Proceedings of the Ninth International Space Syntax Symposium
Edited by Y O Kim, H T Park and K W Seo, Seoul: Sejong University, 2013

THE CITY, WHEN IT TREMBLES:

Earthquake destructions, post-earthquake reconstructions and grid configuration

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Abstract

Two different (yet tightly connected and complementary) wide issues appear to crisscross in this research. The first one is the general question of urban resilience, assumed in its relational meaning: the capacity of an urban system, thanks to the features of its spatial elements, to take abruptly imposed transformations, without significantly changing their mutual relations and hence the whole urban geography: and the transformation imposed by an earthquake (its destruction as well as the successive reconstruction) are undoubtedly sudden and abrupt. A discussion will hence be aimed at determining some configurational parameters, suitable for reproducing the capability of a spatial system to sustain sudden changes and yet to retain its inner working mechanisms.

The second theme more specifically concerns the matter of earthquakes, and will here be aimed at investigating the effect of a seismic event on the inner geography of an urban settlement, thus verifying on several case studies the effects of an earthquake as well as the reliability of space syntax to describe their actual resilience.

Summing all up, this paper aims at pinpointing the configurational features, if any, suitable for reproducing and accounting for the level of resilience a settlement is provided with, and - afterwards - at testing them on urban cases actually affected by earthquake destructions.

The main case study here assumed is the settlement of L'Aquila, in Italy, with reference to the devastating earthquake of April, 6th 2009. The configuration analysis has been applied to the spatial consistencies respectively referred to three distinct phases:

- *before the earthquake;*
- *soon after the earthquake (temporary, but still present situation);*
- *after the earthquake, definitive (yet distant to come) situation, including the forthcoming reconstruction of the perished areas and the new development areas (at L'Aquila, the so-called 'CASE' project).*

Some significant outcome can be drawn. First, this approach allows highlighting the dramatic transformation an earthquake, like other natural disasters, is likely to cause to the inner geography of a settlement, upsetting the distribution of movement flows and the levels of attractiveness and centrality. Even more, the configurational analysis will reveal the likely effects the reconstruction and rehabilitation plans and projects on the variables of the urban system, over and above the fulfilment of recovery claim and the housing supplying. More in general, it will report the far-reaching and long-lasting relevance of urban plans worked out in emergency situation, under the pressure of need and urgency. On such basis, the method is here proposed as a suitable tool for supporting and orienting the temporary (yet often enduring) post-earthquake phase as well as the successive reconstruction planning.

Keywords: *grid configuration, town planning, centrality, earthquake, reconstruction*

Theme: *Urban Space and Social, Economic and Cultural Phenomena*

Introduction

Space Syntax deals with urban space, in that it assumes the grid of its paths as the primary element in determining the patterns of human behaviour and, through them, the inner geography of an urban settlement. Each transformation of the urban grid, each renovation work on streets and squares as well as on the blocks and buildings that materially perimeter and define them, involves a likely effect on the geography of the settlement and on the making of urban phenomena, both at global and local scale. On this regard, space syntax provides the tools for comprehending and predicting such effects.

Also earthquakes, in a different, dramatic way, actually deal with urban space, in that the destructions they generally cause (in the most devastating, unfortunately not infrequent, cases) and the urban reconstruction they successively impose go as far as upsetting the consistency of urban settlements, determining some relevant transformation of their inner geography. What suggests Space Syntax as a unique tool for investigating on the change earthquakes and reconstructions actually involve.

The seismic event can in fact be assumed as a sudden and sharp interruption in the continuous development of an urban organism, what goes up to disrupt its current dynamics and to modify its spatial consistency and its inner geography. Moreover, the reconstruction and redevelopment it urgently imposes, as well as the immediate and heavy need of buildings and houses, make incisive development choices necessary and compelling. In order to interpreter and evaluate them, the use of Space Syntax is therefore suggested as a suitable tool to pinpoint this pivotal interruption: aimed at comparing the distribution of the configurational parameters before the earthquake and after it, and, even more, at revealing and comprehending the effects of reconstruction and development plans.

A seismic event (like any other natural disaster) does hence introduce three different themes, referred to different temporal phases: before the earthquake, investigating around the capability of the urban system to adsorb any possible abrupt transformation; soon after the earthquake, observing the effects of the material destructions on the grid configuration; after the earthquake, analysing the likely effects of reconstruction plans and projects on the inner geography of the settlement. And those three phases will be the main focus of this research.

Summing all up, this paper aims at pinpointing the configurational features, if any, suitable for reproducing and accounting for the level of resilience a settlement is provided with, and - afterwards - at testing them on urban cases actually affected by earthquake destructions.

On closer inspection, in fact, two different (yet tightly connected and complementary) wide issues appear hence to crisscross in this research. The first one is the general question of urban resilience, that hereinafter will be assumed in its relational meaning: the capacity of an urban system, thanks to the features of its spatial elements, to take abruptly imposed transformations, without significantly changing their mutual relations and hence the whole urban geography: and the transformation imposed by an earthquake (its destruction as well as the successive reconstruction) are undoubtedly sudden and abrupt. A discussion will hence be aimed at determining some configurational parameters, suitable for reproducing the capability of a spatial system to sustain sudden changes and yet to retain its inner working mechanisms.

The second theme more specifically concerns the matter of earthquakes, and will here be aimed at investigating the effect of a seismic event on the inner geography of an urban settlement, thus verifying on several case studies the effects of an earthquake as well as the reliability of space syntax to describe their actual resilience.

Perturbations and urban resilience

A wide amount of studies so far have gone applying the configurational approach to the analysis of urban transformations, so as to develop and exhaustively test and validate the space syntax techniques as a tool for enhancing a deep comprehension of urban settlements as well as a decision making support tool.

