. The paved portico mentioned was incorporated into the second phase building and can still be traced through the paved areas in spaces *II 1*, *III 1* and *III 2* (Poursat 1992, p. 42–43).
21 Space *I 13b* appears as one of the better integrated spaces in all analyses except for the visual one, a reason why it has not been included here. Another reason is the metric analysis according to which *I 13b* has local centrality properties, unlike the rest of the metric integration core, which is globally central.

would be a place where people moving from one compartment of the building to the other, or coming from or going upstairs would pass and encounter one another.

Compartmentalization is another common conclusion reached by topological, visual and metric analysis. Through metric integration analysis three clusters can be identified: *I 4, I 10–I 12; III 9, III 16* and *III 17*; and *I 13b, I 19, I 21–I 25*. Given the existence of a 'lustral basin'[22] at the basement level underneath the ground floor space *I 4*, the first cluster is likely to have had some cultic significance. For the second compartment, the existence of benches in *III 16* may signify storage practices, and given that it was found empty during excavations it is possible that this cluster had already been abandoned at the time of the final destruction by fire. The other compartment which was found empty, *I 13b, I 19, I 21–I 25*, is likely to have also been abandoned at the time of the final destruction by fire if not during the entire second phase. In the first phase, however, it may have been a context for culinary practices considering the 'troughs' found *in situ* in *I 19* (Poursat 1992, p. 47)[23] and possible storage spaces to the north, *I 23* and *I 24*.

As mentioned previously in the methodology section, metric analysis failed to identify some of the obvious spatial clusters in Building A, *I 5–I 7* (perhaps also including *I 3*) being one of them. With several storage vessels found *in situ* in these rooms (Poursat and Knappett 2005, p. 158–160), there is barely any doubt that this cluster was used for storage, particularly in the second phase and probably in the first one, too. Spaces *I 14–I 17* and *II 3* form another one of those unidentified possible spatial clusters which may have been used for culinary practices in the second phase, considering the *in situ* storage vessels found in *I 16* (Poursat and Knappett 2005, p. 161) as well as the troughs in *I 15* (Poursat 1992, p. 47); this area may have been rearranged in the second phase, perhaps restoring the practices which had taken place in *I 13b, I 19, I 21–I 25* during the first phase.

From these results, we can say that in the second phase building practices similar to those performed during the first phase found new locales. In fact, the architectural history of Building A shows us a glimpse of the delicate balance between change and continuity in this particular social context, i.e. how change came without denying traditions and habits in a context where traditions and habits did not exclude change. The second phase Building A, with its central zone interfacing between different compartments and floors, appears to be a place where people would continually encounter one another, witness what others were doing and (tacitly) negotiate their social roles. It is a place that could facilitate intense social interaction, awareness (cf. Thrift 2008, p. 6–7) and memory

22 For a recent overview of this particular type of architectural space referred to as lustral basins (or *adyton*, see Marinatos 1993, p. 77–87) and often interpreted as baths or cult rooms in Cretan Bronze Age studies, cf. McEnroe (2010) with references. For further information on the lustral basin in Building A cf. Poursat (1992, p. 37–38).

23 What is referred to here as a trough is commonly known as *gournes* (Greek) or *auge* (French) in Cretan Bronze Age studies. These are stone blocks with single or double cavities of uncertain use (cf. Treuil, 1971; Begg 1975, p. 28 for further explanation).

building; a context where tensions could rapidly emerge through the co-presence of ambitious, competitive actors and where strong social bonds could be (re-)produced through cooperative attitudes.

3.2.2 Comparison of analytical results

The results of topological, visual and metric analysis significantly agree with one another, as was mentioned in the previous section. All three point to well-integrated systems in both phases, while integration values slightly decline for the second phase. Yet do the similar trends in global integration values relate to the same aspects of configuration?

Since the integration value trends for the first and second phase systems largely match, and a numerical comparison is not possible due to the differences in calculation methods, the inclusion of analytical results for the north wing (sectors *I* and *II*; henceforth referred to as 'north wing system') as a subsystem of the second phase is of particular interest in a comparative discussion. As summarized in table 2, axial, visual and metric global integration values for the three systems follow a very similar trend: the north wing system is slightly less integrated than the first phase, whereas the second phase is the least integrated. However, it appears that average global convex integration values are the 'odd ones out' in this context, given that the values for the north wing system are much lower than those of the first phase and slightly lower than those of the second phase system. One possible explanation of this pattern could be sought in the topological depth of new tree-like compartments in the second phase and north wing systems, calculated in relation to the 'main' rings. To be more specific: Each of the three systems under consideration has relatively lengthy rings running through several topologically well-integrated spaces.[24] The second phase and north wing rings, however, differ from the first phase one in that relatively large numbers of deep topological branches comprising the compartments connect to these rings in both systems.[25] Therefore, although the question would need further examination before any conclusive answer can be put forward, the trend of average global convex integration values may be explained by the existence of these deep compartments in relation to the rings in the second phase and north wing systems – a configurational property not prominent in the first phase. As such, average global convex integration values in this particular context may be a reflection of a particular compartmentalization phenom-

24 These rings are as follows:
Ring 1: corridor *a*, *I B*, *I 13a*, *I 1a*, *I 1i* and *I 3* (first phase system).
Ring 2: I 13a, *I 14*, *I 15a* (and *I 15c*), *II 3ii*, *II 3i*, *II 1* and *I 1a* (first and second phase and the north wing systems).
Ring 3: III 15, *III 1i*, *II 1*, *I 1a*, *I 1i*, *I 9*, *I 10* and *I 11* (second phase system).

25 E.g. *III 10*, *III 16*, *III 9* and *III 17*, which connect to *III 1i*; and *I 13b*, *I 21*, *I 22ii*, *I 22i* and *I 23* (or *I 24*), which connect to *I 13a*. Note that in the first phase system the single comparably deep compartment is formed by *I 9*, *I 10* and *I 4*, which is connected to *I 1i*.

Table 2 | (Average) global integration values for the three systems.

	Average Convex	Average Axial	Average Visual	Metric
1st Phase	0.87	1.33	0.65	33 %
2nd Phase	0.72	1.25	0.41	28 %
2nd Phase (North)	0.70	1.28	0.52	32 %

enon that involves deep tree-like elements, a property other global integration values are not necessarily sensitive to.

Note that allocation of areas to 'source points' (or 'root spaces' using space syntax terminology) by metric and topological analysis provides very similar results in Building A. For example, both techniques assign spaces *I 19*, *I 21–I 24* to the northeast entrance. In both phases space *I 13b*, the locally central part of the metric integration core (cf. section 3.1.3), is assigned to the northeast entrance by metric allocation, although not by topological allocation; the result may be another indication of the ambiguous or multi-'functional' nature of *I 13b*: as mentioned earlier, this particular space appears as part of the metric integration core with local centrality properties, while it is also part of hall *I 13* and spatial cluster *I 19*, *I 21–I 24*. It is worth noting that metric allocation, unlike topological allocation, does not require the ascription of entire rooms to specific areas, but affords the researcher the possibility of making distinctions within rooms. For example, while the north entrance receives only parts of *I 1a*, *I 1i*, *I 3* and *I 4* in the first phase metrically, spaces *I 3* and *I 3a* are assigned to the north entrance and *I 1a* and *I 1i* remain with the south entrance in the corresponding topological mapping. Another difference between topological and metric allocation results is that in the second phase space *II 1*, one of the more central parts of the building, is assigned to the north entrance metrically and the southwest entrance topologically. At any rate, there is considerable agreement between the two techniques, which offer possible alternatives to one another.

4 Second case study: Pylos

4.1 Analysis

4.1.1 Topological properties

As in the case of Building A at Malia, the palace of Pylos (Blegen and Rawson 1966), which served as the centre of a Late Bronze Age state as evidenced by the Linear B tablets found in its archive rooms, provides a particularly promising context for topological studies and other analyses of configuration because of our ability to distinguish an earlier and later building state, as was first coherently set out by Wright (1984), with later additional discussions by Nelson (2001, p. 207–216) and Thaler (2009, p. 56–70). Space syntax analyses of the palace were undertaken relatively early on by Lane (1993, p. 28–32, pl.s 3–4),[26] who, however, based his work on topological graphs which did not capture the building in its entirety in either phase, and later by Thaler (2005; 2009, p. 56–83), whose main results are summarized here.[27]

An almost inescapable starting point for the topological analysis of the Pylian palace is the assumption that changes to the palace consistently served to "restrict access and circulation" (Shelmerdine 1987, p. 564), which has long been taken as one of several architectural reflections of a long-term economic decline and sometimes even been associated with fortificatory intentions (Deger-Jalkotzy 1995, p. 370; Shelmerdine 1998, p. 87). The assumption that circulation was restricted fails to find corroboration in topological analysis, as average convex integration is only marginally lower at 0.70 in the later than in the earlier building state at 0.72, and the same is true for axial integration with an average of 1.01 for the first and 0.96 for the second building state.[28] Integration of the complex with the exterior as a topological measure of ease of access, on the other hand, does experience a more noticeable decrease from 0.84 to 0.69 for the convex and 1.27 to 1.11 for the axial break-up;[29] however, both measures of integration for the carrier space remain close to the average integration of the building complex even in the second phase, thus belying any fortificatory intent and suggesting that the observable changes may be better understood in the context of functional and potentially social differentiation. Partly, this seems to take the form of effectively channelling movement within and particularly into the palace, which will need to be discussed in more detail, but is already hinted at by the increase in proportion of spaces of type b, 29 % in the earlier and 38 % in the later building state, and the concomitant decrease of d-type ring-connectors, 18 % and 9 % respectively.

