Emerging Urban Aural Patterns: Finding Connections between Emergence in Architecture and Soundscape Ecology

By Dr. Merate A. Barakat & Dr. Michael Weinstock

Abstract

Cities are dynamic, spatial and material systems that exhibit power scaling and self-similarity across a range of scales. Spatial designers are informed by mathematical and biological systems and use concepts and processes abstracted from them to analyse the emergent phenomena of dynamic complex systems. Although there is an increasing interest in integrating aural perceptual phenomena within the discourse of spatial design domains, both of these fields continue to develop separately. Urban factors, activities, and morphologies determine the aggregate pattern of aural spaces. In turn, the sonic character affects social order within urban patches. Currently, borrowed epistemological concepts are integrated into both domains, where emergence of architecture and soundscape ecology form the current state-of-the-art for research on urban and soundscape design, respectively. This paper explores soundscape ecology as a point of departure to build on the theory of emergence in architecture by drawing parallels and contrasts between these two domains.

Keywords

Architecture; Urban; Design; Research; Emergence; Soundscape; Ecology

Introduction

Soundscape studies, as a field, provided a paradigm-shift for urban design. Characteristically, theories of soundscape and urban design share commonalities. Like soundscape environments, cities are unique in that each has a recognisable 'shapeness' (Marshall, 2005) or morphological form. A general pattern results from a collective unitary order that defines it as a city where humans live in built and natural environments that create an aggregation of human-shaped atomically indivisible units. Programmatic designations and social unit structures determine both types of territories (built and natural). These associations are the result of the corresponding relationship between the city and soundscape.

Modern urban sonic contributions are found to affect animal populations, having profound changes on their behaviour and, in some cases, creating a growing risk of extinction. The reciprocal relationship between sounds and organisms (including humans) is presented as a distinct branch of ecological research, namely Soundscape Ecology (Farina, 2014). Soundscape ecology recognises and integrates components from the fields of acoustic ecology, landscape ecology, bioacoustics, urban and environmental acoustics, behavioural ecology, and biosemiotics (Pijanowski & Farina, 2011). This new field is part of the encompassing theoretical and applied discipline of Ecoacoustics that regards sound as a material form of ecological information to investigate the ecology of populations, communities and landscapes (Sueur & Farina,

2015). The idea of soundscape ecology was presented to a landscape ecology congress in 2009, entitled Soundscape Ecology: Merging Bioacoustics and Landscapes (Pijanowski & Farina, 2011; Farina, 2014). Other soundscape researchers from various disciplines have recognised the significance of the presented concepts (Davies, 2013).
The borrowed epistemological concepts are in alignment with the current spatial design theory adopted within the architectural and urban design research, namely The Architecture of Emergence (Weinstock, 2010a). These domains recognise that there is a characteristic arrangement of material in space within all forms of nature and all forms of civilisation. As such, these dynamic complex systems have form. Architectural shape, size, attendant organism behaviour and duration determines, and is determined by, the dynamic processes and phenomena of the natural world, and vice versa (Weinstock, 2010b).

The field of design research is turning to fundamental sciences (e.g., mathematical and biological systems) to understand how these dynamic complex systems emerge, the composition of interconnected elements, and causation within interaction (Weinstock, 2013a). Cities are no longer considered mere artefacts, they have become the largest and most complex material form constructed by humans (Weinstock, 2011). As temporal organisms, cities are dynamic spatial and material systems that exhibit power scaling and self-similarity across a range of scales (Weinstock, 2013b).
These concepts have been integrated into spatial design research at various scales ranging from climatic research of forest patterns (Greenberg & Jeronimidis, 2013; Yu, et al., 2014), city infrastructure; micro-scale urban morphologies (Aish, et al., 2013); intelligent building systems (e.g., form-finding and structure) (John, 2014; Sarkisian & Shook, 2014); building envelope (façades) response to environmental factors; and biomimetic material investigations (Kotnik & Weinstock, 2013). The assimilation of biological and mathematical models allows for designing computational models for social, environmental and material inquiries (Tamke, et al., 2012; Narahara, 2013; Sarvani & Kontovourkis, 2013).

The connection between the overall domains of soundscape and spatial design is limited to rare theoretical references and there seems to be a lag in considering this interaction, specifically in the recent research. The appraisal of the concept of soundscape should depend primarily on its association with the setting (or context) in which it occurs (Carles, et al., 1999). The majority of soundscape literature follows Schafer's (1977/1993) focus on the taxonomy of a soundscape as a distinct and separable entity from the environment or ecology (Carter, 2003). Raimbault and Dubois (2005) suggest that there is a relational correspondence between the soundscape and urban morphologies which may be examined with reference to the informational content of the sound signals present. Urban soundscape analysis depends on the identification of the activities occurring in the urban space. Characteristic urban morphologies propose settled functions, which are activities that create various soundscapes. In return, sounds (like keynotes and soundmarks) could subsequently shape territories (Raimbault & Dubois, 2005).