The vast majority of those researches are mainly focused on two different issues: on the one hand, the analysis of the genesis of urban settlements, aimed at investigating and understanding the mechanism of their growth and diachronic development; on the other hand, the analysis of urban development plans and projects, aimed at pinpointing their likely effect on several material and immaterial variables. Both those lines of research are based on the assumption of a primary role of the grid configuration in the making of urban phenomena (Hillier, Hanson, 1984; Hillier, 1996) and supported by the evidence of a remarkable correspondence of configurational indices with some fundamental aspects of urban working, primarily the distribution of movement (Hillier et al. 1993; Hillier, Iida, 2005) and centrality (Hillier, 2000; Hillier, 2009).

The matter here concerned is somehow different, and actually scarcely investigated: to observe the effects of the abrupt, short duration and traumatic natural event represented by an earthquake, that suddenly upset the material consistency of a city for the transitory (yet actually not brief) period necessary for the reconstruction. Obviously such effects depend on the actual and specific extent of the destructions, which varies case by case and hence can hardly be reduced into categories and typologies. But it also depends on the capability of the urban system, thanks to its own spatial features, to take and adsorb those transformations without radically (or even significantly) changing its inner geography: what evokes the matter of urban resilience.

The theme of urban resilience in front of natural disasters has been widely discussed with reference to the capability of a city to hang over them, mainly retaining the efficiency of its plants and infrastructures (Jha et al. 2013) as well as its social wholeness and cohesiveness (Paton, Johnston, 2006; Pelling, 2003). But even if appraised as a spatial feature, depending on the geometry and configuration of the street network, still the matter of urban resilience is not really a virgin field: on such path, some relevant recent studies have gone discussing the role of the urban grid on vulnerability in case of disasters (Gil, Steinbach, 2008; Muhareb, 2009; Muhareb, 2011), as well as the possible use of configurational indices so as to indicate and reproduce the level of resilience, even with specific reference to the seismic risk (Sarı, Kubat, 2011). Nonetheless, such researches actually focus on resilience as a matter of efficiency of the street network and its performance in the immediate post-perturbation phase, with particular reference to urban accessibility and evacuation.

The target of the present research is therefore quite different. This discussion will rather focus on network resilience, investigating on the spatial features, if any, that can assure an urban settlement a relevant capability of sustaining disruptions and local alterations of the grid with limited changes on its global behaviour. The importance of this spatial property should not be overlooked: since urban land uses are so narrowly correlated with the grid configuration, any transformation of the grid may modify the precondition for the activities location and efficient working, thus bringing into question their durable staying and the whole urban geography as well.

Therefore, taking for granted the primary role of grid configuration in the making of urban phenomena, the investigation will then focus on the search for the configurational parameters that can reliably reproduce such a precious quality.

It can be argued that a relevant element of the resilience of a settlement is the richness in different paths connecting each other all its parts, so that a local transformation (for instance, the removal of some connections) will leave a wide choice of paths from any origin to any destination, hence not significantly modifying the relational (and then configurational) state of the system. The crucial importance the redundancy of connections assumes in workable cities has been sharply stressed, comparing (Salingaros, 2005) urban networks to the brain (Fischler, Firschein, 1987), which can still work, even if, for different causes, missing some connections: this is precisely what it means resilience. In order to favour a better understanding of the matter, let us consider the two different grids of figure 1 and suppose the interruption of a single line, in both cases centrally located. This variation will determine some effect on the relations between all the other lines, thus modifying the global configurational state of the system: it's easy to notice that such variation, dramatic in the first case, is hardly perceivable in the second grid, which hence appears having steadily adsorbed the change.