Generally, a higher degree of spatial differentiation in the later building state, in terms of circulation within the palace complex as well as access from outside, is particularly evident in the case of the major courts, particularly courts *58* and *63*. While both form part of

26 We would like to thank Louise Hitchcock for pointing out to us an even earlier application of a space syntax approach to the analysis of Pylos by Yiannouli (1992), to whose unpublished PhD thesis we unfortunately did not have access at the time of writing.

27 To ensure consistency, analyses which had previously been carried out manually (Thaler 2001) or with the older UCL Macintosh-Bundle (Thaler 2005; 2009) were reworked with Depthmap 8.15.00c. The underlying ground plans are, except for the omission of staircases, the same as in the two latter studies, which revise the architectural discussion in the first in some details. Results, however, remain consistent.

28 With regard to the issue of normalization (cf. section 2.1), it is well worth noting that results are reversed for both the convex and axial analyses if the normalization formula suggested by Teklenburg et al. (1993) is applied instead of the standard one, although the differences in integration values remain minimal (cf. Thaler 2009, p. 71–72).

29 For technical reasons, the axial carrier was represented by a frame of four interconnected axes and its integration was calculated as the average value for these four spatial units in Thaler (2009, p. 73), resulting in values of 1.15 and 0.90 for the earlier and later state respectively. The present analysis uses Depthmap's link-functionality to render the axial carrier as a single spatial unit, which results in the higher values given here.

Figure 10 | Pylos, palace: a) plan of earlier building state with topologically shortest routes to throne room *6* indicated and peaks of local integration highlighted in grey with local integration ranks inscribed in black; b) plan of later building state with topologically shortest routes to throne room *6* indicated and peaks of local integration highlighted in grey with local integration ranks inscribed in black.

an undifferentiated ring of hypaethral spaces in the earlier building state and are, at a low depth of 2 and 3 steps respectively, easily reached from the outside, they come to fulfil distinctly different roles in the later building state. At a topological depth of 6 steps from the outside and no longer part of the shortest topological route to the throne room (fig. 10), court *63* is of little importance for access to the palace; its integration value of 1.17, however, the maximum value for the complex, demonstrates that it forms the single most important node of internal communication. Court *58*, on the other hand, with a noticeably lower, though still high global integration value of 0.92, retains a comparatively low depth of 3 and forms, in the later state, the point where the shortest topological access paths to the throne room converge. This offers a first indication of this court's role as the most important interface between the palace and the outside in official matters.

Court *58*'s importance as an interface, for which it is well suited as the space with both the highest local integration and the highest number of immediate neighbours, becomes clearer still by mapping the areas most closely associated with each of the three main courts, which takes into account court *88* alongside courts *58* and *63* (fig. 11a). All three are not only peaks of local integration, i.e. more highly integrated at radius 3 than any adjoining space, but also the three spaces with the highest absolute values of local integration in the complex and thus identified as primary integrators (fig. 10). In this map of primary control, both the palace archive consisting of rooms *7* and *8* and the Northeastern Building – recently and

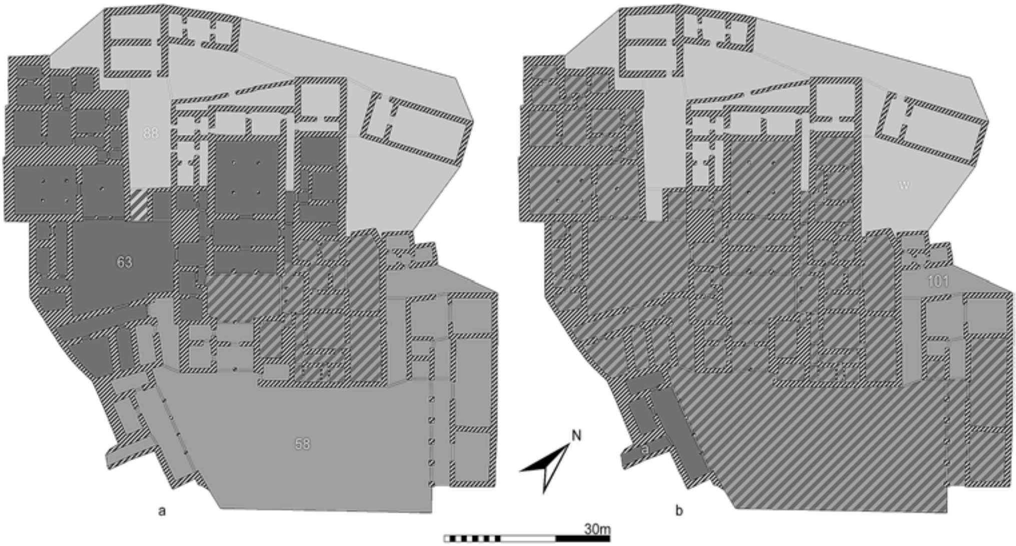

Figure 11 | Pylos, palace: a) plan of later building state with areas of primary control indicated by shading; b) plan of later building state with areas of primary access indicated by shading.

convincingly re-interpreted as a clearing house functioning within the redistributive palatial economy (Flouda 2000, p. 215; Bendall 2003, p. 181) – fall within the area of primary control of court *58*, thus confirming its role as an interface for official visitors to the palace.

In addition, the mapping of areas of primary control shows court *88* as the centre of an area which overlaps almost perfectly with the area most easily accessible from the outside through space *w*. This is particularly noteworthy since *w* is the one entrance to the palace that bypasses court *58* and also the one from which the complex as a whole, i.e. beyond this area of primary access (fig. 11b), appears deepest and least accessible; the latter is illustrated by a comparison of j-graphs for this northern and the two southern access points (fig. 12). Since the area controlled by *88* and accessible via *w* encompasses most of the palace's storerooms, notably the oil and wine magazines and the main pantries, Kilian's impressionistic and perhaps anachronistically phrased, but highly perceptive identification of a 'tradesman's entrance' (Kilian 1984, p. 43: "Lieferanteneingang"; Kilian 1987, p. 207: "entrée des fournisseurs") at the back of the palace is clearly confirmed as a prime example of the above-mentioned efficient channelling of access to the palace. As such it forms the direct counterpart to the shifting of shortest topological paths to the throne room, previously alluded to in discussing court *58*: while these paths use side entrances of the Main Building in the earlier building state, they come to coincide with what architectural elaboration and the parallel contexts at the palatial sites of Mycenae and Tiryns lead us to identify as the canonical access route through spaces *1* to *5*, i.e. the propylon and megaron court and then the porch and vestibule of the megaron, into room *6*, i.e. the throne room, the importance

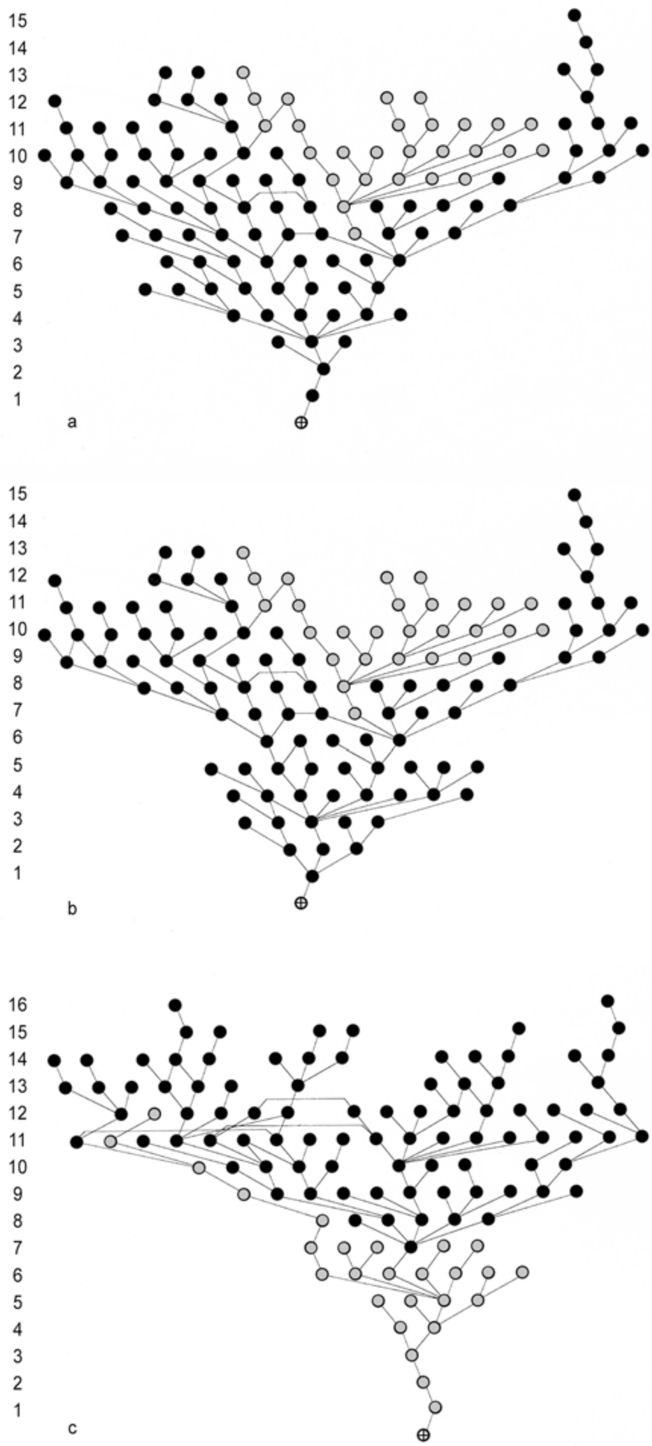

Figure 12 | Pylos, palace: a) j-graph of later building state for access through space *a* only, topological depth indicated on the left, area of primary access through *w* in grey and carrier space by a cross; b) j-graph of later building state for access through space *101* only, topological depth indicated on the left, area of primary access through *w* in grey and carrier space by a cross; c) j-graph of later building state for access through space *w* only, topological depth indicated on the left, area of primary access through *w* in grey and carrier space by a cross.