Nature and Civilisation

Soundscape ecology defines the soundscape as *"the distribution of sounds across a landscape when the landscape is considered a geographic entity and not a complex cognitive agency"* (Farina, 2014, p. 3). Akin to the broad scientific and educational context of ecology, soundscape ecology considers the term soundscape as the geographic distribution of multi-source sound perceptions (Farina, 2008). Similar to other research into emergence, the ecological soundscape is regarded as a result of sounds produced by agents (i.e. biological, geomorphological or mechanical). There are two types of agents: 1) abiotic, and 2) biotic, which are first perceived and then subsequently interpreted by organisms (Farina, 2014). Overall, the global domain of soundscape and its associated concepts recognise soundscape as a regional sonic context and a cultural field that significantly contributes to defining the characteristics of a region, culture and heritage (Scarre & Lawson, 2006; Cain, et al., 2013). Humans are considered one of the agents. Similarly, a city is described as a congregation of organisms inscribing its associated biological heritage within its boundaries. Urban morphology is shaped through the contiguous temporal behaviour of the collective. Such territories are claimed, formed, and developed as a result of the inhabitants' behaviours, as dynamic spatial, energy, and material systems of spatial unit arrays (Weinstock, 2011).
The perpetual construction, recondition and growth episodes of territories result from their associated informational network systems (communication, food, transportation, and industry) that are constantly expanding (Weinstock, 2013a). From this perspective, cities are not merely stand-alone entities aggregated by static arrays of building structures and concrete street networks, but exist within a hierarchical environmental system that acts on the associated subsystems. In turn, the flow of energy and material across the boundaries of each system modifies the whole (Weinstock, 2010b; 2013b). The concept of information network system constructing the sonic ecological structure is as complex as a city's infrastructure.

There are three categories of ecological sounds that are strictly related to the structure and function of geographic landscapes: 1) *geophonic* (e.g., wind, flowing water, volcanic eruptions), *biophonic* (e.g., alarm or song vocalisations), and *anthrophonic* (e.g., industrial and urban activity) sources (Pijanowski, et al., 2011). The biophonies are defined as the sounds produced by biological organisms and are directly influenced by geophonies and anthrophonies. High levels of the two latter sound categories depress or modify the biophonic patterns (Krause, 2012; Bucur, 2007). In return, urban soundscape research explains that these natural sounds (birds' songs and water features) are preferable to humans and create a sense of well-being and relaxation (Kang & Zhang, 2010). The strict and continuous contacts between sound and both built and natural environments emphasises the importance of the sonic context in shaping evolution and reinforcing the cognitive sense of place for all organisms, including humans, influencing their culture and heritage (Farina, 2014).

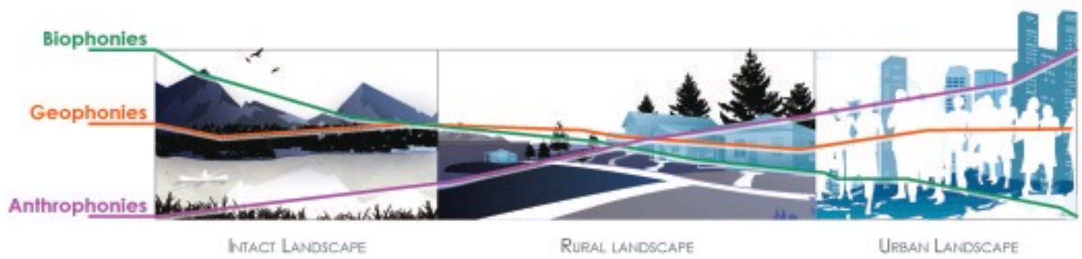

Figure 1
As the human intrusion increases along a gradient from intact Landscape, through the rural landscape, and urban landscape, geophonies seem to remain constant, but biophonies decrease and the anthrophonies increase. Graph information adapted from (Farina, 2014)

Climate and Forms of the Atmosphere

The informational network systems within a landscape maintain a choreography of energy and material exchange between contiguous systems that mediates and is altered by an encompassing metasystem, namely the climate (Weinstock, 2010a). This holds true for soundscape ecology and urban systems alike. The association between sonic patterns and climate relates to indirect effects of climatic shifts called phenology. Climate change is reported to produce biological responses, such as changes in the calling patterns of species, thereby redefining the associated habitat regions (or patches) (Gibbs & Breisch, 2001). The cause-and-effect relationships within the cityscape and the multitude of spatial and temporal scales involved result in the emergence of a "patchwork" system of local climate zones. These formations are associated with complex surface geometry structure, cover, fabric and metabolism (Mills, 2008).