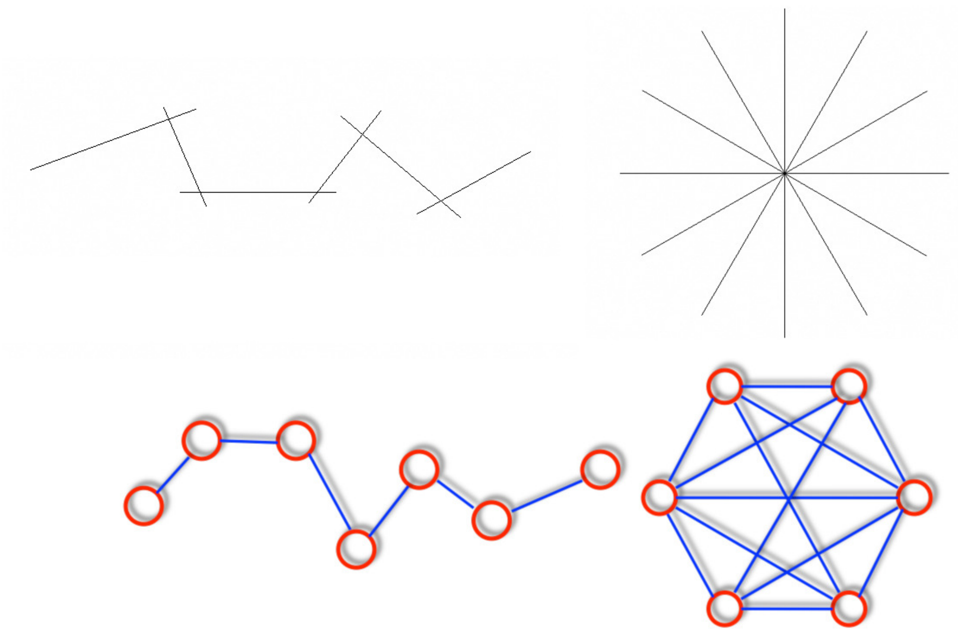

Figure 1 The extreme cases: a tenial grid and a star-shaped one

On such regards, two kinds of spatial system can easily be assumed as paradigmatic, in that respectively represent extreme cases: a tenial grid, where each line is chain connected only to the preceding line and to the successive one, and a star-shaped grid, where each line is connected to all the others. The tenial grid is obviously the less resilience case, in that every path (from any origin to any destination) is actually strictly obliged, and hence each local transformation will involve the whole upset of the settlement, since up to its destruction as a connected system: any line interruption, in fact, will prevent the connection between couples of other lines. On the contrary, the star-shaped grid is the most resilient system, since the paths between the elements, and hence the configurational state of the grid, won't be modified by any transformation: any interruption, in fact, will regard only the interrupted line, leaving unchanged all the other connections. If, then, the richness in alternate paths is the key element of spatial resilience, such a feature can be reproduced by the mean connectivity value of the grid, assuming a low value standing for the frequent presence of obliged paths between the elements. Of course, connectivity is a local index, in that its value is computed taking into account only the lines that surround (and are actually connected to) the considered one. All the same, the mean value of connectivity, calculated with reference to all the lines, all over the grid, can be assumed as a global feature of the whole system, so as to reproduce the density and the variety of paths connecting each line to all the others of the axial map. Should a line (and then a path) be interrupted, a high mean value of connectivity would guarantee a dense presence of alternative paths. Being n the number of the lines of the system, the range of CM values is obviously included between 2(n-1)/n, rapidly approaching 2 as the axial map grows (the tenial grid case), and n-1, indefinitely growing with the dimension of the grid (the star-shaped case). Summing all up, the connectivity mean value is here proposed as a basic index of urban resilience: it is expected to vary from 2 to n, thus reproducing the capability of the urban system to resist and absorb a material transformation of the grid without significantly modifying its relational state; or, in other words, its capability to adapt its movement pattern to the different spatial layout.

Basing on the assumption that resilience, roughly speaking, is a matter of diffused richness in alternative paths from any origin to any destination, its value could be somehow reproduced by the level of distribution of the shortest paths: being resilient the systems that are provided with a diffused presence of shortest paths all over the grid, and, on the contrary, vulnerable (that is less resilient) those that are characterized by a dense concentration of shortest paths through a limited number of spatial elements. In order to take such aspect into account, another indicator of resilience could be the ratio of the highest choice value and the maximum frequency a line could present, what would occur if it were located on all the shortest paths between any couple of the other lines of the system. If we consider an axial map of n lines, it can be shown that the total amount of the shortest paths (excluding the observed line, thus assumed just as a possible intermediate element) is

$$k = n^2/2 - 3/2\ n + 1$$

then the proposed index would be

$$v = choice_{max}/k$$

Of course the proposed index will vary from 0 to 1, increasing as the resilience of the system decreases. If a line is located on all the shortest paths connecting all the other couples of lines (what makes v = 1), the system results vulnerable to its highest degree, in that each of its paths will depend on that single line.

The idea that urban resilience somehow depends on the capacity of the whole spatial system to take and adsorb local perturbations suggests to consider a further configurational parameter, that is the strength of the correlation between the distribution of integration values at different scales (local versus global). In fact, since integration value was proved suitable for reproducing the distribution of urban centrality at different values of radius, a narrow correspondence of global and local integration can be assumed as a clue of steadiness of the spatial system: in such case, any perturbation (such as a street interruption) will hence be expected not to significantly modify the local distribution of accessibility, as strongly anchored to its global pattern. On the contrary, a punctual transformation of a scarcely correlated system will be likely to cause significant changes in the local configurational state.

In other words, the determination coefficient R2 of the correlation radius 3 versus radius n integration, obviously varying from 0 to 1, appears suitable for indicating resilience and vulnerability. Such parameter and the two presented above, taken together, are therefore proposed as a tangible clue – if not even an indicator – of the resilience of the urban system.

It's worth noticing that the assumption of such variables does, at least to a certain extent, correspond to (and support) the findings of previous studies (Sarı, Kubat, 2011), which suggested and tested connectivity, integration and choice as indicator of resilience/vulnerability with reference to access to and evacuation from urban disaster areas.

A suitable example to be taken as a paradigm of spatial vulnerability is the labyrinth, that collapses as a single line is interrupted; on the other side, we assume as a conceptual paradigm of resilience a sort of urban panopticon, in which each spatial element is in visual connection with every other, partially materialized by the Renaissance fortress-city of Palmanova, whose settlement provides a large amount of direct visual connections (and hence alternative paths) between any couple of urban locations (fig. 2). The distribution of global integration values in the axial maps is here represented in figure 3.

As it is shown in table 1, the values the three indices proposed above appear to support and justify those assumptions.

Figure 2 Two paradigms of resilience: the labyrinth and Palmanova

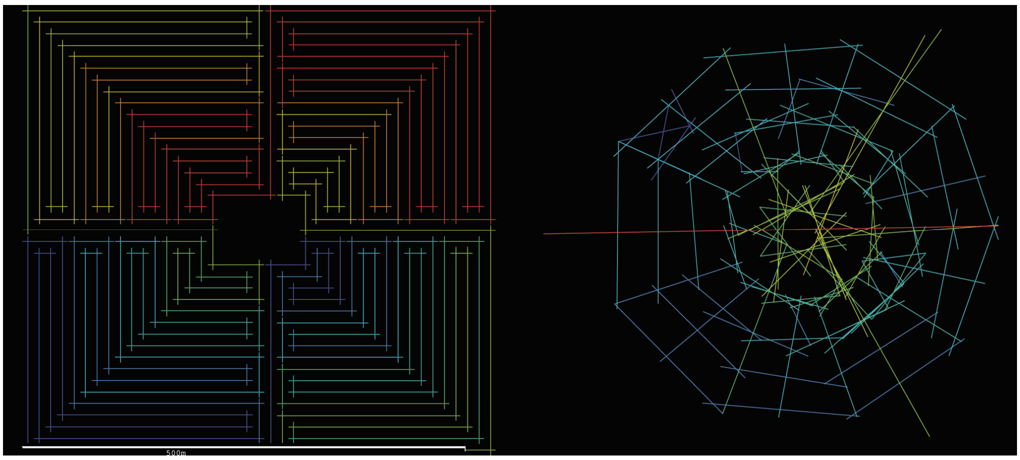

Figure 3 The distribution of integration values in the axial maps of the labyrinth (left) and Palmanova (right)