of which is reflected by its being the most integrated a-type space in the Main Building. In this latter instance, it is conceivable that social customs assured a similar 'channelling' in the earlier building state, but it is only in the later one that it becomes 'inscribed' in the architectural layout of the palace. More generally, none of the elements of spatial differentiation here described for the later building state are evident in the earlier. In particular, the integrated economic unit at the back of the palace is only made possible through a reconfiguration of access to rooms at the Main Building's western corner.

4.1.2 Visual properties

As in the case of Malia, some of the tendencies observed in topological analysis are further illustrated by the results of VGA (fig. 13).[30] The first and – given the sensitivity of visual analysis to the size of spaces – most obvious of these is the great importance of the major courts as main foci of integration, clearly observable in both building states; but the visual analysis helps to add an interesting nuance here: in both the earlier and later state, the hypaethral areas around the back of the Main Building are noticeably less integrated than corresponding frontal areas, corroborating the identification of a 'back area' of the palace complex. Front and back are at first identified intuitively on the basis of the orientation of entrances to the major buildings, most notably the propylon of the Main Building and porch *64* of the Southwestern Building.

It should be stressed, however, that this could, in principle, be an analytical artefact to some extent, since the exact limits and, consequently, the size of specific courts are often difficult to ascertain and thus have to be set with some degree of arbitrariness; since this has a bearing both on VGA results – illustrated most clearly by a map of visual connectivity for the later state (fig. 14), in which the large court *58* could not stand out more clearly – and on the results of metric analysis set out below, some explanatory comment is needed here: the southwestern limit of the complex is defined by terrace walls and thus secure; the northeastern limit, where the ground continues as a plateau of comparable level, is approximated for the first building state by a line including the northeastern wall of a small outbuilding identified as part of the palace proper and for the later state by a serious of outbuildings on the northeastern edge of the complex and should thus be fairly reliable. The northwestern and southeastern limits provide the real challenge, since these are decisive for the size of 'frontal' and 'back' courts, but more difficult to delineate archaeologically

30 It should be noted, however, that in the case of Pylos even more than in the Maliote example, this may be partly due to the researcher's view being guided to some extent by expectations resulting from the topological analysis previously conducted, particularly since the latter was repeated in several versions with corroborative results (cf. above, footnote 27). This problem may be compounded by the fact that the grid point is an intuitively much less meaningful unit of analysis than the convex space which so closely approximates what is more commonly called a 'room', a unit of analysis that we almost automatically 'think back to'.

Figure 13 | Pylos, palace: a) plan of earlier building state with visual integration indicated by shading (lighter shading denotes higher integration); b) plan of later building state with visual integration indicated by shading (lighter shading denotes higher integration).

than those just discussed. In the northwest, the scarp of the plateau is relatively steep, so even allowing for some erosion, as the plans analysed here do (cf., e.g., Blegen et al. 1973, fig. 302), we should not expect spaces much wider than what is preserved today; in the southeast, however, where the edge of a very incompletely preserved stucco floor in court *58* abutted the Main Building, there is a gentler slope today with two less pronounced scarps, rendering an estimate of the court's original size much more difficult. For the later state, it was assumed to extend slightly beyond the southeastern edge of room *100* of the Northeastern Building, which, however, is itself reconstructed rather than preserved,[31] and a comparable extent is thought likely for the earlier state.

To see how much this might influence the outcome of visual analysis, a trial run was undertaken with a plan of the earlier building phase in which the southeastern extent of court *58* was reduced by approximately half (fig. 15).[32] This did indeed attenuate the predominance, in terms of visual integration, of frontal hypaethral space over back areas to some extent, but by no means neutralize it. As this is most effectively explicable by the

31 Room *100* is reconstructed slightly wider along its northwest-southeast axis in the present plans than in most other published plans (e.g. Blegen and Rawson 1966, key plan) to allow for an even spacing of the pillars suggested in Westerburg's (2001) inspiring discussion of the original layout of the Northeastern Building.
32 This brings it in rough correspondence with the southern corner of the – *nota bene* – earlier Building X, a position which seems, if anything, even more arbitrary, but is probably still the most reliable minimum estimate available.

Figure 14 | Pylos, palace, plan of later building state with visual connectivity indicated by shading (lighter shading denotes higher connectivity).

Figure 15 | Pylos, palace, alternative plan of earlier building state (reduced size of court 58) with visual integration indicated by shading (lighter shading denotes higher integration).

aforementioned orientation of main entrances to the major buildings, the intuitive first identification of front and back is clearly corroborated by the analytical results.

Still, VGA should and does offer more than this, if we look more closely at those courts and particularly at court 58, previously identified as the main interface between the building complex and its carrier space in the later building state. It is the concomitant channelling of access to the throne room towards the canonical route which is also reflected in visual integration analysis. Whereas in the earlier state the most visually integrated sections of court *58* are lateral ones which connect to other open-air spaces on the ring around the Main Building, a central core zone of visual integration within the court, which is focussed and thus focuses the visitor on the propylon, is observable in the later building state. This is perhaps the most noteworthy result of visual analysis and nicely parallels Kilian's earlier observation on how the width of the propylon in comparison to the widths, less by half, of ramps *59* and *91* helped to orientate visitors towards what is here termed the canonical access route (Kilian 1984, p. 43). While the most highly integrated area within the Main Building is linked with the connection of courts *3* and *63* in the later building state – partly apparently a result of eliminating porch *41* as an alternative 'attractor' by walling off court *42* –, the main axis of the megaron is now characterized by higher integration relative to its surroundings than previously[33] and thus provides, to a certain degree, a continuation of the visual focus on the canonical access route.

A brief remark needs to be addressed to absolute values for visual integration, the average of which is almost twice as high in the earlier phase at 0.62 as it is in the later one at 0.33. Is circulation restricted after all, as was suggested in the hypothesis of an economic decline? There is good reason not to consider the results of visual analysis evidence for this, but to place much more weight on the evidence of topological analysis discussed before. The reason for this lies in the fact that a simple characteristic of the earlier layout accounts much more effectively for high visual integration than any socio-historical narrative: where the later building state has courts hemmed in and separated from one another by suites of rooms, the earlier one has a large undifferentiated ring of hypaethral space, which is characterized by high visual integration in almost the same way as, for example, a football pitch is. To better illustrate this, it is worth contrasting visual integration for the entire complex with visual integration of the Main Building considered on its own; the latter shows an average of 0.48 for the earlier and 0.42 for the later layout and thus a much less pronounced decrease. Nevertheless, the loss of visual integration must have made itself felt for visitors to the palace, but in all plausibility much less as a restriction of circulation than by reduced intelligibility of a complex which is still well integrated topologically. This would, of course, only add to the effect of visual channelling towards specific routes, such as the canonical access route to the throne room: the relatively high visual integration of this route must have made it all the more conspicuous when other sight-lines were cut short.

Agent-based analysis in the form outlined in the methodology section has, unfortunately, little to contribute in the case of Pylos (fig. 16). The sheer size of courts compared to indoor spaces and again of court *58* in particular offers an inescapable attraction to agents of the standard direct perception type (Turner 2007c, p. 172), as Turner also notes in a com-

33 In absolute terms the main axis of the megaron is less integrated in the later state than in the earlier, but this has to be seen against the background of the lower average of visual integration values in the later building state (cf. below, next paragraph).

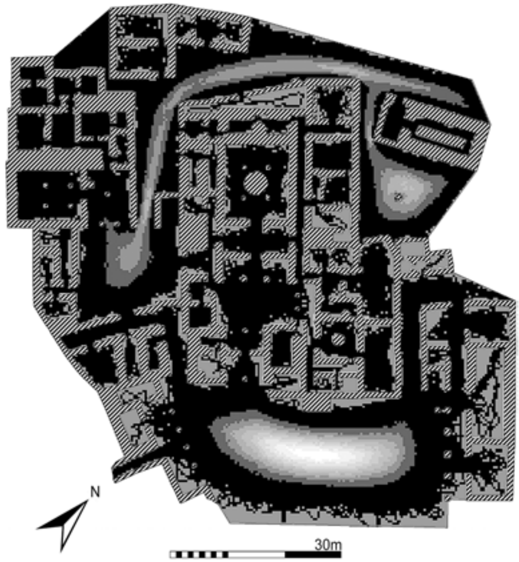

Figure 16 | Pylos, palace, plan of later building state with gate counts of agents (lighter shading denotes higher density of movement).

parable case study: "their direct perception leads them towards open spaces" (Turner 2007c, p. 169). To emphasize the positive, we may take this as further strong corroboration of the overarching importance of the Pylian courts as primary integrators of movement within the palace complex.