Urban climatologists traditionally separate urban climate zones from rural (or countryside), as two distinct domains. Recent research finds that the surface features defining cities (people, cars, buildings and industries) release heat and pollutants directly into the atmosphere and modify the surface thermal, moisture, and aerodynamic regimes, creating distinguished local city climate zones (Stewart, 2013). This segregation of climate patches is a hierarchal system occurring across a continuum of scales and systems. Specifically in terms of the sonic ecology, the predicted effects include the absorption of lower frequencies and the enhancement of higher frequencies with the rise in temperatures, and changes in atmospheric pressure and relative humidity. The change in climate modifies the leafing patterns of plants that in turn alter the sonic ambience during the vocal performances of many species (Møller, 2010). Some species regulate their sound power in response to ambient temperatures by changing the neuromuscular structure of the vocal organ (Sueur & Sanborn, 2003). Consequentially, calling sites are changing, affecting sonic ambience, and correspondingly the design of songs, mating success, and prey–predator interactions (Farina, 2014).

This adaptation that modifies the associated communication sonic networks across ecological patches also occurs in the city surface network system where the inputs, output and throughputs derive the regional urban microclimates (Weinstock, 2013a). The urban morphology has a reciprocal relationship to its associated microclimates that behave in a similar manner as ecological systems (e.g., rainforests). The formation of distribution patterns and growth strategies emerge from the interaction of climate with the energy and genetic information flow through the region, producing regional differentiation in the urban fabric (or forest) and its microclimates (Greenberg & Jeronimidis, 2013).

Surface Forms | Patch and Edge

The emerging complex patterns described in the presented epistemological domains of soundscape ecology and emergent architecture stem from landscape structure. The unified components that conceptualise landscape include the geographical description, spatial arrangement of ecosystems, and cognitive aspect of the organisms inhabiting these domains. From a geographical perspective, the landscape is a complex hierarchical system of elementary units or patches divided by ecological edges.
Patches are aggregated in further higher-order units that are components of a larger system, formulating a fractal structure. In a homogenous geographical matrix, patches represent the spatial unit, and its associated main characteristics depend on the shape, size, edge irregularities, spatial distribution, and (bio) diversity present there. Distribution and organism diversity (or cohesion) fragmentation of a homogenous patch is a result of disturbances (e.g., climatic, human). This disturbance affects the survivorship of the interior species and facilitates the intrusion of alien species and predators. If the system does not collapse as a result of the patch fragmentation and pattern reorganisation, the outcomes are not necessarily considered negative. Edges or the borders located between one patch and another is a tension zone (i.e. ecotone) through which energy, materials, nutrients, organisms, social interaction, and information pass. These ecotone edges exist at all scales, within a fractal hierarchy (Farina, 2008; Weinstock, 2010b).

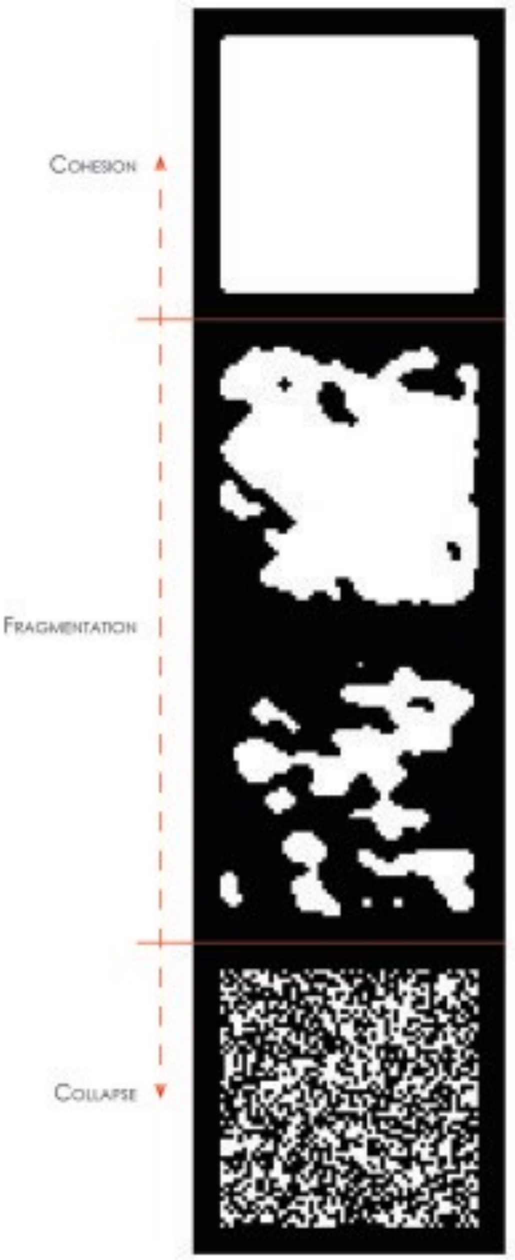

Figure 2
Dynamic complex systems are an emergent balance; it does not change or collapse until a disturbance occurs. Disturbance changes the configuration of the patch-edge relationship and creates information at the edge of the disturbance process. Patterns are generated by a simple Cellular Automata simulation code.