Table 1 Configurational resilience values of the paradigm cases

	labyrinth	Palmanova
mean connectivity value	1.99	12.85
$choice_{max}/k$	1.00	0.20
R3 int. vs. Rn int. R^2	0.04	0.93

Two Italian well known urban settlements can be taken as ideal case studies to apply and exemplify the application of those parameters: Pisa and Venice appear quite similar with reference to their respective dimension (around 100,000 inhabitants) as well as radically different for what concerns any geometric and morphologic aspect: Pisa derives from the radial development of an ancient inner core, while Venice is the result of the dense urbanization of several small islands scattered in the Venetian lagoon. Apart from that, a singular aspect appears to be shared by the two cities: the presence of a river (the river Arno in Pisa, the Canal Grande – not really a river, to be honest, but a sea watercourse - in Venice), in both cases crossed by four bridges. The processing of the axial maps of Pisa and Venice provides results that, with reference to the matter above, are summed up in the table below.

Table 2 Configurational resilience values of Pisa and Venice

	Pisa	Venice
mean connectivity value	6.46	2.71
$choice_{max}/k$	0.26	0.44
R3 int. vs. Rn int. R^2	0.63	0.05

On the basis of such values, it can be stressed that the relational state of Pisa is expected by far more resilient than Venice, and hence much steadier if subjected to any local transformation. In order to verify such prevision and to materialize this feature, an easy example can be briefly discussed. If we consider the distribution of integration values in the respective axial maps (fig. 4, on the left), in both cases the main integrator can be identified as coincident with the main urban bridge (the Ponte di Mezzo in Pisa, the Ponte di Rialto in Venice).

Let's now suppose to locally modify those settlements and to build a new (the fifth) bridge, simply adding a single line to the respective axial map, in both cases located close to that main integrator, as it is shown in figure 5. The resulting distribution of integration (fig. 4, on the right) and its comparison with the existing one confirm any expectation and highlight the outstanding difference between the two observed cases: while the configurational state of Pisa remains actually unchanged, the position of the integration core of Venice appears definitely shifted southbound, so as to radically transform the grid configuration. It can hence be stated that Pisa is much more resilient than Venice, or, inversely, that Venice is much more vulnerable: what the values of the proposed configurational parameters made to expect. Actually, the spatial system of Venice is more resilient than it appears (both in the proposed parameters and in our simulation), thanks to the presence of a dense network of invisible connections on water (by *gondola*, by *traghetto*, by boat), that provides an amount of flexible path options: what configurational analysis cannot appraise. But this is quite another question, not to be discussed here.

If, then, space syntax can be usefully applied in order to evaluate the actual resilience of an urban settlement and its capability of retaining – at least to a certain extent - its inner geography despite seismic destructions, the effects of an earthquake involve a further question, that is the strategy of the successive urban reconstruction. And here, despite any obvious difference, due to the specific amount of buildings destructions, it is possible and also interesting to propose a rough (yet not irrelevant) distinction, referred to the philosophy and the actual purpose of the reconstruction: in other words, and in general, any urban intervention can be referred to the explicit purpose of a punctual rebuilding of the perished parts of the settlement, or to the (expressed or just implicit, or even hidden) idea of some transformation of its inner geography. In many cases, in fact, post-earthquake reconstructions were the occasions for working out different development strategies, taking advantage of the interruption of urban dynamics due to the seismic event, of a condition of urgency and need and, in many cases, also of extraordinary housing funds. On such regard, space syntax can make to emerge the intimate meaning of the intervention and to reveal the implicit strategy of any urban reconstruction, comparing the pre- and post-earthquake configurational state of the settlement.

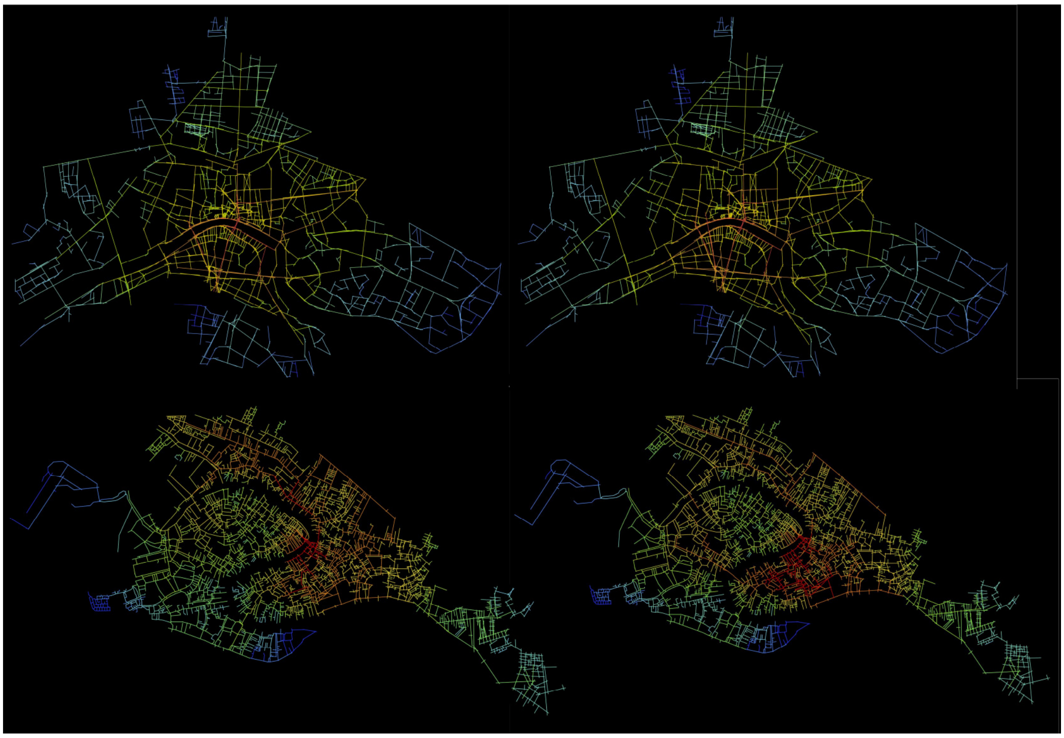

Figure 4 Distribution of integration in Pisa (above) and Venice (below), before (left) and after (right) the new bridge