4.1.3 Metric properties

For the first phase of the Palace of Pylos, spaces *2*, *3* and *4* and a large surrounding area (particularly spaces *8*, *10*, *11*, *12*, *37*, *38*, *44*) have low AMD and STMD values and, as such, would be the central area for the entire spatial system in terms of metric distance (fig. 17a, 17b). In a system where AMD values range between 37.1 m and 83.4 m and STMD values between 14.6 m and 28.7 m, these areas with AMD values ranging from 37.2 m to 39.2 m and STMD values ranging from 14.6 m to 16.2 m stand out as globally central. Note that despite being at the periphery of the metric integration core (where AMD values range between 37.2 m and 44.9 m), areas to the southwest (court *63*) and northeast (space *41*, *p*) of the Main Building are to a certain extent globally central, with relatively low AMD (43 m, 39.7 m, 41.6 m respectively) and STMD (19.1 m, 16.5 m, 17.4 m respectively) values. The southeastern part of the core, however, is not globally central, where spaces *1* and the northwestern part of court *58* (with AMD values of 39.2 m and 42.1 m respectively) have relatively high STMD values (18.2 m and 22.1 m), pointing to a locally central area.

Another potentially important property of the spatial system in this phase is that there is a considerable difference between the respective trends of AMD and STMD values for the

Figure 17 | Pylos, palace: a) AMD map of the earlier building state; b) STMD map of the earlier building state; c) AMD map of the later building state; d) STMD map of the later building state. The border of the metric integration core for each case is shown by a solid line.

areas within the Main Building: the latter – being low and almost uniform (from 14.7 m to 16.5 m) – are certainly not directly correlated with the patterning of AMD values ranging from low to relatively high numbers (from 37.2 m to 64.5 m). In fact, the cause of this pattern is found in the metrically isolated areas in the Main Building (spaces *19, 20, 21, 23, 24, 32, 33, 34, 50, 53*) with low AMD and high STMD values, as they are connected to the rest of the building by narrow corridors (*13, 25, 28, 35, 45, 48, 49, 51*). Note that spaces *64* to *81* in the Southwestern Building have AMD values ranging from medium (46.8 m) to high (83.2 m). Although there is largely a direct correlation between medium AMD and STMD values in this building, simply indicating the relatively peripheral nature of these areas, the high AMD values of the westernmost spaces (*77, 78, 79, 80, 81*), between 73 m and 83.2 m, do not directly correlate with the relatively low STMD values ranging between 22.9 m to 23.2 m. The high AMD and low STMD values for these areas, again, should be explained through the narrow corridors (such as *70* and *75*) that link them to the rest of the system as well as the tree-like topological organization of the area. The spaces around the Main Building – including the structure to the northwest (*82, i, j, k, l*) – seem mainly peripheral, with high AMD values in relatively direct correlation to high STMD values.

If one takes the relative increase in the metric integration core's size as an indication of a metrically better integrated system, then the second phase complex appears to be better integrated than the first. While the size of the spatial system considered for the metric analysis increases a mere 7 % in the second phase (from 5768 m² to 6194 m²), the size of the metric integration core experiences a more significant increase from 1237 m² (21 % of the entire spatial system) for the first phase to 1951 m² (31 % of the entire spatial system) for the second. Here, centrality is a phenomenon that does not exclusively characterize spaces *2, 3* and *4*, but also spaces to the west of these, concentrating partially on court *63*. As fig. 17c shows, the metric integration core includes courts *63* and *88,* parts of court *58* as well as large parts of the Main Building. As for the first phase, the northwestern part of court *58*, which is picked up as part of the metric integration core, is perhaps the least globally central part of the entire core, potentially being central only to the court itself and the immediate surroundings. The larger second phase complex has higher AMD values for the metric integration core than its smaller first phase counterpart; these values range between 44.9 m and 59.7 m. Moreover, the second phase AMD and STMD values both have generally wider ranges than the first phase values, viz. 44.9 m–110.8 m and 21.8 m–43.68 m respectively. Therefore, we can say that the second phase system is only *contextually/locally* better integrated, while the local centrality has a considerable impact on the global integration index. In other words, better integration properties would be relevant only for those actors involved in the set of activities that entailed circulation between the Main Building and the areas south, southwest and west of it rather than those walking from one side of the complex to another; the latter would experience the later building state as the metrically less integrated one.

Combinations of relatively high AMD and low STMD values occur in many spaces, including those in the eastern (*38–43, 46–50, 53*) and northern parts (*27, 32*) of the Main Building as well as spaces in the Southwestern Building (*77, 78, 79, 80, 81*), as in the first phase. It is noteworthy that despite the increase in the size of the area considered for the metric analysis of the second phase, the AMD value in one of the more isolated parts of the spatial system, space *81*, increases by 3 metres only (from 83 m to 86 m). This fairly negligible increase is at odds with the more significant augmentation for the spatial system and is another indicator of the better-integrated nature of the second phase Main Building and the areas south, southwest and west of it. For the northern, northeastern and eastern parts of the system (spaces *91*, *94–100*, *101*, *102*, *103*, *104*, *105*, *u*, *v*, *w*, *x*, *y*), however, corresponding trends of AMD and STMD values point to the peripheral character of these areas. Hence, these parts appear to have been almost left out in the second phase while the rest of the system operates more in unison.[34]

Results provided by least-cost path analysis and cost-allocation elucidate further the configurational changes of the second phase in the Pylos case. Firstly, the first phase features least-cost paths leading from the south (*a*) and northeast (*q*) access points to the throne room (space *6*), passing through the entrances on two of the Main Building's sides (spaces *12* and *41* – fig. 18a, 18b). In the second phase, however, movement towards the throne room is clearly channelled into a route passing through spaces 1 to 5 (fig. 18c, 18d). Secondly, the allocation of areas to the three large courts (*58*, *63* and *88* – fig. 19a, 19b) and the access points (*a*, *q/101* and *o/w* – fig. 19c, 19d) reveals that the construction of spaces *42* and *47* at the northeast of the Main Building influenced the role of court *58* and access point *q/101* in the second phase. In fact, court *58* appears to be the closest court for 40 % of the spatial system in the first phase, while in the second the percentage decreases to 36 %. Similarly, access point *q* at the northeast of the spatial system is the closest entrance/exit for 30 % of the spatial system in the first phase while access point *101* at the same location serves only 17 % of the system in the second phase. Thirdly, court *88* starts to serve the northwest part of the Main Building during the second phase as the closest large open space, resulting from the openings set within the southwest walls of spaces *21* and *22*.

4.2 Interpretation

4.2.1 Archaeological interpretation

The conclusion that, from the perspective of metric analysis, the later building state appears to be, in terms of the size of the integration core, the more highly integrated system when compared to the earlier one leads us back to the oft-cited hypothesis that an economic decline was reflected in architectural changes to the palace of Pylos, which the topological analysis took as its point of departure: while in topological terms integration remained fairly stable

34 Note that, despite the obvious existence of spatial clusters to the west (spaces *64* to *81*) and northwest (space *82*, *n*, *o*, *p*, *q*) of the Main Building, metric integration analysis was unable to pick centres for these individual buildings (which would typically have low AMD and high STMD values) and as such identify these spaces as spatial clusters. Although future research should elaborate on this issue, as discussed in the methodology section, this phenomenon is likely to be related to the small size of these clusters in relation to the entire spatial system considered for the analysis.