Patches and edges are spatial patterns while fragmentation and edge effects are processes (Farina, 2008). Soundscape ecology also distinguishes sonic patterns from sonic processes, and emergent architecture differentiates between the urban fabric morphology and the infrastructure networks mediating these formations. In urban design, the urban patch model expands on the block-street unit concept. By adopting the same epistemological concepts, the patch-edge unit configuration exists at different scales within a hierarchal fractal mathematical system. The divisions (or edges) are associated with a multitude of factors–anthropological (e.g., social logic, transportation arteries), ecological (tectonic, landscape), and/or climatic (at micro and macro scales) (Stewart & Oke, 2009; Weinstock, 2011). Similarly, the sonic patch termed sonotope (Farina, 2014), is a distinct sonic unit produced by the inter-scaled overlap of geophonies, biophonies, and anthrophonies. Sonotopes are patterns created by biotic and abiotic sonic agents, where the distribution in time and space of the different sonic patches reflects quality, disposition, occurrence in time, and spatial overlap of sound sources. These sonic patches are delineated by sonic edges that are termed as sonotones (Farina, 2014), and defined as sonic environments that are the result of the partial overlapping of adjacent patches (Farina, 2015). For example, the distribution of sound around a waterfall or river passing through a city creates a sonic pattern mediated by an abiotic agent (Farina, 2014).

Like the concept of ecotones in ecology, there are thresholds between urban patches as well, dividing what is considered "private" territories. In the private-public relationship, these thresholds are considered "public" domains. Similarly, the sonic edge effect impacts many system acoustic functions (e.g., ranging, mating choice, territory patrolling, and acoustic partitioning). Species that cross into a sonic patch other than the one they inhabit are regarded as foreign, inserting attributes that fulfil needs or elicit annoyance. Thus, these defining borders are not one-dimensional lines but also tension zones where a social interface occurs between the two territories and where an interplay of natural, cultural and social activities are defined and practised (Lathouri, 2013).

Forms of Metabolism

The morphology, scale, and behaviour of biological systems within the associated habitats is related to their rate of metabolism. The flow of energy, information and material is vectored through the ecological system that is constructed and inhabited by these living forms (Weinstock, 2010a). Most vocal animals have complex organs of vocalisation. There is a relationship between their body mass and the frequencies utilised in vocal performances (Fletcher, 2004; 2014; Wallschläger, 1980). The acoustic energy produced is proportional to multiple factors besides the size of the species. Body mass is one morphological adaptation; it is hypothesised that organisms with large body mass utter vocalisations with a lower frequency than smaller species. Larger animals communicate at greater distances than smaller ones to cover their associated habitat and ranging domains. Organisms utilise frequencies in relation to the communication range required to reduce sound degradation. This contributes to factors of communication across sonotopes from one sonotope to another (Farina, 2014).

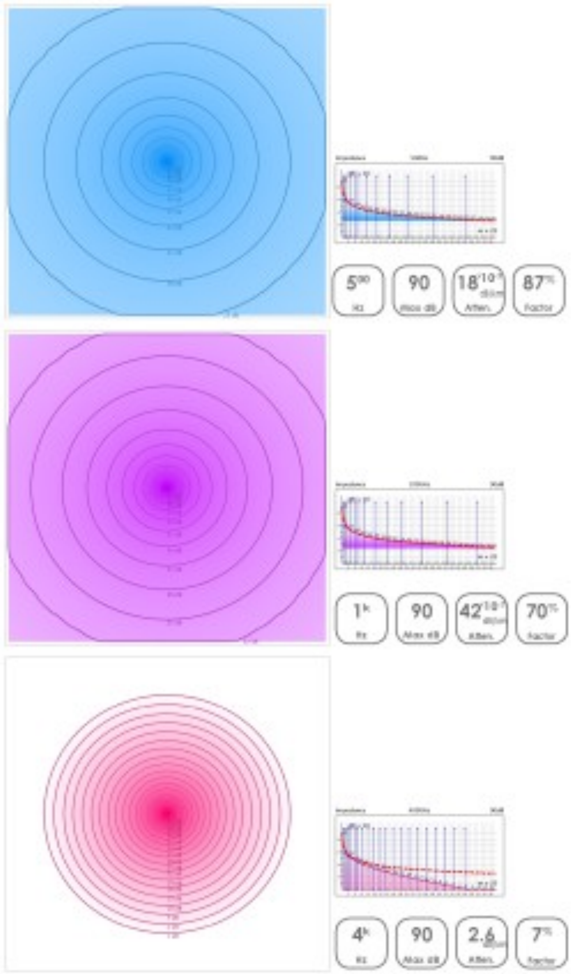

Figure 3
Lower frequency signals cover larger distances than higher frequencies. This allows increased communication ranges within a larger sonic patch. Figures generated by an Object-Oriented Programme simulating frequency dependent attenuation of the sound energy emitted from a point source in a free field.