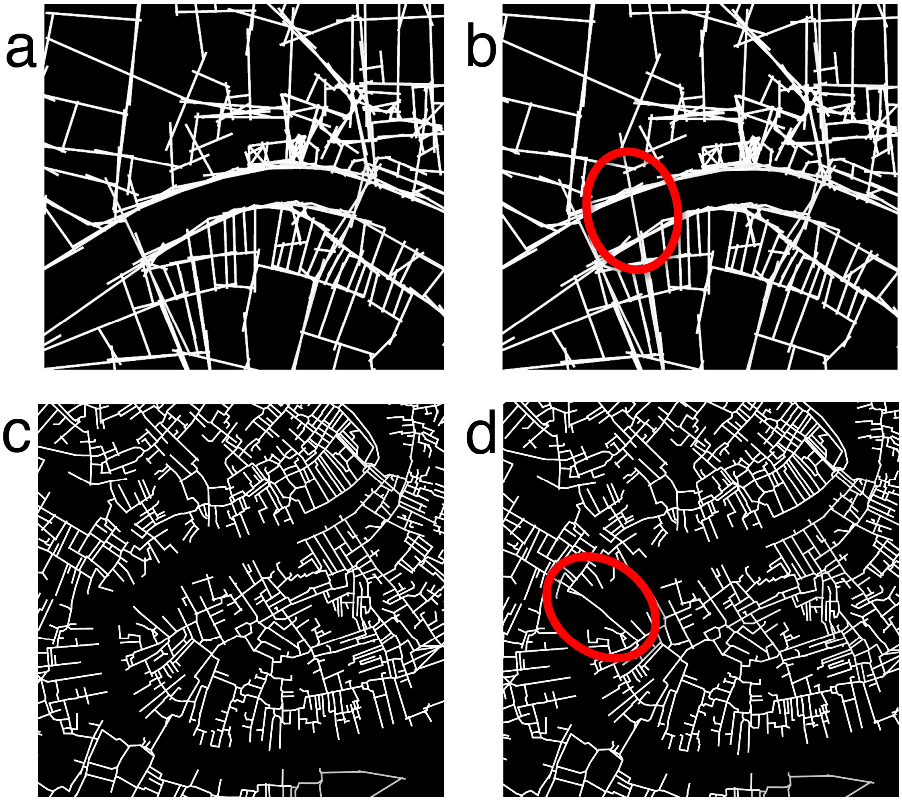

Figure 5 Addition of the fifth bridge, circled in red, to the axial map of Pisa (above) and Venice (below); on the left, the present situation

Urban resilience and earthquakes

Moving from resilience, as potential capability of resisting material perturbations, to the actual perturbation of a strong earthquake, the urban settlement of L'Aquila can be assumed as a highly significant case study for the discussion of the assumptions above. L'Aquila will here be observed with reference to the devastating earthquake (6.3 Richter grade) that heavily run over its urban area on April, 6th 2009, causing death (over 300 persons) and serious destruction on a wide region around.

The configuration analysis has been applied to the spatial consistencies respectively referred to the two distinct phases:

- before the earthquake, and hence coinciding with the urban consistency at the dawn of April 6th, 2009;

- soon after the earthquake, since those dramatic 38 seconds up to the present days: as it can be seen, it's a temporary situation, yet destined to persist through the years, so as to likely determine long-lasting effects on the inner geography of the settlement.

In the following, a further urban settlement will be observed by configuration analysis, that is the consistency of L'Aquila after the earthquake, definitive (yet distant to come) situation, including the forthcoming reconstruction of the perished areas and the development of new housing areas (at L'Aquila, the so-called 'C.A.S.E.' project), as they can be seen in the plans and projects so far worked out.

The distribution of the main configurational indices of the axial map of L'Aquila, as they result from the processing of its grid by Depthman software, is here represented in figure 6; the clear presence of a main orthogonal structure in the inner core of the city, consisting of the crossing of the two axis Corso Vittorio Emanuele II (approximately north-south) and Corso Umberto I (east-west) that respectively trace the cardus and the decumanus of the ancient Roman settlement, appears to strongly characterize the geography of L'Aquila, so as to stand as its integration core as well as its choice core. On the other hand, such evidence appears perfectly correspondent to the actual functional state of the settlement, since those main axes, respectively north-south and east-west oriented, are by far the most crowded with any kind of uses and economic activities.

Going back to the matter of resilience so far discussed, and with reference to the parameters proposed above, their values are here summed up in table 3, so as to attest the grid of L'Aquila as characterized by remarkable qualities of resilience. On April 6th, 2019 this supposed resilience was to be put on probation by a devastating earthquake.