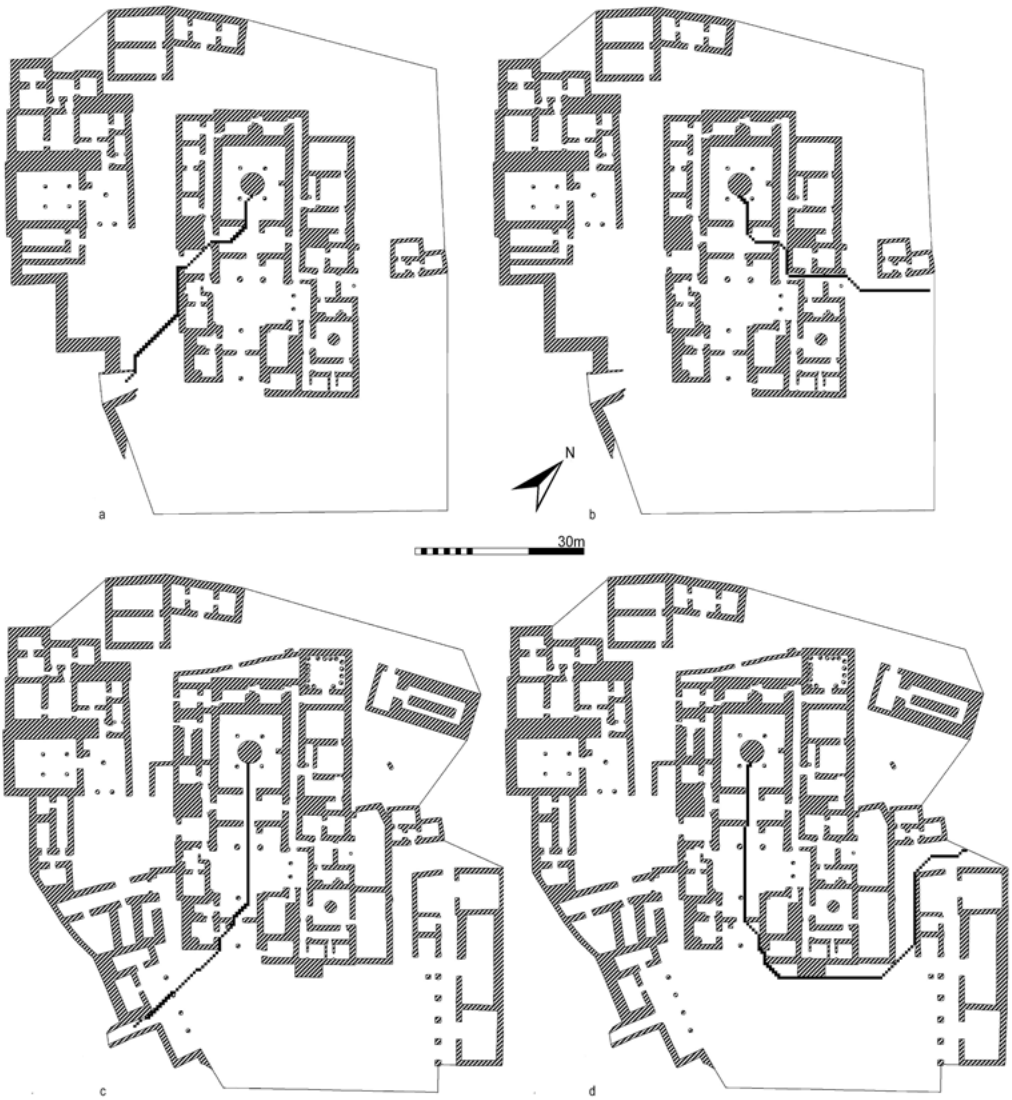

Figure 18 | Pylos, palace a) least-cost path from the southern access point to the throne room in the earlier building state; b) least-cost path from the northeastern access point to the throne room in the earlier building state; c) least-cost path from the southern access point to the throne room in the later building state; d) least-cost path from the northeastern access point to the throne room in the later building state.

and the analysis thus suggested that internal circulation was not restricted in the later state, as advocates of the hypothesis of economic decline assumed,[35] metric analysis can be seen to

35 The lower average visual integration in the later state will be commented on in the subsequent comparative section.

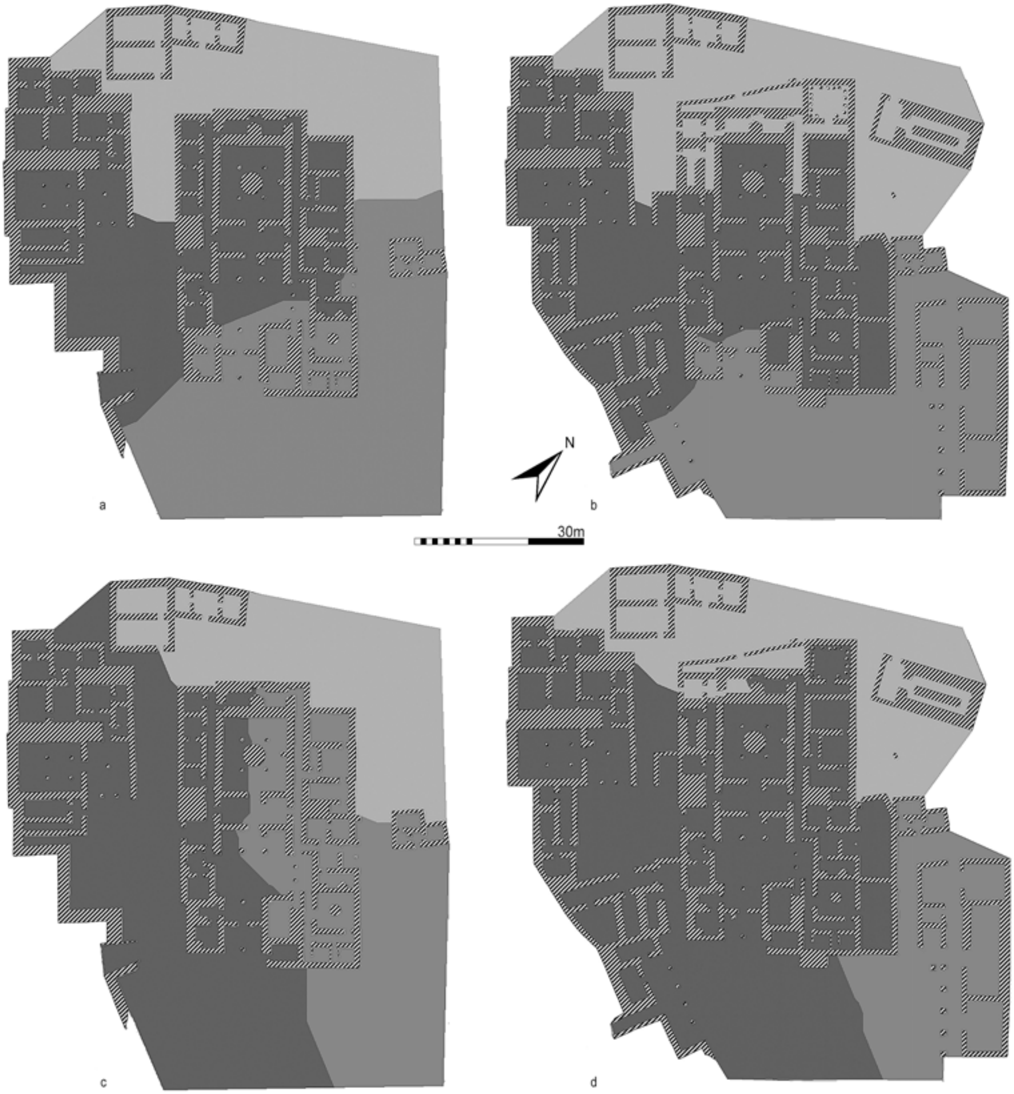

Figure 19 | Pylos, palace a) metric allocation of areas to the main courts in the earlier building state; b) metric allocation of areas to the main courts in the later building state; c) metric allocation of areas to the access points in the earlier building state; d) metric allocation of areas to the access points in the later building state.

contradict the underlying assumptions of the decline hypothesis even more clearly. Since recent studies suggest that the hypothesis also fails to account for a variety of other observations (Bendall 2003, esp. p. 225–226; Thaler 2006), we will not discuss it further here.

Focussing instead on the positive results of the analyses set out above, two keywords may guide a new understanding of changes to the palatial architecture of Pylos, both of which have already occurred in the analytical section: differentiation and channelling. Since it is, ultimately, one aspect among others of functional and social differentiation, we will look at the channelling or focussing of access on specific routes first: official visitors enter the palace through either staircase *a* or space *101* in the later state and can only reach the inner sections via court *58*. Several observations may suggest a further differentiation between those coming to the palace in political or religious matters, on the one hand, and in official economic matters, on the other, although this partly transcends what can be demonstrated analytically: staircase *a*, with which we may associate the former group of visitors and which is the only entrance for which we have clear evidence of monumental elaboration, is oriented towards the propylon and thus directs visitors to the canonical route to the Megaron. Space *101*, by contrast, is closely linked with the Northeastern Building, which most probably functioned as a clearing house and could even be entered from *101* without first entering court *58*; there is also little doubt that space *101* was approached along the same street across the plateau of Ano Englianos as court *w*, the third point of access, which gave access to the economic unit at the back of the palace. While it thus seems plausible that both *101* and *w* provided access for visitors in economic matters, there are, again, also important contrasts: the store-rooms in the economic unit, on the one hand, to which 'tradesman's entrance' *w* gave access were used, as far as we know, to stock wine, oil and pottery, i.e. bulk goods,[36] of which at least a high proportion was destined for consumption within the palace (Whitelaw 2001, p. 54). The Northeastern Building, on the other hand, which was accessed through *101*, presumably dealt in goods to be redistributed – as accords well with its position on the fringes of the palaces, particularly in terms of AMD and STMD –, partly at least more costly goods and, quite importantly, goods closely monitored and recorded in detail by the palace administration. It therefore makes good sense, with regard to *101*, to speak of traffic in official economic matters in order to differentiate it from the delivery of supplies through *w*.