Cities are like living organisms; larger animals have different forms compared to smaller ones. When considering a city as a biological system, the urban morphology is a porous surface comprised of cavities or edges (streets and public spaces) with material folds (buildings and blocks) (Steadman, 2008). The relationship between the texture of an urban fabric and its associated local climate and energy consumption can be mathematically expounded to analyse the differentiated material and spatial conditions across the urban surface (Weinstock, 2010a). The diversity present influences and moderates the local urban microclimate (Stewart & Oke, 2009; Stewart, 2013), behavioural conditions and energy consumption (Weinstock, 2011).

To extrapolate, if a city can be regarded as an aggregation of sonotopes within a larger sonic patch, the rate and projection of the sound energy and information flow are multi-scalar processes. The processes can be derived from understanding the differing scales and metrics of metabolic flows through cities (Besserud & Sarkisian, 2013). The size of the city is a result of the scaling patterns of its infrastructure and their aspects of information flow periodicities, velocities and quantities. The larger the city, the faster these processes are (Bettencourt, et al., 2008), and the further the information can travel. In turn, the faster and further information can flow through a city, the faster the city grows (Weinstock, 2013a).

Forms of Information

Biological and artificial communication and information networks share common features owing to the similar operational constraints that derive them, such as spatial embedding, optimisation and self-organisation (Valverde & Solé, 2013). Sonic perception of context requires a particular capacity that has a genetic or cultural origin by every perceiving agent (humans and nonhuman organisms). The emergent sonic configuration creates a context in which sonic information and acoustic communication represent tools these organisms use in active and passive cognitive processes. The complexity that emerges from the information contained in a soundscape can be analysed and interpreted by the application of functional models (Farina, et al., 2011).
Similar to the acoustic communication theory developed by Truax (2001), there is a sender-receiver connection where an informative signal vectors through an informational conduit, namely the acoustic channel. This channel is an important component of an organism's life (reproduction and survival) and the cohesion and growth of the populated sonic patch. The acoustic information provides orientation and organisational cues that agents employ to find resources, to avoid predators, and to find or adapt locations for reproduction (Farina, 2014).

In terms of metabolism, species' communication is costly, thus, organisation and physiological attributes are employed to create a communicative framework and overcome environmental factors (topography, vegetation cover, and natural or anthropogenic noise-masking) that influence the communication channels (Farina, 2014). In long-distance communication, types of acoustic adaptations occur that are correlated with the habitat acoustics to maximise the transmission efficiency (Morton, 1975). Transmission of energy (including sound) in an urban context occurs through various communication channels, such as infrastructure networks. The urban morphology and density and the evolution of communication and transportation technology stimulate the energy and material flow through cities (Weinstock, 2011). The advancement of infrastructure systems configuration creates a shift that is based on multi-scalar patterns, and variable speed of that flow can produce emergent spatial configurations (Mangelsdorf, 2013).

The reverse process of fragmentation is connectivity, in which isolated patches are secondarily connected to the network (Farina, 2015). Biological and cultural networks continuously grow by the addition of new nodes (or hubs) that are commonly located at a central position of a patch. The new nodes predominantly attach to already well-connected nodes. Consequentially, the topology of the whole network has only a few nodes that have a high number of connections and that are linked to all the other nodes that have lesser numbers of connections, progressively. The flow volume, velocity and patterns of energy, information and materials predominantly vector through the highly connected nodes (Weinstock, 2011). The number and size of the network nodes and connections configuration determine the complexity of the system and the flow rate of information vectoring through the network. It is worth noting that the complexity of the information system is the critical determining flow factor.

Characteristically, urban sound sources are positioned locally within the network nodes, and can be perceptually experienced through the infrastructure network (via information media). Infrastructural networks exhibit some similar characteristics to those exhibited by the branching metabolic networks of living forms, which are emergent quantitative features based on empirical scaling relationships (Weinstock, 2013a). For example, low-frequency signals travel through vegetation more efficiently than high-frequency signals, and short, repetitive signal bursts travel longer intervals in dense vegetation. Therefore, for biophonies, environmental constraints are a factor in choosing the calling frequency band, where species change their spectral patterns to avoid competition or adopt frequency bands that have lower degradation (Farina, 2014). Although this holds true for smaller urban-scale sonotopes, such as urban public spaces and socially contiguous districts, technological advancement in communication overcomes some of these constraints for long-distance human and social communication.