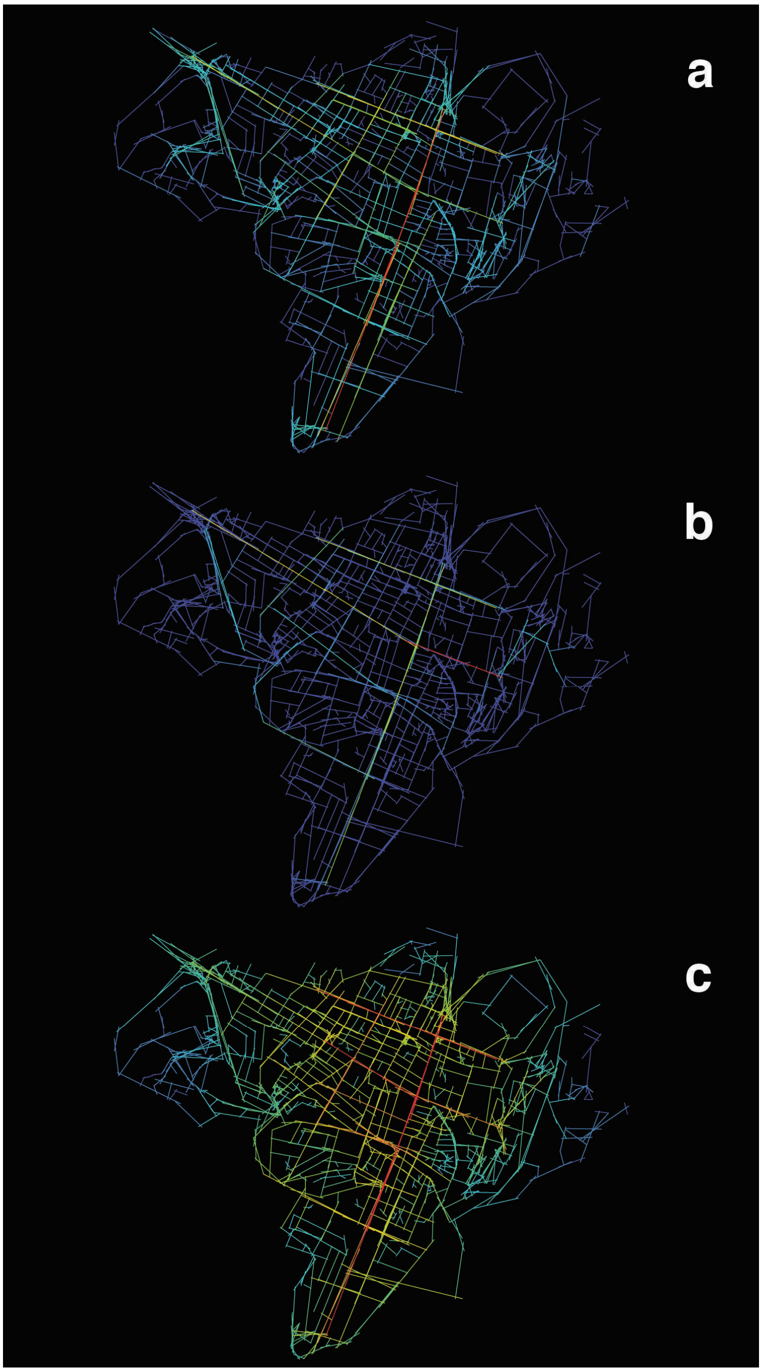

Figure 6 The distribution of connectivity (a), choice (b) and global integration (c) values in the axial map of L'Aquila, before the earthquake of April 6th, 2009

Table 3 Configurational resilience values of L'Aquila

	L'Aquila
mean connectivity value	8.95
$choice_{max}/k$	0.28
R3 int. vs. Rn int. R^2	0.72

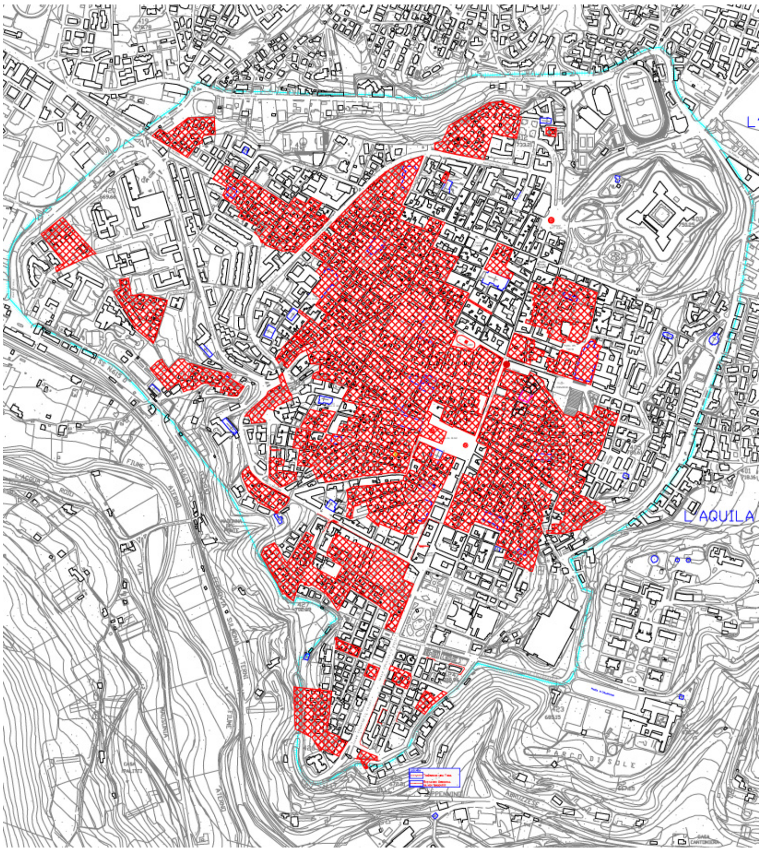

Figure 7 The 'red zone' of L'Aquila, declared off-limits and closed to access since May 2009

The mole of the disaster occurred in the earthquake can be easily expressed by some rough numbers: over 15,000 buildings destroyed or seriously damaged, over 75 % of the buildings within the historic core of L'Aquila declared unsafe and not usable, as well as the entire area within the ancient town walls. But, even more than any number, a map of the city of L'Aquila provides a clear view of what happened in those 38 seconds: in figure 7, the so-called 'red zone' identifies and perimeter the extension (around 1,600,000 m^2) of the urban area that, after few weeks and some light works of buildings restoration, was declared off limits and severely closed to access, due to the destructions of April 2009 as well as to persisting risks of crashes.