The economic unit itself exemplifies differentiation not only in terms of access, but also internal organization, since it forms an internally coherent subsystem set apart in topological and functional terms from the rest of the palace in a back section of the complex; in metric terms, too, at least a part of the unit is identifiable as isolated from the complex as a whole. It should not need stressing that both the visitors and 'residents' of this area would have been socially distinct from those in other parts of the palace, at least in the roles they fulfilled in specific contexts. Another functional area can be seen in the 'interface zone' focussed on the frontal court *58* and encompassing the remaining two points of access *a* and *101* as well as both the Northeastern Building and the palace archive. This is captured most effectively in the metric allocation of areas to courts (fig. 19a, 19b), which clearly sets

36 The term 'bulk goods' is here used merely to denote goods which arrived or at least were stored and presumably consumed at the palace in large quantities; specifically, nothing is implied as to the status of foodstuffs as staples or otherwise (cf. Palmer 1994, p. 132).

apart both the economic unit and the interface zone from the core of the palace; the latter encompassed all possible and plausible 'halls of state', i.e. throne room *6* as well as rooms *46* and *65*, and was focussed on court *63* as the main integrator of internal circulation in topological and, in conjunction with court *3* and *88*, also in metric terms.

While court *63*, despite this overarching importance for internal circulation, did not fall on any of the main access routes into the palace discussed above, yet another form of socio-spatial differentiation ascribes it a clearly defined place with regard to rights of access, the importance of which for Mycenaean architecture has been rightly stressed in recent years (e.g. Wright 1994, esp. p. 51, 60). While this is only hinted at in formal analyses of the palace's layout such as the ones presented here, it is strongly corroborated by both comparison with the linear court sequence of the highly elaborate palace at Tiryns and the study of Pylian pantry inventories. With reference to both its topological characteristics and the associable drinking vessels (Bendall 2004, p. 112–124; Thaler 2005, p. 332; 2006, p. 98, 105; 2007, p. 302), it occupies a middle position between outer court *58* and an inner area, identified as either the megaron (Bendall 2004, p. 122–123) or the megaron court *3* (Thaler 2006, p. 98), indicating a three-tiered hierarchy of participants in palatial feasts. That corresponding distinctions of rights of access associated with specific courts were also in effect in the everyday use of the palace is not only suggested by comparisons with neighbouring cultures (Thaler 2007, p. 305), but also by the light which the results discussed above relating to both the economic unit and the interface zone shed on the general importance of such distinctions.

After these extensive comments on the later building state, only one thing needs to be stressed with regard to the earlier one: none of the above is apparent in the earlier building state – all of the above results from changes to the palace and its architecture during, roughly, the 13th century, although the possibility should again be noted that, in some instances, social conventions may have anticipated elements that were later embodied architecturally. Unless we assume, as seems possible given the available evidence for the relative recency of the megaron palace as an architectural type (e.g. Maran 2001), that the earlier building state represents a monumentalized version of smaller prototypes such as Mansion 1 at the Menelaion (Catling 2009, p. 23–32), which proved functionally inadequate to the needs of the Pylian polity and had to be modified accordingly, the conclusion seems almost inescapable, as indeed the proponents of the decline hypothesis were right to point out, that these architectural changes reflect political or economic and thus ultimately social changes. Continued territorial expansion of the Pylian polity during the 13th century or a rise in importance of palatial feasts as occasions of the re-constitution of palatial society have been suggested elsewhere as possible explanations (Thaler 2006, p. 107–108), but other hypotheses could certainly be added, and this is not the place to try to settle the issue. However, it may well be helpful to point out a common denominator of both of the above and other plausible scenarios: the spatial differentiation of the palace, e.g. into distinct functional sectors to which different social groups would have had differential access, as well as the channelling of visitors towards specific routes, may well reflect efforts to manage visitors who would have come to and entered the palace or parts of the palace in noticeably larger, rather than smaller, numbers in the later stages of the palace's existence than they previously did.

4.2.2 Comparison of analytical results

Taking a step back again from archaeological interpretation to evaluate how and what specific forms of analysis contribute to it, the first thing that captures our attention is the remarkably close correspondence in the results of several topological and metric analyses: shortest topological routes to the throne room (fig. 10) are virtually identical to least-cost paths determined metrically (fig. 18) and the attribution of areas of control to the main courts, particularly for the later building state, for which it could be meaningfully interpreted, differs little between its topological (fig. 11b) and metric version (fig. 19b), the main difference lying in the latter's ascribing what appears as a 'contested' zone between courts *58* and *63* in the former to court *63* exclusively. This difference, of course, is easily explicable since metric analysis does not allow an in-between position in the way topological maps do, which also explains the more noticeable differences between the topological and metric mapping of primary access: in both cases, entrances *a* and *101* share the control of access to court *58*, but only in the topological perspective does this by necessity mean that they share control of access to areas beyond court *58*.

This could be taken to suggest that topological analysis may provide a 'cost-effective'[37] substitute for metric analysis in some contexts, whereas metric analysis may provide a sharper resolution where ambiguities arise from pure topology; ambiguities in the available data, on the other hand, such as, in the present case, both the exact position of the point of access associated with space *w* and more generally the exact metric dimensions of the hypaethral spaces, may suggest topology as the more robust approach for some archaeological contexts. Alternatively, the different approaches, rather than judging their respective merits for specific contexts, can be taken as complementary perspectives: the topological mapping of primary access for the later building state allows us to appreciate court *58*'s role as an interface, and the metric perspective may reflect the overarching significance of staircase *a* as the main entrance to the palace.

The generally close correspondence as well as the explicability of divergences among these analyses is, of course, contingent upon the fact that the very same phenomena are

37 What is subjectively perceived as 'cost-effective' will to some degree depend, of course, on how well one is personally acquainted with specific approaches as well as the corresponding computer software. Yet the fact that topological analysis is quite feasible in many contexts without the aid of a computer may be considered a more objective criterion here; topological allocation to entrances, for example, requires no other computational 'features' than the ability to count.

approached in very similar manner; therefore, we next need to consider less similar approaches and their results. Here again, there are a number of clear parallels, e.g. with regard to the focussing of access on the canonical route to the throne room between, on the one hand, visual analysis and, on the other, the topological and metric observations discussed above. Another parallel, in this case between topology and metric study, can be seen in the identification of distinct zones, most notably with respect to the absence of such zones in the earlier building state and the presence of the economic unit in the later. Despite not delineating a fully congruent area, but rather a noticeably smaller one than, for example, topological mapping of primary access suggests for the economic unit, metric observations on the peripheral nature of the area of the Wine Magazine, which comprises rooms *104* and *105*, can be seen to capture a corresponding trend in the development of this area of the palace. This confirmation is particularly helpful, since analysis of AMD and STMD values does not, in contrast to both the topological and metric mapping of, for instance, areas of primary control, need to rely on the prior definition or designation of a set of root spaces. In the present case, however, visual analysis in turn provides corroboration of the focus on courts as root spaces. The independence from pre-defined root spaces or comparable categories is especially important in the case of the negative evidence for the earlier building state, which naturally cannot be ascribed to a 'wrong choice' of root spaces where none are used. Topological and metric allocation mapping and their interpretation, on the other hand, do offer a richer and more varied, albeit perhaps more easily disputed picture, as evidenced by the identification of the 'interface zone' in the later state.

While these results can easily be understood as complementary, there is one point in which topological, visual and metric analysis would appear, at first sight at least, to contradict one another, viz. the issue of the overall integration of the palace in the earlier and later building state: topology suggests stability, visual analysis – although there are specific reasons for this which we have discussed – a pronounced loss, and metric analysis an increase in overall integration, at least in contextual terms, i.e. in the form of a wider distribution of relatively highly connected areas. Several observations may help to reconcile these perspectives: the loss of visual integration, although mostly explicable as an effect of the sensitivity of visual integration to surface area, in conjunction with the breaking-up of the earlier undifferentiated ring of large hypaethral spaces, may well be explained as a further aspect of the channelling documented not least in the visual integration map itself; if channelling occurs, the whole complex need not be intelligible for a visitor as a visually integrated system, but only specific routes. Topological or metric integration, on the other hand, should more effectively describe the ease with which those who relied on their knowledge rather than their spontaneous understanding of the architectural context could move within it; maintaining or increasing these could be as important for the efficient functioning of the palace architecture as its growing functional differentiation. Still, the divergence in analytical results between topological and metric integration may need further discussion. The key to this may lie in the fact that, on the one hand, topological analyses in the space syntax tradition conceive of the 'integration' of a building as a normalized measure, thus relying on absolute values for the purpose of inter-building comparison, whereas, on the other hand, the metric analysis outlined in this study uses the relative proportion of raster cells that fall within the core in order to compare 'integration' between buildings, where inclusion in the core is based on a cell's low AMD value in relation to the distribution of AMD values for the individual building. The latter approach is not only valid in its own terms, but certainly also a helpful complement to the way the topological approach conceptualizes integration. However, it may ultimately preclude direct comparison with integration as a normalized topological measure, for which a normalized version of, as it were, an 'average AMD', i.e. an AMD calculated not for specific raster cells, but for the system as a whole, might be needed.[38] But if topological and metric integration should capture, as was suggested for visual integration, different spatial qualities of the system under study, comparative studies of present-day contexts may be necessary to clarify this issue.