The emergence and development of the twin factors of high-density fossil fuel and equally high-density information systems has enabled increasingly rapid acceleration in the rate of growth of human populations over the last two centuries. The flow of information and energy has accelerated accordingly, the population of the world is rapidly expanding and the complexity of the world's system continues to increase. The energetic expense of complexity in the system continues to accelerate, with increasing numbers of people in specialised roles to generate and process the flow of information, and in manufacturing, constructing and maintaining its physical infrastructure. The emergence of the urban topologies and physical architecture of the network systems is a result of the interdependencies and integration of differing infrastructural systems (Weinstock, 2011). Information flow through such infrastructures has a reciprocal and intricate relationship with the urban morphology and growth to an extent that cities can be considered sentient or conscious. The term "smart city" becomes a much more profound description of its metabolic flow processes and emerging morphology (Weinstock & Gharleghi, 2013).

Organisation and Emergence

Emergence is mediated by the autonomous behaviour of social organisms. The interaction and coordination processes between these living forms create organisational configuration within patches and across edges, which results in a whole complex system exhibiting an intelligent collective behaviour. The sonotope paradigm is potentially subdivided to a further coordinated organisation, namely soundtopes (Farina, 2014). The soundtope is considered an active intra- and interspecific vocalised coordination employed as a strategy to reduce foreign intrusion in a private local community. The complex mechanism of information exchange dictates its intensity and duration (Hoffmeyer, 2008). A collective community with specific goals that are independent of environmental constraints creates a soundtope, which is a fundamental sonic pattern that has more information than a sonotope. The sonotope is determined by environmental constraints while the soundtope is a patch that emerges from the inhabiting life forms' behavioural processes (competition, courtship, etc.) (Farina & Belgrano, 2006; Malavasi

& Farina, 2013). At the edge where two sonotopes come into contact, a stochastic acoustic configuration occurs across the heterogeneous medium. A complex sonic area then emerges where signals cannot be properly de-codified due to masking and overlap (Farina, 2014).

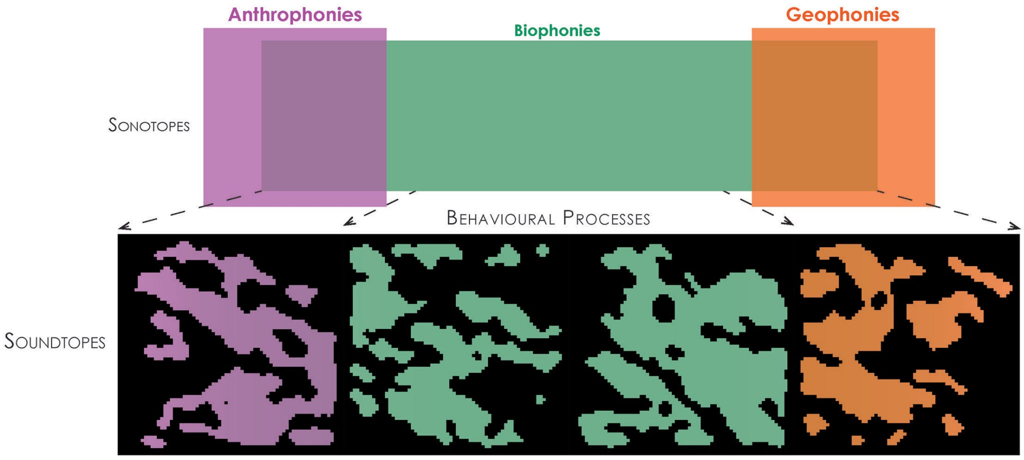

Figure 4
Sonotopes are a result of the spatial overlap of geophonies, biophonies and anthrophonies. Inside a cohesive patch, the behavioural process of the inhibiting agents creates distinct hierarchical domains, namely soundtopes. The same holds true for other information and material exchange for all life forms. Information obtained from (Farina, 2014).

As in biological complex systems, urban elements are interconnected in an integrative process where, in a cause-effect relationship, what is an effect at one scale may be a cause at a higher (or lower) scale (Corning, 2002). Cities are regarded as emergent phenomena that are embedded within a hierarchal system, which has a reciprocal relation to the climate and ecology at one scale and spatial variation and temporal organisation at another (Weinstock, 2013a). In both types of complex systems, the temporal changes emerge according to simple rules. When optimisation occurs and the system becomes an emergent balance, it does not change or collapse until a disturbance occurs (Weinstock, 2010a).
This emergent behaviour occurs at all scales, including urban public spaces. The behaviour and interaction of the people and technology inhabiting these domains create self-assembled communities that define the spatial morphology in addition to the building or space enclosing it (Moreno & Grinda, 2013). At the edge of these social self-organisation territories, a stochastic social interplay occurs that creates a spatial division (Lathouri, 2013). There are many examples of urban patches that exhibit morphological cohesion and stochastic interaction with the adjacent domains across an abiotic edge. One can be found in Central London between the boroughs that are currently named the City of Westminster, North of the Thames River, and Lambeth and Southwark in the south. Historically, this point along the river has maintained a strong conduit for information (energy and material) exchange. The continuous stochastic social interface occurring between these territories show in its demographic distribution.