In March 2013, almost 4 years after the earthquake, still a large parte of that area (over 10,000 economic activities, as well as houses, streets and squares) remains included in the red zone and hence actually taken away from any kind of urban life.

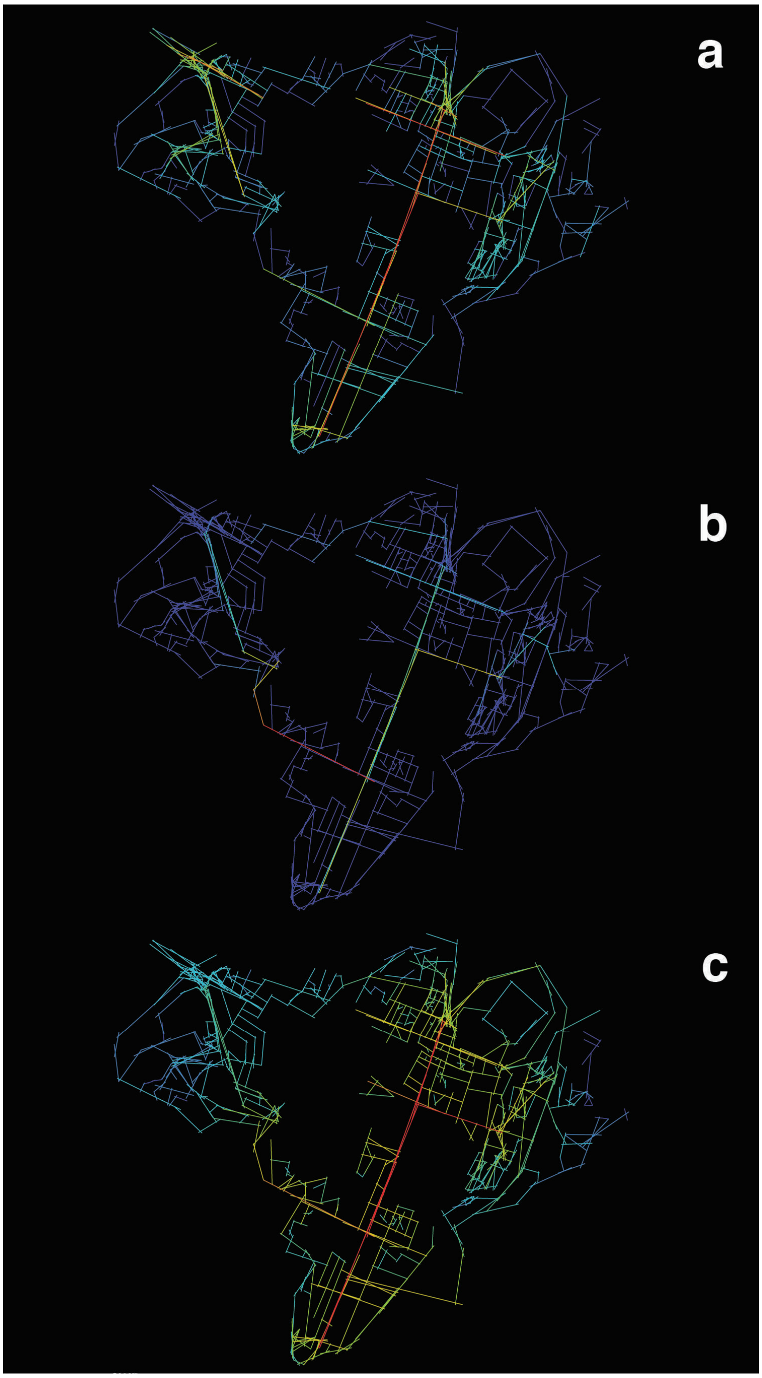

Figure 8 The distribution of connectivity (a), choice (b) and global integration (c) values in the axial map of L'Aquila, soon after the earthquake of April 6th, 2009 and up to the present days

The description above highlights the deep gap an earthquake can determine in the urban dynamics, so as to identify and separate an ante and a post situation; the differences, which can be observed by a configurational approach, obviously depend on the actual amount of the destructions. At a later stage, a further aspect will be the situation after the reconstruction, whose features can be conversely connected to some recurring tendencies.

The essential element suitable for identifying and discriminating any post-earthquake intervention can be found in its actual purpose; on such regard, in front of ruins and destructions, taking for granted the immediate and urgent need of new buildings, three orientations appear recurring.

- On the first side, the reconstruction assumed as a new urban construction, aimed at building a new settlement, detached (or even far) from the existing one (generally in a safer position), which remains in ruins and often gets abandoned; the several Baroque cities (Noto, Ragusa, Avola, etc.) (Tobriner, 1982) which were built after the earthquake that run over eastern Sicily in 1693 represent a suitable example of this orientation.

- On the second side, the reconstruction assumed as a calligraphic rebuilding of the pre-existing city, in order to make it to resurge in its original state; in this case, the abrupt interruption the earthquake has imposed to the urban dynamics is assumed as a tragic break, to be closed and overtaken as soon as possible, going back to the previous consistency.

- On the third side, the reconstruction assumed as an opportunity for providing (and complying to) new and different development directions, thus assuming the tragic event of the earthquake as an occasion to modify the urban dynamics so far, in many cases exploiting extraordinary financial funds as well as the possibility of radical and expedited decisions the urgency actually imposes.