5 Future perspectives

As stated at the outset, one of the aims of this study is to contribute to a body of comparative research into the results of topological, visual and metric configurational analyses in archaeology. Taking into account its immediate results, it seems fair to say that it also offers a clear illustration of the need for further comparative work in this vein, if future students of the archaeologically preserved built environment are to make informed methodological choices: in many instances, specific results could not be compared immediately in the form of the data-output of the respective analyses, but only in mediate form, i.e. once an initial interpretation of these results had taken place. While this does offer useful controls to see whether different strands of analysis and argument can support the same interpretations, the more compelling results of parallel analysis may still be seen in those cases where more direct comparisons of results are possible at the data level. Examples of the latter in the present study include the topological and metric definition of shortest paths between two spaces and of allocation of areas to root spaces. Since these, however, have already been commented on in the comparative discussions, merely a short note of encouragement will be added here: since topological allocation, i.e. the mapping of areas of primary control and access, and determination of individual path lengths does not require large computational effort, but hardly more than the ability to count doors, it may form an easily accomplished and – as we hope to have shown above – worthwhile adjunct to any metric study of such properties.

38 Sailer's (2010, p. 132) suggestion to normalize metric distance by division by the square root of the surface area of the system could prove helpful. It should be noted, however, that the metric distances she works with are based on a spatial representation derived from the axial break-up and not the cost-of-passage surface used in this study.

Still, the question remains open how other forms of analysis might be conducted in a way that allows similarly direct comparisons between topological, visual and metric perspectives, and this leads, if we return to the notion of space syntax and GIS research as two distinct traditions in archaeology, to the question of what one might learn from the other. Here, we simply want to highlight one aspect of each which may bear further scrutiny with regard to its high potential utility to the other.

One of the long-established key aspects of space syntax is the conceptualization of integration as a normalized measure which allows for the easy comparability of this decisive spatial characteristic between systems of different sizes and dissimilar layouts. Metric integration study, as outlined here as a new approach within GIS-based archaeological research, approaches the phenomenon of the overall integration of a building in a distinctly different manner by comparing the surface area of its metric integration core, which is based on a statistically defined size class of AMD values, to the surface area of the entire spatial system. As a result it mainly captures the 'distributedness', rather than the 'degree' of integration within a system. While this forms a reliable basis for meaningful interpretations, as we have seen, it could well prove a worthwhile pursuit to complement this approach by the introduction of a normalized measure of integration. If space syntax, however, is to provide the model for this, the as yet unresolved issues concerning different formulae for normalization within space syntax need bearing in mind (cf. section 2.1).

A major strength of GIS methodology and software, on the other hand, is the multiple possibilities for manipulating the primary data.[39] From a statistical point of view, GIS can be used to define a core area of integration on the basis of size classes of integration values. For instance, in the metric study set out here the histogram and standard deviation of AMD value distribution was employed to delineate an integration core. A corresponding approach could offer a more inherently meaningful substitute for the simple 10 % rule applied in determining topological integration cores. Comparison with GIS studies could thus inspire a more statistically-minded space syntax approach. In practical rather than conceptual terms, too, GIS software will, despite the ingenuity and effort of the space syntax community, often offer more effective ways of managing data generated in space syntax software such as Depthmap than the latter can offer itself; following the previous remarks on metric and topological integration cores, the GIS-based derivation of the map of the integration core from VGA data generated in Depthmap would be a promising example.[40]

The possibility of manipulating space syntax data in a GIS environment also leads to a final perspective which we wish to mention, one not concerned with comparison or selective adoption, but with the integration of topological, visual and metric analyses: map-alge-

39 Cf. Gil et al. (2007) for an explanation of the Confeego tool set, which serves as a plug-in for the MapInfo Professional software and was created on the basis of similar premises regarding the benefits of using GIS to further process space syntax results. Cf. also Jiang and Claramunt 2002.

40 While recent versions of Depthmap include more GIS-like features themselves, they also offer the option of exporting data in a GIS format (e.g. MapInfo's *.mif).

bra functionalities in GIS software could be used to create not merely an overlay of maps of different spatial properties, but to merge these into a single representation. Provided that issues of normalization can be solved adequately, incorporating data on convex, visual and metric integration into a meta-mapping of cumulative integration appears the most promising option that springs to mind. As stated at the beginning, however, the availability of an analytical methodology at the press of a button should not be mistaken for the advisability of pushing that button. Rather it presents a reason for methodological reflection, to which we hope to have contributed in this paper from a comparative perspective – a comparative perspective which we consider a necessary precursor to and precondition for even the idea of merging analytical techniques.

Appendix 1
Metric integration analysis: a methodological description

What is referred to as metric integration (or metric) analysis in this study is an original technique anchored in GIS-based[41] cost-distance analysis carried out with raster datasets. Considering absolute distance as a configurational measure is not new and has been highlighted by space syntax theory, which cautioned against its positively misleading character at the 'non-local level' (Hillier and Penn 2004, p. 505–506; Hillier et al. 2007). It is indeed possible within the current set of space syntax techniques to calculate metric integration or metric (mean) step depth values by using a weighted visibility graph (Turner 2004, p. 13), or through segment representation of space (cf. Sailer 2010, p. 70–71, fig. 3–2). The methodological framework of GIS-based metric integration analysis comes particularly close to the first of these space syntax techniques, since both measure metric distances across a surface (i.e. a cost-distance surface) or a pseudo-surface (i.e. a two-dimensional space tessellated into a dense grid) respectively rather than along a line, as segment representation does. Despite these similarities, the GIS-based methodological framework presented here deviates from the weighed visibility graph analysis conducted in Depthmap on three principal points. The primary difference is that a GIS-based metric integration analysis affords a consideration of topographic variability in buildings, i.e. it can be employed to take into account the existence of stairs, ramps etc. Secondly, it enables calculation of varied statistical measures[42] such as those that correspond to space syntax's mean depth (which is referred to as average metric distance [AMD] here) as well as the standard deviation of metric distance values (STMD). Furthermore, metric integration analysis allows for plotting AMD value distributions for spatial systems as a histogram and provides statistical qualities of the

41 The analyses presented here are conducted with the commercial GIS software package ArcGIS 9.2 (ESRI).
42 Regarding spatio-statistical applications, the new statistical tools added to Depthmap software explore statistical avenues similar to the ones presented here (cf. Turner 2007b).

distribution. This particular quality of the GIS-based technique can assist the interpretation process in various ways, including definition of a main integration core in a statistically-informed manner, as illustrated above for the Malia and Pylos cases. And thirdly, although not exemplified in this study, the raster-based modelling in GIS affords modelling attractors in the built environment by assigning low cost-of-passage values to the areas surrounding these attractors.[43]

As for the methodological particularities of the metric integration analysis, the technique is based on a binary conceptualization of the built environment as comprised of two material categories: those that do and those that do not block human movement. The first step in creating such a binary model is to vectorize all features that allow movement (floor surfaces, ramps, stairs etc.). At this stage of the modelling process, it is of capital importance to vectorize inclined (stairs, ramps) and flat surfaces as separate polygons. At a later stage, a column for entering cost-of-passage values for each polygon is created in the attribute table of the spatial database. In this column, each polygon representing an approximately flat surface is assigned '1' as cost-of-passage value, which results in taking cost-distance as equal to the metric distance for these cells. Stairs and ramps, on the other hand, are assigned a value in accordance with their slope. For this study the length of inclined surfaces has been taken as $1/\cos(\alpha)$, where α is the angle of inclination. As such, the cost-of-passage for the inclined surfaces is rendered equal to the length of the inclined surface.[44] The following step performs a 'vector-raster' conversion in order to transfer the digitized polygon features into a raster surface on the basis of the cost-distance values assigned to respective polygons. The newly created raster surface constitutes the cost-of-passage surface used for metric integration analysis (fig. 20a).

In order to calculate AMD and STMD values based on this cost-distance surface, a two-dimensional point cloud is created (fig. 20b), in which each point serves as a source (i.e. starting) point for the cost-distance analysis. This can in fact be compared to the way in which Depthmap software conducts VGA, which is "the analysis of the visual relationships of (potentially humanly occupied) points in space to each other" (see Turner 2007b, p. 45).

Note that a dense point cloud with points located in relative proximity to one another will give more robust results while calculating AMD and STMD values. On the other hand,

43 See also Stahle et al. (2007) for an overview of the Place Syntax plug-in for the GIS software MapInfo, where attractors are also modelled but as part of the axial representation.

44 In this study, the inclination angle for ramps and stairs has been uniformly taken as 30 degrees, which led to the cost-of-passage being calculated as 1.155 at these locations. The reason for using a uniform value for all the inclined surfaces was the limited availability of architectural information with regard to the inclination of these surfaces and number of steps for the stairs. What is more, the direction of movement is not considered in these analyses, as metric distance is inherently isotropic (cf. Conolly and Lake 2006, p. 215). It is acknowledged here that analysing time and energy expenditure while circulating within the architectural systems would be (given that it is human-oriented) a more appropriate approach than analysing the metric distance traversed. At this preliminary stage of metric integration analysis, however, only isotropic metric cost is employed, leaving the use of anisotropic types of costs to future studies.