With the construction of Westminster Abbey, the southern boroughs began, and continued, to be frequented and inhabited by people that are associated with Westminster. The geographical and political adjacency meant that this location has always been a North-South arterial link (Stanley, 2002). Since silence is a privilege, the introduction of the combustion engine may be considered one of the disturbances that changed the demographic character and urban fabric of the southern areas (LaBelle, 2010). However, the informational conduit remains strong through the infrastructure.

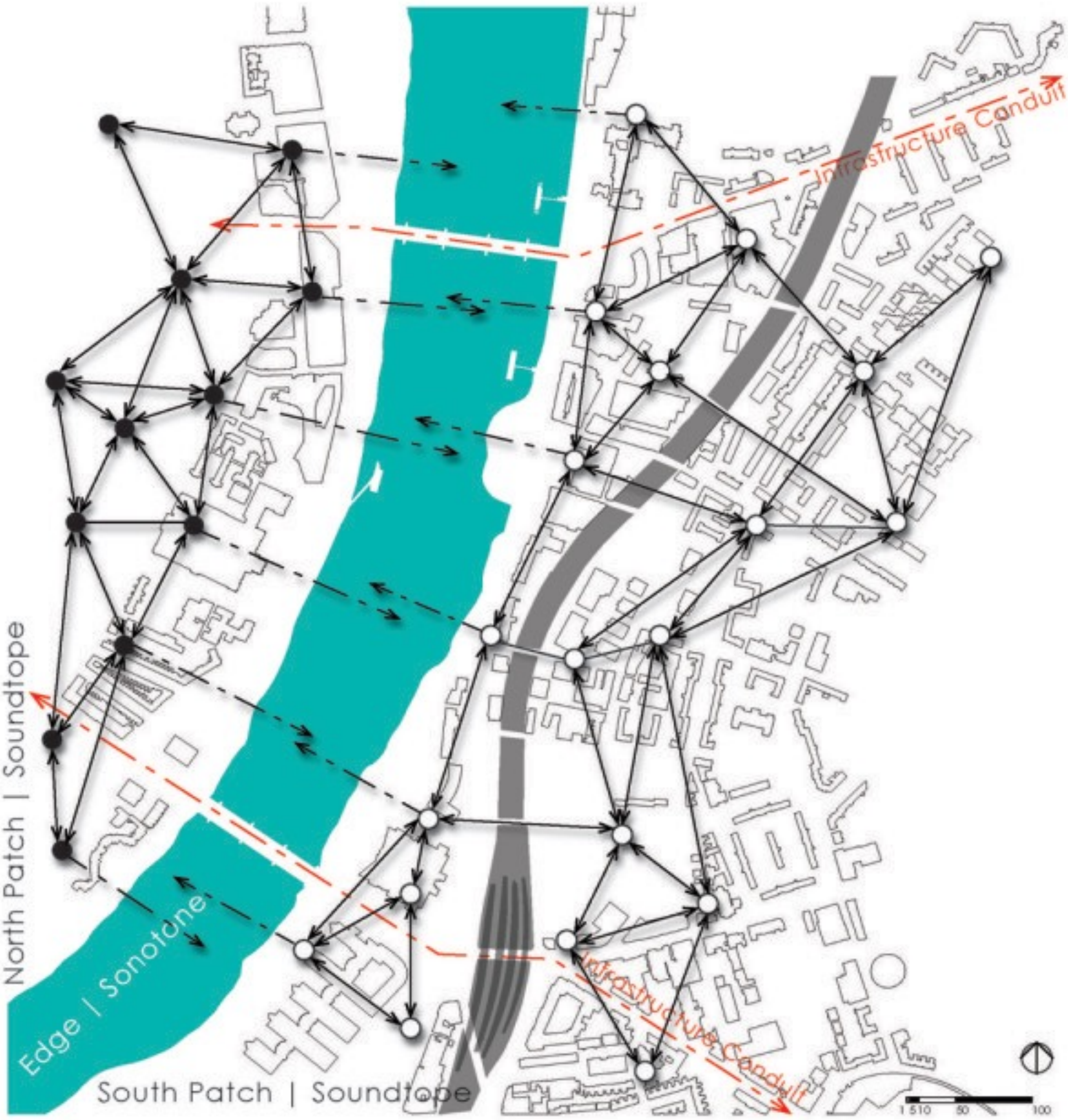

Figure 5
Across an edge (ecotone or sonotone) a stochastic social interplay occurs that creates a spatial division between territories. Information obtained from (Farina, 2014) and original digital map from (RIBA Competitions, 2013).

Communication technology has changed the concept of "local" territories, and organised communities are not only confined to proximity; consequently, homogeneous digital social patchworks emerge (Young & Davies, 2013). These communication channels are creating a further fractal division that derives urban morphology (Weinstock, 2013a).