Setting aside the first orientation, which actually does not differ from the general theme of the new towns, in the other cases a configurational approach can reveal and make to emerge the purpose of the plan and to predict its likely effect on urban geography. On such regard, some examples among the many others can be drawn out of centuries of disastrous earthquakes, so clear and significant as to be assumed as paradigmatic. On the side of the calligraphic rebuilding of the pre-existing urban grid, an archetype can be found in the case of San Francisco, razed by a catastrophic earthquake in 1906: the city was rebuilt according to an urban reconstruction plan aimed at narrowly tracing its preceding structure and morphology (Godfrey, 1997), with only slight alterations to alignments and blocks (apart from a relevant increase of residential density (Siodla, 2012)). A similar orientation characterizes the more recent reconstruction of the Italian cities (Gemona, Venzone) destroyed by the earthquake that upset Friuli in 1976, where also the three-dimensional features of the settlements were confirmed (Nimis, 1988). On the other side - the side of urban reconstruction as urban transformation – we can gather a wide collection of cases, since the effects of any natural disaster can be exploited as an infrequent opportunity to modify urban environments. Among the many others, the cases of Lisbon and Messina, after some of the most catastrophic earthquakes ever, appear exemplar: on the ruins of the terrible earthquake of 1755, the reconstructed city of Lisbon appears a completely different urban settlement (Dynes, 1997), characterized by an orthogonal grid of wide and straight streets which was superimposed to the pre-existent irregular mesh of narrow and tortuous paths (Heitor et al., 1999); in Messina and Reggio Calabria, both destroyed in 1908 by a devastating earthquake, which caused over 120,000 deaths, the post-earthquake reconstruction was assumed as an opportunity for the urban development towards the sea-front (Valtieri, 2008), what radically changed the respective inner geography (Passalacqua, 2007).

Assuming those few examples as useful references, we may then observe the urban reconstruction that at present is still ongoing, with many difficulties, at L'Aquila. Here two conditions were to be assumed as binding: on the one hand, the relevance of the architectural heritage within the town walls, imposing to preserve the ex-ante consistency of the ancient historic core; on the other hand, the need of houses for the thousands (over 40,000) evacuated people, mostly from the inner core of L'Aquila. A further problem derives from the necessity of restoring so many and prominent ancient buildings, what involves difficulties, additional costs, delays and lengthening of the rehabilitation and reconstruction works. On the basis of the conditions above, the reconstruction strategy was hinged on the accurate rehabilitation and restoration of the inner core, within the town walls, and on the realization of nineteen development areas (improperly called new towns) in the surrounding outskirts: those developments, called C.A.S.E. (Complessi Antisismici Sostenibili Ecocompatibili) plan, were specifically aimed at hosting the displaced persons before the complete restoration of their damaged houses, and at successively housing students and tourists.

Summing all up, and with reference to the discussion above, the intervention at L'Aquila appears to assume elements of accurate restoration (for what concerns the inner, ancient core of the settlement) as well as elements of new urban development, and hence transformation of the whole city. After more than 4 years, the reconstruction of L'Aquila still appears far from being concluded, and, for what concerns the restoration of the historic core, at present it's even to be seriously undertaken: what, apart from the scandal and polemics it is provoking (not to be discussed here), makes the present, temporary consistency still enduring, with likely permanent effects on the geography of the settlement.

Figure 9 The distribution of radius 3 integration values in the whole urban area of L'Aquila, before the earthquake (above) and after the completed reconstruction (below)

Regardless of difficulties, delays and any present incompleteness, nonetheless the forthcoming consistency of the whole urban area, as it is described in the plans and project so far worked out, can be observed and analysed by space syntax, in order to highlight the configurational state the settlement will be likely to assume.

A comparison of the configurational states that respectively correspond to the grid consistencies before and after (still forthcoming) the earthquake of 2009 allows stressing the most relevant effects the urban reconstruction is likely to cause.

Those effects can be summarized in a slight weakening of global integration within the inner historic core and in the emerging of some local integrators in the surrounding suburbs, scattered around in the fragmented edge of the settlement, as it can be slightly distinguished in figure 9.

Furthermore, in order to recall the discussion on the matter of urban resilience, the alteration of the three parameters proposed and discussed above, observed in the case of the reconstruction of L'Aquila, appears worth highlighting. On this regard, such values, respectively referred to the ex-ante and ex-post situation, are summarised in table 4.

It can be noticed that, despite the limited number of additional axial lines (2165 with respect to 2141) introduced with the new development areas, all the same their insertion appears determining some perceptible effects: a slight drop of mean connectivity, a slight drop of uniformity in the distribution of choice, a slight drop of correlation of local versus global integration: on the whole, on the basis of what was discussed above, a slight increase of the vulnerability of the urban settlement. It can hence be argued that the reconstruction plan of L'Aquila, and in particular the new development areas in its outskirts, seems to determine a slight decrease of the resilience of the whole system. Hoping, of course, that such resilience won't ever again be put on probation.

Table 4 Configurational resilience values of L'Aquila, before the earthquake and after the reconstruction

	before Apr. 9,2009	after the reconstruction
mean connectivity value	6.78	6,35
$choice_{max}/k$	0.50	0.46
R3 int. vs. Rn int. R^2	0.72	0.68

Conclusions

The outcome of the observation of the reconstruction plan of L'Aquila can be roughly summarized in the shifting of centrality from the historic urban core and in the development of some segregated areas, scattered around in the fragmented edge of the settlement; what furthermore involves some degradation of the resilience of the urban system.

Some significant conclusions can hence be drawn. First, a configurational approach allows highlighting the dramatic transformation an earthquake is likely to cause to the inner geography of a settlement, upsetting the distribution of movement flows and the levels of attractiveness and centrality. The extent of such alteration obviously depends on the magnitude of the disaster and on the seriousness of its damages; but it will also be influenced by the inner resilience of the spatial system, which can be somehow predicted by a configurational approach. Even more, the configurational analysis will reveal the likely effects the reconstruction and rehabilitation plans and projects on the variables of the urban system, over and above the fulfilment of recovery claim and the housing supplying. More in general, it will report the far-reaching and long-lasting relevance of urban plans worked out in emergency situation, under the pressure of need and urgency. On such basis, space syntax is here proposed as a suitable tool for supporting and orienting the temporary (yet often long enduring) post-earthquake phase as well as the successive reconstruction planning; even more, it can orient towards more resilient cities, in order to enable them to face and bear any kind of disaster or abrupt perturbation.

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