Figure 20 | Pylos, palace a) the cost-of-passage surface of the earlier building state; b) a two-dimension point cloud overlaid on the cost-of-passage surface of the earlier building state.

such small distances between points will automatically increase the amount of time required to complete the analysis (at least when the analysis is conducted manually rather than with the help of a computer script). For example, for a 60 m^2 spatial system, creating a two-dimensional point cloud with 10 cm intervals will result in 6000 points. If we consider that cost-distance analysis should be conducted for each of these points in order to calculate the AMD and STMD values, we can anticipate how time-consuming such an analysis could potentially be. For the analysis in this paper, Building A features a 1 m-by-1 m and the Palace of Pylos a 4 m-by-4 m point-cloud.[45,46]

After cost-distance analyses have been conducted for each of the point cloud components, the cost-distance rasters are put into the 'Cell Statistics', whereby the average metric distance value for each raster cell location is calculated. The result is a new raster surface

45 One of the future research directions for metric integration analysis is to assess the relationship between the selected point-distance for the point-cloud and the changing accuracy of the results. Preliminary observations revealed that although, to a certain extent, the accuracy of the AMD values keeps on increasing with decreasing point distance, at some point the decrease stops affecting the results. This observation strongly supports the existence of an optimum point-distance to conduct metric integration analysis with. The way in which this optimum value varies with size and shape of the spatial system requires future in-depth study.
46 An easy way to create two-dimensional point clouds is to resample the cost-of-passage surface to a specific raster cell size which is equal to the point-distance decided on. Subsequently a 'Raster to Point' conversion can be applied whereby GIS software creates a set of point features located at the centre of the raster cells. Then each of these points – whose distance to other points is equal to the edge length of the raster cell – can be used as a source point for cost-distance analysis.

which has the AMD values for each cell across the entire spatial system. Similarly, through 'Cell Statistics' a new raster surface can be created which has the STMD values for each raster cell location.

Appendix 2
A note on Akrotiri's West House and upper storeys

In the above, we have limited our comparative study to two sites only, not only in an effort to keep the text at a readable length, but also and more importantly because of our particular familiarity with these two sites and our conviction that familiarity with the archaeological details of the context under study is essential. Ultimately, in our opinion, it outweighs purely methodological competence in its importance for meaningful spatial analyses, although both are undoubtedly necessary preconditions. Still, we undertook further analyses in the preparation of this paper and would briefly like to discuss one of these for the sake of its particular methodological interest: the combined convex and visual analysis[47] of the West House in the early Late Bronze Age settlement of Akrotiri on the island of Thera (Palyvou 2005, p. 46–54).[48] The importance of the West House lies, firstly, in the unusual completeness of its preservation, with not only the ground floor, but also the complete first and parts of the second floor uncovered by archaeological excavations, and, secondly, in the fact that the layout of the ground floor, in most other cases all that is preserved archaeologically, differs radically both from that of the first floor and the building as a whole (cf. Thaler 2002, p. 114).

The former is almost entirely linear – if represented without the carrier space, i.e. the outside of the building, and the staircase to the upper floor, it is indeed nothing but a line of rooms –, whereas the first floor has one central ring and the whole building three non-trivial rings, two of which intersect and one of which connects the ground and first floor (fig. 21). The most integrated space of the ground floor seen by itself is, obviously, the middle of the line, room *4–1*, with an integration value of 0.73, whereas the integration value of 0.38 for the carrier space and thus the integration of the building with the outside is well below the average of 0.49 and even close to the minimum integration of 0.31. For the first floor, which has a noticeably higher overall integration of 0.65, the maximum of integration is the value of 0.91 for room 5–2, where the ring connects with a tree-like element, while again, the integration of the carrier at 0.39 is clearly below average and indeed does

47 The absolute values given in this appendix result from a convex analysis conducted 'manually', i.e. without the help of Depthmap or other specific space syntax software. All values are calculated for the system inclusive of its carrier space, but the designation as most integrated space relies on an alternative calculation without the carrier space where the primary analysis does not yield an unambiguous result. VGA was conducted, as in the other case studies, using Depthmap 8.15.00c.
48 The plans reproduced use Palyvou (2005, p. 47 fig. 46) as a reference.

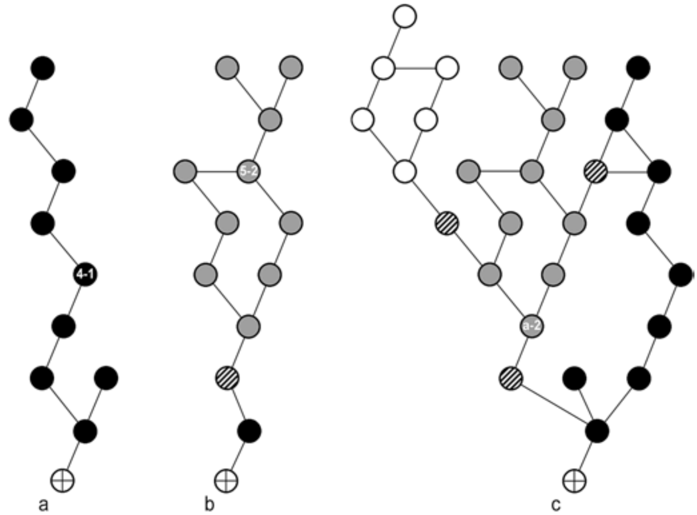

Figure 21 | Akrotiri, West House: a) j-graph of ground floor with ground floor spaces indicated in solid black and the carrier space by a cross; b) j-graph of first floor with ground floor spaces indicated in solid black, first floor by grey fill, stairs by hatching and the carrier space by a cross; c) j-graph of entire building including reconstructed second floor with ground floor spaces indicated in solid black, first floor by grey fill, second floor by white fill, stairs by hatching and the carrier space by a cross.

represent minimum integration. For the building as a whole, however, due to the frontal position of the main staircase, the integration value of 0.56 for the carrier, while still below the average of 0.63, no longer represents one of the lowest values, and the most integrated space at 1.01 is now a flight of the main staircase, *a-2*, i.e. a transitional rather than a use space. Representations of visual integration (fig. 22) confirm these observations, although they also demonstrate that in the total system room *5–2* of the first floor retains its integrative importance. If the visual integration maps for the ground and first floor are set to a common colour scheme, the segregative nature of the former's linear structure becomes yet more clearly visible.

Do these drastic discrepancies between different analyses of the same building or parts thereof mean that computer-aided and more generally formal configurational analyses face problems which should caution against their use in archaeological contexts? Perhaps not entirely surprisingly, we do not think that caution in and towards the use of such analyses should go so far as to refrain from their use entirely. Two main reasons can be given for this position: firstly and quite simply, the problem does not lie in the applied methodology, but in the incompleteness of the archaeological record. Every understanding of the archaeological past which we formulate is based on partial evidence, and the evidence does not become less partial if we discard any particular methodological tool. That formal analyses such as those presented here might in principle even provide a means to approach the problem of incomplete preservation is indicated by Romanou's (2007) study of Maliote architecture. Secondly, and more importantly, the question whether the partial plans we have available for analysis represent meaningful subsystems within a lost overall plan is worth considering. For many buildings – the palace of Pylos being a point in case – the assumption that the upper floor or floors would have been less accessible to visitors provides a plausible, though

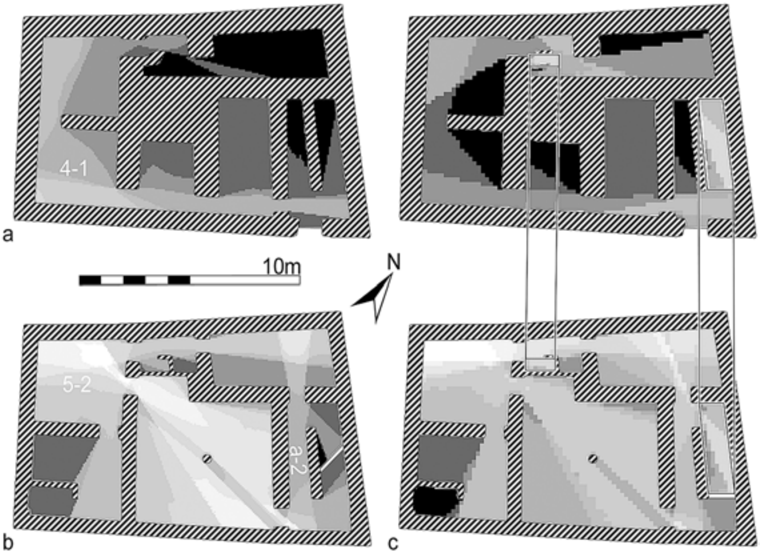

Figure 22 | Akrotiri, West House: a) plan of ground floor with visual integration indicated by shading (lighter shading denotes higher integration, set to the same range of shades as b); b) plan of first floor with visual integration indicated by shading (lighter shading denotes higher integration, set to the same range of shades as a); c) plan of ground floor and first floor with visual integration calculated for both in conjunction indicated by shading (lighter shading denotes higher integration).

ultimately unprovable, reason to accept this premise. In the specific case of the West House, *in situ* finds indicate that the ground floor housed storerooms and workspaces only, whereas the living quarters were upstairs (Palyvou 2005, p. 46–54); this means, although we would obviously miss a lot of information on Akrotirian domestic architecture if the upper floor had not been preserved, that the ground floor does indeed represent a meaningful subsystem. The most important point to be learnt from this is, in our view, that formal configurational analysis will rarely if ever achieve useful results in archaeology if we cannot integrate it with other information, such as the installations and movable finds recovered in the West House. Familiarity with archaeological detail, as stated at the beginning of this appendix, is essential.

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