Discussion

Ecology and climate have been, and are still, strongly coupled to the emergence of the cultural systems of cities, to their subsequent evolutionary diversifications and developments, expansions and contractions, and to their eventual collapse and reorganisation. Information flowed back from the metropolis to the colonies, accelerating their territorial expansion and increasing their complexity in turn. Increased complexity required higher levels of organisation, with increased numbers of specialists to process, manipulate and to communicate greater volumes and more kinds of information, and they had to be supported by the surplus production of energy and materials in the system. Complexity consumed energy, and each increase in complexity required a further rise in the flow of energy. The process of finding, developing and collecting more energy and materials over greater distances and larger territories required an increase in information processing and consumed yet more energy. The emergence and subsequent evolutionary development of information systems and the systems of cities were strongly coupled, each acting as a positive feedback on the expansion and growth in complexity of the other.

The distribution of information networks exhibits many similarities to the hierarchical branching of biological metabolic networks. A number of other culturally produced systems also exhibit comparable 'scale-free' power law characteristics, including soundscape. This is most likely to be generated by the way in which the systems grow through a network of nodes and hubs through which the trajectory of the energy, information and material patterns primarily vectors through the well-connected nodes. These properties characterise the evolution of biological systems and culturally produced metabolic systems. It is important, however, not to confuse the topology diagram with the physical reality. Physical infrastructures are generally massive, constructed from dense materials, with geometry and scale that do not resemble biological networks. Ecological connectivity networks are linear habitats that strategically formed to preserve biodiversity and maintain the heterogeneity of the ecological matrix.

In a continuation of the on-going inquiries of the relations between natural systems and the cultural architectural systems of civilisation, what were then standard architectural practices are undergoing a substantial reconfiguration. The force of convergence between disciplines is igniting an evolutionary process that has begun to act on the boundary between "the natural and the made". The emergence of architecture area of research outlines the cultural convergence of biology, medicine, engineering, data networks and flows, computation and material sciences in service of an argument that architectural knowledge is actively constructed, provisional, and subject to recombination and improvisations in formulations of thought and materialised forms.

Considering the processes of nature and civilisation as systems serves to accentuate the interactions and connectivity of the different parts of the systems and the interactions between the various organisms. The literature of complexity theory is extensive, with varying emphasis and different foci in the natural sciences, in mathematics and computation, economics and artificial intelligence. There is, as yet, no unified complexity theory, but a central tenet is that the concepts and processes of complex systems may be understood as independent of the domain of any one particular system.
In continuing research across differing domains that are examining and informed by the natural world as well as assimilating methodologies, metrics, and semantics from natural world disciplines, the hypothesis that cities have sonic characters and are part of an encompassing soundscape metasystem can be realised. Architecture has its own instruments and metrics for classifying and interpreting data that places them in relation to its own body of investigations, concepts and scholarship. Knowledge of the historical development of each informing discipline and how each intersects with other contingent bodies of knowledge is necessary for the identification, evaluation and selection of concepts and data relevant to any research agenda involving sound.
The consideration of sound within urban design is a nascent on-going research field, owing to the complexity of the cognitive aspects of sound. Contrary to general perception, urban sounds are not always considered pollutants. Although anthrophonic interventions do cause some sort of disturbance to biophonic patches, urban sounds like soundmarks (e.g. church bells) and sonic heritage sources can create a sense of citizenship and cohesion at the scale of urban districts and townships. Spatial designers can benefit from these concepts when designing urban spaces and the associated sonic characters. There is a unique opportunity here where the two domains—design research and soundscape—are informed by and adopting the same concepts that have been established in the natural science fields, specifically ecology. In an attempt to seize this opportunity, this cross-disciplinary discussion aims to integrate sonic phenomena with current architectural and urban design discourses and also to suggest connections between spatial design and the domain of soundscape.

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Bio

Merate Barakat is an architect, and is currently an Associate Instructor at the School of Architecture, University of Utah, and Director of the AA Alexandria Visiting School. She holds licences for both North America and the Middle East, has worked on a number of projects that have received design AIA (American Institute of Architects) Awards and also holds a degree in Computer Science and Information Technology. Her current research focuses on the potential for creating a tool that integrates theoretical spatial and soundscape design connections to aid spatial designers.

Michael Weinstock is an Architect, Director of Research and Development, and Director of the Emergent Technologies and Design programme in the Graduate School of the Architectural Association School of Architecture, London. His published work involves research into the dynamics, forms and energy transactions of natural systems, and the application of mathematics and processes of emergence to cities, to buildings and groups of buildings. His work has made a significant contribution to the theoretical discourses and pedagogies of architecture and raised awareness and understanding of the historical and current impacts of complexity, natural systems, and climatic and ecological changes in human architectures.